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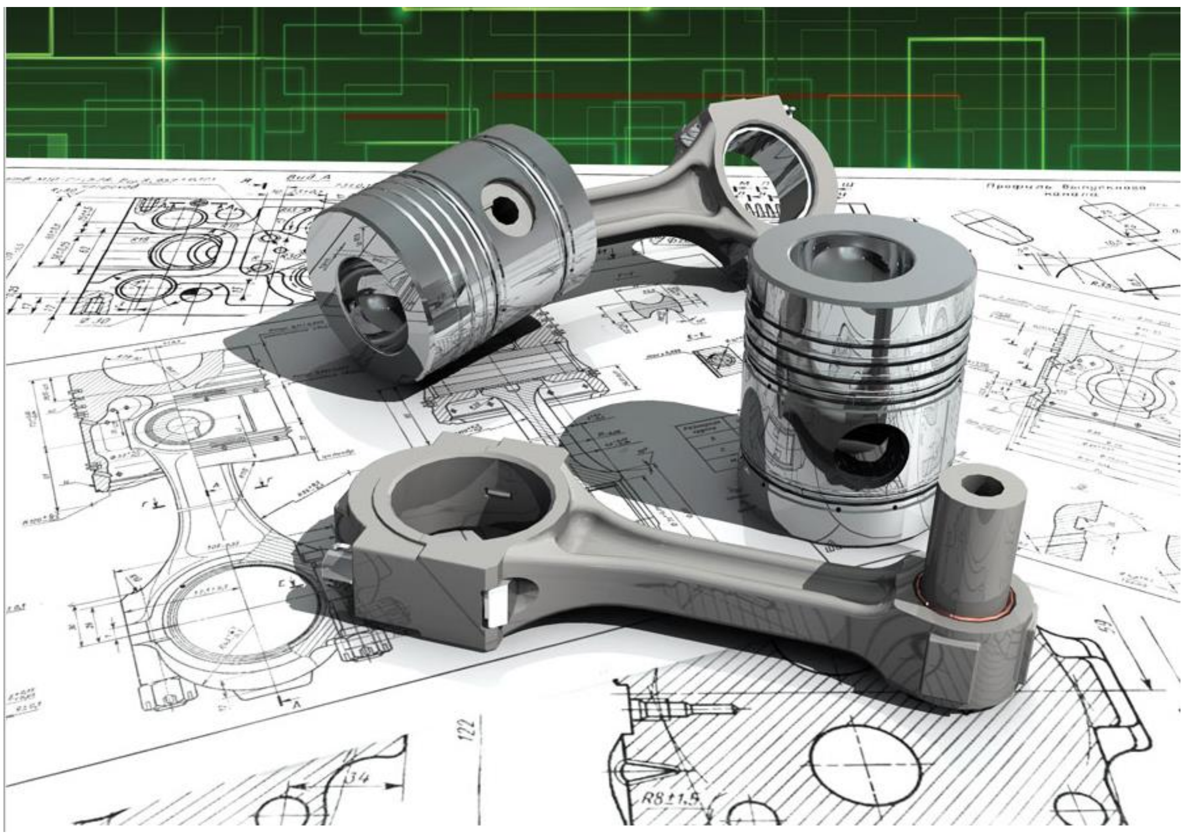

Siemens Engineering Design

A secondary school course featuring Solid Edge

--- Teachers Edition ---

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--- Acknowledgement ---

Siemens PLM wishes to acknowledge the talents of Tom White, Terry Nagy, and Dick Blais in the development of the ***Siemens Engineering Design*** curriculum. We believe this curriculum to be a “Best in Class” model for excellent contemporary project/problem based engineering design curriculum for secondary school students. We are pleased to offer the ***Siemens Engineering Design*** curriculum to secondary schools at no cost.

About the authors:
Tom White, Terry Nagy, Dick Blais, and other talented teachers at the Shenendehowa Central School District in Clifton Park, New York developed and operated a highly successful high school engineering curriculum. The Shenendehowa program began in 1988 and operated for 11 years before the curriculum became *Project Lead The Way (PLTW)* in 1999.

In 1999, Dick Blais left the Shenendehowa Central School District and founded *Project Lead The Way*. Shortly thereafter Tom White left the Shenendehowa Central School District and joined *Project Lead The Way* as Director of Technology. Terry Nagy continues to be an exemplary engineering teacher at the Shenendehowa Central School District.

From 1999 through 2009, Blais and White worked with other talented people to expand *Project Lead The Way* to all 50 states to include over 3500 school sites. Through that period they developed an expanding high school engineering curriculum and added the *Gateway To Technology* middle school curriculum as well as some elementary curricula through a relationship with NASA.

In 2009, Blais joined the Southern Regional Education Board (SREB) and became director of the *Preparation for Tomorrow* curriculum initiative. This initiative would be renamed *Advanced Career* (AC). In his role, Blais led the development of several AC Pathway Curricula. He is still contributing to the work of the SREB AC initiative but now as a part time Senior Advisor. Blais was a 2008 recipient of The Harold W. McGraw, Jr. Prize in Education.

White created Tom White & Associates LLC in 2010 to write programs and technical educational materials and projects for a wide variety of schools, industries and governments. His work includes automation, civil engineering, computer numeric control, computer science, control systems, data acquisition and analysis, electronics, Field Programmable Gate Arrays (FPGAs), game design, GIS, instrumentation, Programmable Logic Control (PLCs), product design, rapid prototyping, robotics, the science of golf (Chevron), Variable Frequency Drives, welding and several freshmen engineering curricula. His work is utilized worldwide and been translated into many languages.

Nagy, an exemplary engineering teacher and teacher educator has collaborated with Tom White & Associates LLC on several curricula providing expertise in motivation for students. He has taught engineering technology to high school, college and as a master teacher working to educate other teachers in strong classroom project based learning.

Siemens would also like to extend thanks to the hardworking staffs at Quantum Leap Concepts and Tom White & Associates.

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Contents

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Content Standards

Engineering Design Process

- Create and maintain an Engineering Notebook for daily reflections, research and prototype creation documentation.
- Apply the design and problem solving process as an iterative process incorporating sciences, mathematics and engineering to optimally convert resources to meet a stated objective.
- Communicate solutions utilizing technical writing skills including correct spelling, proper grammar and dependent vocabulary.
- Assume and carry out a role in the smooth running of a team working toward the solution of a problem.
- Assemble a quantitative plan for successful completion of the project.
- Assume responsibility for leadership roles and responsibility for actions, decisions products and policies in the governance of a project.
- Evaluate the need for and costs of resources necessary for the completion of a project.

Sketching

- Create sketches utilizing basic shapes such as lines circles and ellipses.
- Communicate ideas to a group through the use of sketches and other documentation.
- Apply isometric and orthographic sketches to add clarity to design.
- Create necessary sketches to communicate basic ideas during the design process.

3D Solid Modeling/Fabrication and 3-D Printing

- Apply geometric relationships between lines and shapes to create a mathematical database to describe design ideas.
- Create solid models utilizing concepts of Parametric Modeling.
- Analyze models for appropriate engineering design features needed.

- Develop strategies for the creation of solid models for the rapid creation of design solutions.
- Apply the concepts of digital prototyping to accelerate the time frame between ideation and completed project.
- Access, generate, process, and transfer information using appropriate technologies.
- Design and create a model using additive manufacturing technology sometimes called a rapid prototyping system.
- Apply new principles of more rapid and less costly development and deployment of new materials.
- Utilize rapid prototyping/additive manufacturing to create highly complex parts designed in a CAD system.

Renderings/Working Drawings/ Design Presentations

- Create renderings to communicate design ideas and engineering principles to the general public.
- Generate an image from a model utilizing light, texture and shading to create a proposed final appearance of a product.
- Apply rendering techniques to create presentations of design for a non-technical audience.

Assembly Modeling/Documentation/Exploded Assemblies/Bill of Materials

- Conduct model documentation as the process of recording details such as size, material composition, and instructions for assembling, installation and servicing, analysis, development process that describes a model for the purpose of communication of ideas.
- Create a bill of materials to communicate materials and other information about a design.

Reverse Engineering/Engineering Features

- Apply the principles of design for manufacturing enabling the efficient and effective production of products.
- Apply the green principles of design for eventual disassembly and resource recovery.
- Investigate activities that a business conducts with the intention of making a discovery that can either lead to the development of new products or procedures, or to improvement of existing products or procedures and to know the new approaches of rapid development and deployment that saves time and is more efficient.
- Disassemble a product into its parts, utilize precision measurement to create sketches, drawings and models of the product and identify the basic processes, systems, designs, and materials used in the manufacture of the product.

Simple Machines

- Utilize mathematical analysis, scientific inquiry and engineering design to develop solutions to open ended problems.
- Access, generate, process, and transfer information using appropriate technologies
- Apply the design process in the design of a mechanical system.
- Read and analyze detailed descriptions of machinery and provide a concise summary for documentation purposes.
- Assign mathematical relationships to analyze mechanical advantage.
- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.
- Assign mathematical relationships to analyze mechanical advantage.
- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.

Mechanical Systems

- Utilize mathematical analysis, scientific inquiry and engineering design to develop solutions to open ended problems.
- Access, generate, process, and transfer information using appropriate technologies.
- Apply the design process in the design of a mechanical system.
- Read and analyze detailed descriptions of machinery and provide a concise summary for documentation purposes.
- Assign mathematical relationships to schematics to apply forces.
- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.
- Apply the design process in the design of a mechanical system.
- Design a system of elements that manage power to accomplish a task that involves defined movement.
- Read and analyze detailed descriptions of machinery and provide a concise summary for documentation purposes.
- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.

Structures/Forces

- Create models that are mathematical or physical systems set up to obey certain specified conditions whose behavior is used to understand study or evaluate a design or system.
- Conduct model analysis using FEA and simulations as a detailed examination of the elements, structure or behavior of a physical system under certain imposed conditions.
- Assign mathematical relationships to schematics to apply forces.
- Conduct a systematic study of the relationship of the material, members, and the construction of the structure when loaded to determine the resulting deflections and forces.

- Apply knowledge of stress and strain to the design of a problem solution.
- Analyze strength of materials to predict behavior of solid bodies subjected to various types of loading to determine the stresses, strains, and displacements caused by the loading.
- Predict loads exerted on a product, machine, or structure during any foreseeable use to determine safety.
- Analyze complex structures by breaking them down into components.
- Test scale models to verify the strength predictions made from mathematical models.

Engineering Systems

- Utilize mathematical analysis, scientific inquiry and engineering design to develop solutions to open ended problems.
- Select and defend a material for use in a product, explaining material properties and characterization, based upon manufacturing processes, chemical composition, internal defects, temperature, previous loading, dimensions and other factors.

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Major Units and Associated Projects

Major Units

- Engineering Design Process
- Sketching
- 3D Solid Modeling/Fabrication and 3D printing
- Renderings/Working Drawings/Design Presentations
- Assembly Modeling/Documentation/Exploded Assemblies/Bill of Materials
- Reverse Engineering/Engineering Features
- Simple Machines
- Mechanical Systems
- Structures and Forces
- Engineering Systems

Projects by Quarter

Quarter 1

Engineering to the Engineering Design Process

- Introduction to the Engineering Design Process

Sketching

- Sketching and Documentation

3D Solid Modeling/Fabrication and 3D printing

- Name Plate Holder
- Chess Set
- Sport Drink Container
- Package Design
- Kitchen Tool Design

Renderings/Working Drawings/ Design Presentations

- Shower Caddy Rendering
- Table Driven Kitchen Measuring Instruments

Quarter 2

Assembly Modeling/Documentation/Exploded Assemblies/Bill of materials

- 3D Puzzle
- Mold Design
- Coaches' Cart

Reverse Engineering/Engineering Features

- Reverse Engineering Project

Quarter 3

Simple Machines

- Bathroom Door Latch
- Nutcracker
- Ball Launcher

Mechanical Systems

- Differential Gear Design
- Merry-Go-Round

Quarter 4

Structures and Forces

- Playground Design
- Truss System
- Hybrid Toy Connector

Engineering Systems

- Centrifugal Pump
- Automatic Training Wheels
- Mechanical Bank
- Glider
- Child's Toy

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Attributes of the Projects

Project Title: **Introduction to the Engineering Design Process**

Essential Question: How can we approach a problem and have the greatest chance of designing a successful solution?

What students will do to answer the essential question: Students are given a piece of paper and challenged to find a way to keep it aloft for the longest possible time. They spend time researching and documenting the research in their engineering notebooks. They follow the design process and develop a solution they demonstrate to the class.

Project Title: **Sketching and Documentation**

Essential Question: How do I document an original idea so I can communicate with others easily?

What students will do to answer the essential question: Students receive a part. They measure and document the part with annotated sketches and then sketch out a new component that will fit the original. Students present their designs utilizing the sketches they created.

Project Title: **Name Plate Holder**

Essential Question: How can a 3-D model be used to display a student name card and store two pencils?

What students will do to answer the essential question: Students will design and produce an object that will hold a 3 x 5 name card and two pencils. The object will be limited in size to no more than a 2" H x 3" L x 2" D. The primary criterion is the minimal use of material to meet the goal of the model. Students produce the 3D model with a 3D printer and demonstrate its effectiveness.

Project Title: **Chess Set**

Essential Question: How can we design a themed chess set to attract new players?

What students will do to answer the essential question: Students will interview prospective clients and design a regulation chess set. Students will use the 3D printer to create a prototype example to demonstrate their design for their customer.

Project Title: **Sport Drink Container**

Essential Question: How can a design for a container be created so it can be modified through a single dimensional change to produce a proportional design to hold different volumes?

What students will do to answer the essential question: Students will design a sport drink container in Solid Edge and dimension the design with the use of formulas to allow for the original shape to meet different volume requirements with the change of a single dimension.

Project Title: **Package Design**

Essential Question: How can we support and display sporting goods for consumer purchase?

What students will do to answer the essential question: After basic research into package design, students design and construct a package to display a specific sporting product or ball. They design a product that can be stacked and displayed for marketing purposes.

Project Title: **Kitchen Tool Design**

Essential Question: How can we make a tool to perform a kitchen task routinely done by hand?

What students will do to answer the essential question: Students will research kitchen tools. They apply their knowledge in the design of a new kitchen tool to simplify a cooking/food prep task. They explain the ergodynamics of their design.

Project Title: **Shower Caddy Rendering**

Essential Question: How can we safely store and efficiently move certain bathroom necessities from one room into another?

What students will do to answer the essential question: Students brainstorm types of products that will be necessary to move. They utilize the list of needed products to design a bathroom caddy that will transport needed items from a living area (bedroom, dorm or hotel) to a bathroom area.

Project Title: **Table Driven Kitchen Measuring Instruments**

Essential Question: How do we create a set of measuring instruments that look similar but hold different specified amounts?

What students will do to answer the essential question: Students will design a set of measuring instruments for a kitchen setting that will hold specific volumes of material. The set should look similar and nest when not in use. Students develop a spread sheet to drive the variables in the design and utilize a lookup process to select the correct dimensions.

Project Title: **3-D Puzzle**

Essential Question: How can we make a challenging 3d puzzle for a desired difficulty level and age group?

What students will do to answer the essential question: Students research puzzle types for specific age groups, design, build and test a 3d puzzle for an appropriate age range. It will be 3d printed and tested. Students report on the engagement of their desired audience with the puzzle.

Project Title: **Mold Design**

Essential Question: How do we make a unique mold cavity to produce a chocolate candy bar?

What students will do to answer the essential question: After researching molds and mold characteristics students design and produce a mold cavity so that they are able to cast their own chocolate candy bar. Students will 3D print the molds and must allow enough relief to allow the extraction of the candy bar.

Project Title: **Coaches Cart**

Essential Question: How can we transport certain materials from inside a school building outside to an athletic field for coaches and players to use?

What students will do to answer the essential question: Students interview coaches about their needs. Students will design a portable cart to hold specified items to transport back and forth from inside a school to an adjacent athletic field. Students create a model to display during presentations.

Project Title: **Reverse Engineering Project**

Essential Question: How can the use of reverse engineering expose key concepts in engineering design?

What students will do to answer the essential question: Students will select a multiple part product, disassemble and analyze it, measure all parts, produce an exploded assembly drawing with bill of materials and create a visual example gluing the exploded parts to a display to accompany the exploded assembly drawing produced with Solid Edge.

Project Title: **Bathroom Door Latch**

Essential Question: How can we design, build and test a mechanical door latch for public bathroom stalls that also will tell if someone is using the stall or if it is vacant?

What students will do to answer the essential question: After researching simple machines and mechanisms students will design a mechanical tamper proof bathroom door latch that when operated, will securely lock the door and indicate if the space is occupied or not.

Project Title: **Nutcracker**

Essential Question: How can we design an object to mechanically break the shell of a tree nut?

What students will do to answer the essential question: Students research mechanical advantage. Students then design a themed nutcracker that when operated will crack the shell of a tree nut. Students present the findings of the application of mechanical advantage in their design.

Project Title: **Ball Launcher**

Essential Question: How can we design and test a device that will transport an object into a specified target?

What students will do to answer the essential question: Students research ballistics, then design, construct and test a launching device that will transport a projectile a specified distance. Students test the device and create an Excel spreadsheet to allow students to predict landing locations.

Project Title: **Differential Gear Design**

Essential Question: How can we transmit and multiply engine power to the drive wheels of a vehicle?

What students will do to answer the essential question: Students research gear trains and methods of power transfer. Students then use Solid Edge to design and print a functioning gear train.

Project Title: **Merry-Go-Round**

Essential Question: How can we create a working themed merry go round appropriate for young children?

What students will do to answer the essential question: Students research bearings used for merry go rounds and design and create an age appropriate merry go round for young children to use at a park or playground.

Project Title: **Playground Design**

Essential Question: How can we physically design and construct a playground for several young children to safely play?

What students will do to answer the essential question: Students research playground design principles and apply the knowledge to the design of a playground for a specific age grouping. Teams of students design specific equipment for the playground. They create renderings to show the final design.

Project Title: **Truss system**

Essential Question: How can we calculate and design a truss system (roof or bridge) that will hold a specific amount of weight?

What students will do to answer the essential question: Students study forces and how structures are designed to resist those forces. Students design and then utilize the analysis tools in Solid Edge to predict performance of their structure. Students fabricate the structure and apply loading stress to determine if the structure matches the predicted performance.

Project Title: **Hybrid Toy Connector**

Essential Question: How can we take two or more dissimilar toy sets and combine them safely so that children can create a brand new toy experience?

What students will do to answer the essential question: Students will reverse engineer and redesign a toy component that can link multiple different toy sets safely. Students print the part to demonstrate the fit to both toy sets.

Project Title: **Centrifugal Pump**

Essential Question: How can we design a device to use centrifugal force to move water from one location to another?

What students will do to answer the essential question: Students research centrifugal pumps and design, print and build a small centrifugal pump (housing and impeller) and communicate its performance using a pump curve diagram produced by multiple experiments conducted on their design.

Project Title: **Automatic Training Wheels**

Essential Question: How can we design a pair of bicycle training wheels that will easily adjust to different bikes and riding abilities?

What students will do to answer the essential question: Students research mechanisms and design a pair of training wheels for a beginner bicycle. The design will be easily installed and removed as well as adjustable in height to allow the rider to gradually adjust to riding without training wheels.

Project Title: **Mechanical Bank**

Essential Question: How can we use a mechanical device to transport various coins into a storage container?

What students will do to answer the essential question: Students will research mechanisms and design a mechanical bank. The bank will accept a coin and then move it to a different location for storage. Students produce a rendering of their final project.

Project Title: **Glider**

Essential Question: How do we create a glider to land at a desired location?

What students will do to answer the essential question: Students research basic glider design. They design and build a glider to fly a specified course, fly the longest or hit a specified target. Students iterate their designs based upon experimentation.

Project Title: **Child's Toy**

Essential Question: How can we design an animated children's toy?

What students will do to answer the essential question: Students will use knowledge of mechanisms to design and assemble a 3d model of a young child's toy with several moving parts.

Teacher Guide:

One of the many benefits of STEM education is the integration and application of cross curricular content. This allows students to understand the relevance of content learned in other subjects studied in secondary school. To be effective, a STEM program needs to be fully integrated. The easiest and best way demonstrated so far is with a comprehensive project based curriculum. This helps students answer the questions “Why do I need to know this” and “Where will I ever use this”. The *Siemens Engineering Design* course follows this accepted framework.

Project based curriculum allows for deep exploration of a problem. There are 26 projects in the *Siemens Engineering Design* course. Each project is designed to allow different student groups to develop several and distinct solutions to the same problem. The problem presents the student with an opportunity to plan, organize, and conduct research. Enabling activities can provide students with needed skills and knowledge “just in time”. Students utilize their research in the design, prototyping, testing, evaluation, and redesign of a solution.

The term “engineering” implies a mathematical evaluation of a design. This analysis allows students to create mathematical models that can inform decisions and increase the speed at which a solution can be put forth. Once the initial analysis is done, a prototype can be created and evaluated. The data is gathered and organized. Flaws are further analyzed and the design improved.

Once an acceptable design solution is reached, students create final documentation. This documentation includes sketches, drawings, notes, research reports, data analysis, and anything else utilized in the creation of the final design. Students craft explanatory or argumentative writing to detail the merits of their solutions. The writing is “glue” for the integration of the learning. Requiring the explanation of the solution elevates the learning to higher levels.

True project based curriculum needs to be standards based, utilizing several standard sets. There is a temptation to ignore the literacy standards as they do not appear in the STEM designation. They are as important as the College and Career Readiness Math standards. Reading and Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects prepare students for further education and entering into employment.

One of the biggest impediments to successful preparation for careers in STEM fields is the need for remediation before true college work can begin. Project based STEM education provides students with the preparation necessary for successful entry into college programs. Several colleges studying those students who participated in STEM programs in high school, have found higher GPA, improved retention, and better preparation for the rigors of college study.

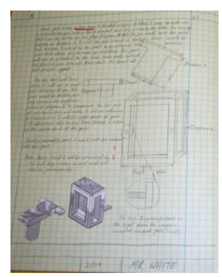
The *Siemens Engineering Design* course utilizes the Solid Edge software as a tool. The object of the course is the application of the tool to address unique problems allowing the students to rapidly create and analyze proposed solutions. Solid Edge is a tool frequently used by industry and understanding how such tools are used in problem solving is critical.

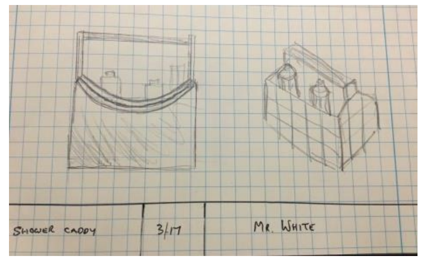
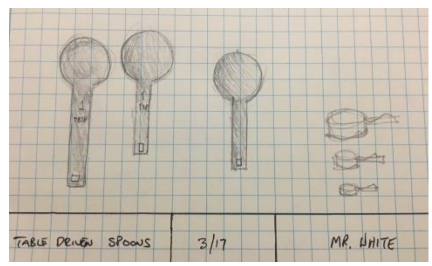
Course Flow Guide

The course is divided into four quarters matching a schedule utilized by many districts. Schools that teach in semester blocks will be able to teach the 4 quarters in one semester. The four quarters build one upon the other. The 26 student projects are intended to utilize the design process, identifying missing information needed for further research and create a solution. Each project has some enabling learning activities providing critical information, but students decide on any additional information needed. Every project has a written component. Every project requires the use of the student's Engineering Notebook to keep track of their progress in the projects. The Engineering Notebook is a critical device used when creating the explanation of a solution. Students present their solutions to the problems they solve. Reading, writing, and presenting are skill sets that improve with practice. Students also apply mathematics and analysis to their solutions, documenting as they progress. In this way students simulate methods used by engineers using Excel to organize data, create graphs, and perform statistical analysis.

First Quarter:

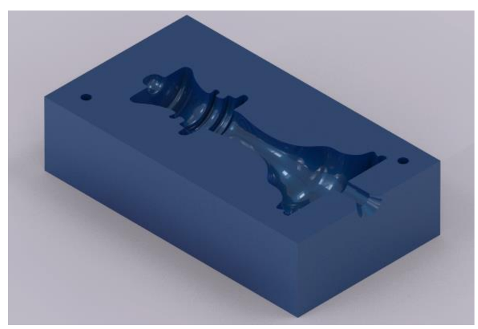
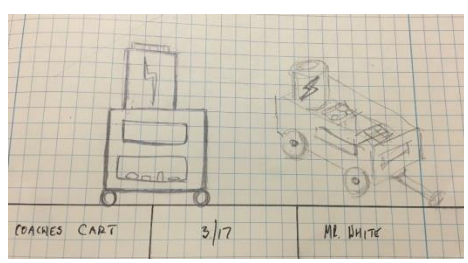
This quarter introduces students to the engineering design process. The first project is a simple design problem intended to introduce and guide students through the design process for the first time. The object is to learn the process. This is followed by an introduction to sketching both isometric and orthographic so students can quickly convey ideas with a pencil and paper. The third project builds on the first two and adds the basics of CAD and the ability to export data to a 3D printer. The fourth project allows for student and teacher choice. The object is to learn how 3D features are created in a solid modeling program. The timing is similar so different groups of students can select the project that interests them. Students are then introduced to creating photorealistic rendering creating the ability to convey ideas quickly. The final required project introduces students to creating dimensions using formulas. Students also add the ability to control a part from an Excel table allowing for the creation of several variations of the part. Time permitting, there is an optional project at the end where students create a package to contain a ball. This project could fit any place in the year in the event students finish early.

Engineering Design Process • Introduction to the Engineering Design Process	
Sketching • Sketching and Documentation	
3D Solid Modeling/Fabrication and 3D printing • Name Plate Holder	

3D Solid Modeling/Fabrication and 3D printing Select one of three • Sport Drink Container • Kitchen Tool Design • Chess Set	
Renderings/Working Drawings/ Design Presentations • Shower Caddy Rendering	
Table driven Parts • Table Driven Kitchen Measuring Instruments	
Optional Project • Package Design	

Second Quarter

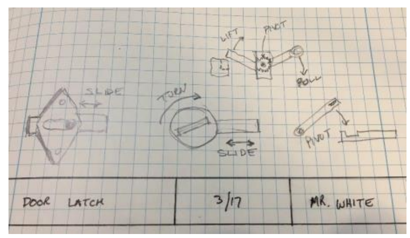
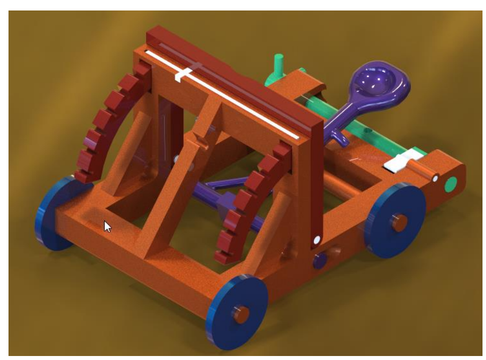
The second quarter begins with an examination of what it takes to create an assembly of parts, and how those can quickly determine how all the parts interact. Students look at motion and how one part interacts with others. Students learn how to create exploded assembly drawings and a bill of materials. Students define materials that will be used. Students then explore concepts of Boolean addition and subtraction and how intricate shapes can be used as molds. Students learn about the processes used to create molded parts and what it takes to create molds for specific machinery. There is an optional project if time allows about the creation of a coaches' cart to bring supplies out to athletic fields. The final project of the second quarter is a reverse engineering project. Students select a product to disassemble and discover precision measurement in order to reproduce the object as accurately as possible. Students identify parts that might be able to be improved. They create a layout of the actual disassembled object, and create all the necessary parts and assembly drawings and point out places where a redesign can improve performance or cost of the device.

Assembly Modeling/Documentation/Exploded Assemblies/Bill of materials • 3D Puzzle	
Assembly Modeling/Documentation/Exploded Assemblies/Bill of materials • Mold Design	
Assembly Modeling/Documentation/Exploded Assemblies/Bill of materials Optional Project • Coaches' Cart	

Reverse Engineering/Engineering Features/Precision Measurement • Reverse Engineering	

Third Quarter

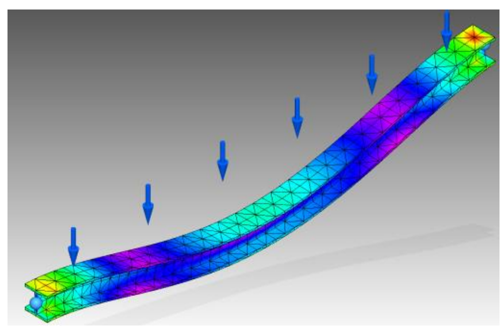
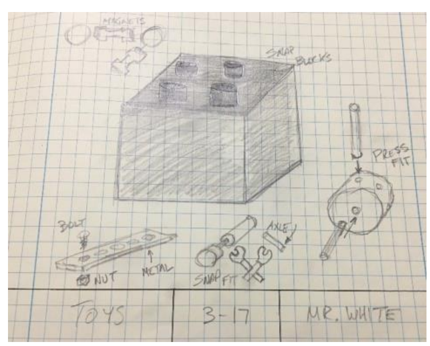
The focus of this quarter is devoted to discoveries in two major areas that affect design. The first is simple machines. Students select either the bathroom door latch or a nut cracker. They are both applications of simple machines. Students have to calculate the mechanical advantage of their designs. They also create motion in their designs to allow for interference checks so they can determine if their design will work or not. The next project is the design of a ball launcher for a toy company. This project incorporates data acquisition and graphing in Excel so the students can judge the accuracy of the performance of their design. The next project looks at gear ratios and how gears are used to change the speed or direction of motion. Students must design a differential gear to use in a Mars Rover type of vehicle. This application looks at the design of a differential gear and utilizes the Solid Edge Gear Designer to create the gears they desire. The last project in the quarter looks at the design of a merry-go-round and how the simple machines and mechanical systems are used in everyday designs.

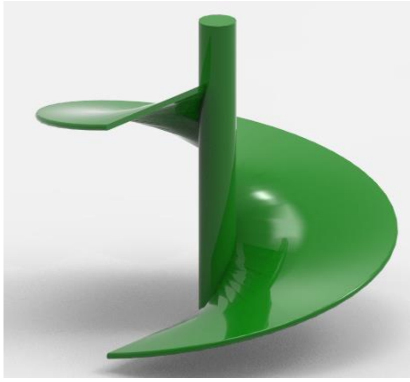
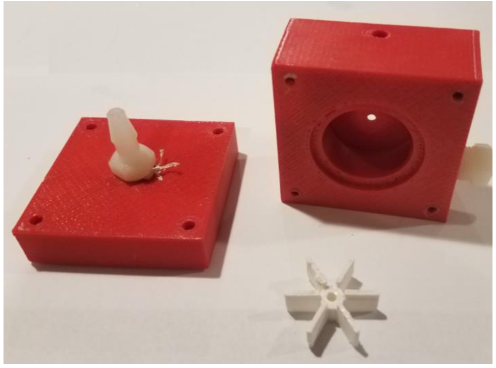
Simple Machines Select one • Bathroom Door Latch • Nutcracker	
Simple Machines • Ball Launcher	

Mechanical Systems • Differential Gear Design	
Mechanical Systems • Merry-Go-Round	

Fourth Quarter

The fourth quarter focuses on structures and forces. Students discover how material science is applied to design. They create structures that combine material properties and strength of shapes to resist the forces that will be applied. They learn how finite element analysis provides information about how well their designs will perform. Students will also learn where they need to change their designs to support the loading they are predicting. Students then move to a project where they discover classes of fit and how parts are designed to fit together in desired ways. They learn tolerances and how to select the ones that allow parts to be created to work together. Students then apply everything to the creation of a playground design. Each team designs a different playground component. All teams communicate together to collectively decide how each playground component is placed on one playground plan. Students share all the team files to create a rendering of the playground. The last project allows for teacher or student choice in which engineering system they wish to explore. Some teachers will allow different groups to select the systems they wish to explore.

Structures and Forces • Truss System	
Structures and Forces • Hybrid Toy Connector	

Structures and Forces • Playground Design	
Engineering Systems Select one • Centrifugal Pump • Automatic Training Wheels • Mechanical Bank • Glider • Child's Toy	

Assessment of Students

There are two forms of student assessment; formative and summative.

The *Siemens Engineering Design* course utilizes formative assessment throughout the course. The formative assessment criteria, usually through a rubric, are a way to clearly show students in advance the level of excellence expected. It is also a way for teachers to provide guidance and support throughout the learning process and to show end-of-project performance.

Solid Edge Certification is an accreditation achieved through an online exam that tests the knowledge and skills of students who are experienced users of Solid Edge design software. Solid Edge certification enhances the competitive edge and reputation of both students and their academic institutions, and provides an industry-recognized credential that students can use to enhance their academic careers and ambitions.

Students can demonstrate their skill level by taking online examinations and qualifying as a Solid Edge Certified Associate Level I (aimed at High School students) or Level II (aimed at University students). The exams are a summative assessment, students completing the *Siemens Engineering Design* course will be well prepared to successfully complete.

Obtaining Equipment, Supplies and Software

Obtaining the Software

The curriculum makes extensive use of industry standard software to allow students to create solutions to design problems with the same tools found in today's business environment. The instructions below describe the process that schools should follow to access necessary software used in the program.

Siemens is making Solid Edge **available to schools at no charge**. Solid Edge is a portfolio of affordable, easy-to-use software tools that address all aspects of the product development process – 3D design, simulation, manufacturing, data management and more, thanks to a growing ecosystem of apps. Solid Edge combines the speed and simplicity of direct modeling with the flexibility and control of parametric design – made possible with synchronous technology. Solid Edge is technically robust, 3D CAD software and the premier design-centric solution in the CAD industry today. It allows for rapid design and testing of a digital prototype. This saves time and materials for students as they can make decisions and refine designs before construction of an actual prototype.

Schools must register for the software at: https://www.plm.automation.siemens.com/plmapp/education/solid-edge/en_us/free-software/teacher. Fill out the registration form found on the page. The schools information is entered into the database and a link automatically generates a link for the software download. This arrives within minutes to the contact listed on the application by email. The software is then available for download. The school may install the software on as many computers as needed by the school and has a permanent license built into the installation that never expires. Students can download a copy for their home computers. Instructors should provide the students with this link. https://www.plm.automation.siemens.com/plmapp/education/solid-edge/en_us/free-software/student.

Obtaining Equipment and Supplies

Schools obtain the necessary equipment and supplies for implementing the curriculum with a single purchase order. Studica, a company long known for great service to educational institutions is providing kits on a sole source basis. The kit has all the necessary equipment, supplies and consumable materials for a class of 24.

The contact for equipment and supplies is Jim Sheehan at Studica. Jim can provide a sole source letter and W9 for business office use. Jim's contact information is:

Jim Sheehan
STEM Education Solutions
jims@studica.com
P: 888.561.7521 Ext. 208
F: 877.754.2807
www.studica.com

SIEMENS
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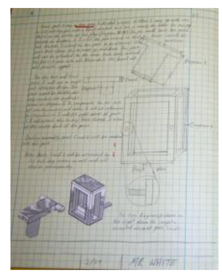
Projects Quarter 1

Engineering Design Process • Introduction to Engineering Design	
Sketching • Sketching and Documentation	
3D Solid Modeling/Fabrication and 3D printing • Name Plate Holder	
3D Solid Modeling/Fabrication and 3D printing Select one of three • Sport Drink Container • Kitchen Tool Design • Chess Set	

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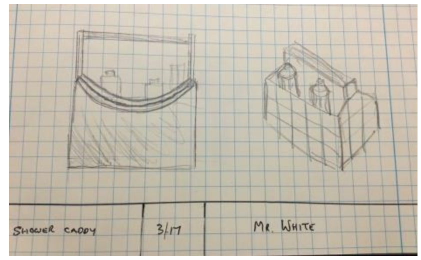
<td>
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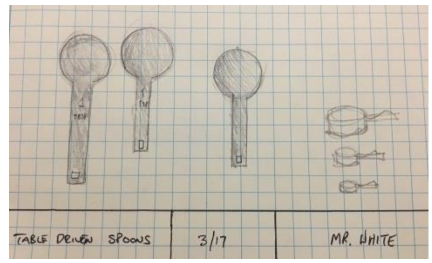
<td>
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SIEMENS

Ingenuity for life

Project: Introduction to the Engineering Design Process

Introduction:

Trial and error is one way to discover a solution to a design problem. Unfortunately it takes a long time and failures have negative or sometimes catastrophic impacts. Rather than approach these tasks in a random trial and error manner, a systematic approach delivers better results in less time.

This systematic approach is called the Engineering Design Process. This first project in the ***Siemens Engineering Design*** curriculum is an introduction to the use of the Engineering Design Process.

Often problems are complicated. The first step in the process involves learning about the problem. This requires gathering important background information about the topic. Teams can utilize the information to clarify a focused statement of the problem assuring a complete understanding of the task.

Complicated problems can be broken down into smaller pieces. To do this, teams define criteria and constraints and use a management plan to guide them through the problem solving process. Brainstorming and filtering information provides guidance to the team to arrive at a solution with a good chance of success. Teams also identify testing protocol to determine if the solution is meeting the needs of the original problem statement. Teams develop the solution and utilize tools such as Solid Edge to produce the design documentation. The creation of a prototype, testing according to the protocol, analyzing, improving, and finally communicating the final solution to an appropriate audience all follow in order to assure a solution is optimal.

There will be times when a team discovers the solution will not solve the problem. However, the information gained is helpful in guiding the team to make adjustments so a solution that does solve the problem is found. Thomas Edison has been quoted as saying, “I have not failed. I have just discovered 10,000 ways that won’t work”.

Purpose of the Project:

This project is the first project in the ***Siemens Engineering Design*** course and is designed to introduce students to the Engineering Design Process. Student teams are given a problem to solve. They are also provided with the "how to use" important information about the Engineering Design Process. As they work through the problem solving process they are introduced to using the Engineering Notebook, creating a problem statement, documenting basic research, creating a design brief, identifying testing protocol, and preparing design documentation. The project is not lengthy, but has many solution options presenting a variety of solutions to student teams.

Concepts:

- Refining problems is necessary to assure the solution is addressing the proper question.
- It is often necessary to divide complicated problems into smaller parts.
- Design is an iterative process; the first idea is rarely the optimal solution.
- Background research about the problem is necessary. Gathering essential information related to the problem is a way to learn key vocabulary.
- The Engineering Notebook contains a chronological record of written documentation of the development of ideas, its author, along with all notes, data, observations, calculations, and other information relevant to discovery and experiments.
- A decision matrix aids in making difficult decisions and preventing bias from impacting decisions.
- Testing protocols are developed before the design to assure objectivity and are never modified to fit the outcome.
- Proper documentation of research is important because it saves time and creates a thought process (road map) so the problem solution can be recreated.
- Project management is an important tool enabling sound resource allocation including time management of the important events in the process.

Outline:

The Design Process
- Ask/Inquire
- Imagine
- Plan
- Create
- Experiment and Evaluate
- Improve
- Communicate

Standards:

Career and Technical Standards

Engineering Design Process

- Create and maintain an Engineering Notebook for daily reflections, research and prototype creation documentation.
- Apply the design and problem solving process as an iterative process incorporating sciences, mathematics and engineering to optimally convert resources to meet a stated objective.

Reading Standards for Literacy in History/Social Studies 9-10

Key Ideas and Details

1. Cite specific textual evidence to support analysis of primary and secondary sources, attending to such features as the date and origin of the information.

3. Analyze in detail a series of events described in a text; determine whether earlier events caused later ones or simply preceded them.

Integration of Knowledge and Ideas

7. Integrate quantitative or technical analysis (e.g., charts, research data) with qualitative analysis in print or digital text.

9. Compare and contrast treatments of the same topic in several primary and secondary sources.

Range of Reading and Level of Text Complexity

10. By the end of grade 10, read and comprehend science/technical texts in the grades 9–10 text complexity band independently and proficiently.

Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 9-10

Text Types and Purposes

1. Write arguments focused on *discipline-specific content.*

2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

Production and Distribution of Writing

4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Research to Build and Present Knowledge

7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.

Range of Writing

10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Science

The projects engage students in the scientific and engineering practices taken from the National Research Council's Framework for K-12 Science Education, Practices, Crosscutting Concepts, and Core Ideas. This is the document upon which the NGSS are based.

These practices are used for two reasons: 1) they parallel the design process utilized in each project, and 2) they serve as the foundation of the NGSS.

The eight science and engineering practices are:

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Standards for Technological Literacy

Standard 2

Students will develop an understanding of the core concepts of technology.

Standard 3

Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Standard 4

Students will develop an understanding of the cultural, social, economic, and political effects of technology.

Standard 6

Students will develop an understanding of the role of society in the development and use of technology.

Standard 7

Students will develop an understanding of the influence of technology on history.

Standard 8
Students will develop an understanding of the attributes of design.

Standard 9
Students will develop an understanding of engineering design.

Standard 10
Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Standard 11
Students will develop the abilities to apply the design process.

Standard 12
Students will develop the abilities to use and maintain technological products and systems.

Standard 17
Students will develop an understanding of and be able to select and use information and communication technologies.

Standard 19
Students will develop an understanding of and be able to select and use manufacturing technologies.

Assessment:

Assessment is both formative and summative. It is an integral part of quality instruction. During the course of each project, one of the teacher's main functions is to work with student groups, keeping track of progress and providing formative assessment in the form of feedback and promoting reflection on the part of students. The focus should be on promoting lifetime learning and 21st century skills. The goal of instruction is to promote abilities in research, problem solving, designing, experimenting, testing, collecting and analyzing data.

Rubrics are used in the assessment process to communicate expectations of quality. Rubrics should be shared with students at the beginning of each project so they can understand the learning expectations before beginning work. Students can then build the skills and gather knowledge to solve the problem presented to the level of excellence described.

General Rubrics for Literacy tasks:
Argumentative_Pursuasive
Informational_Explanatory

Essential Question:
How can our team come to consensus and produce a design to solve a problem?

Student Scenario:
Students are members of a design team. New Products Inc. is looking for a team of designers with a different approach to solving their problems. They are interviewing teams to see if they demonstrate the ability to solve problems and have a process in place that provides the best chance at solving the problem challenges they face. The company provides the team with a piece of paper and challenges them to design a way for the paper to stay in the air the longest. Part of the evaluation is the ability of the team to deliver a final product, and the rest of the evaluation is based upon the team's ability to work together following a logical process.

Deliverables include:
- Engineering Notebook
- Outline of the engineering report
- Data collected as a component of the testing process
- Presentation of the process

Daily Plan:
Day 1
Key Question: What is the Engineering Design Process and how can it help create solutions?

The teacher should give an overview of the course. The teacher should explain how students will be divided into teams both for learning activities and for creating collaborative problem solutions. The teacher divides students into the teams for the first project. The design process is introduced having the students watch the video on engineering design. https://www.youtube.com/watch?v=5Dp2qHz8r2U Once the video has been viewed the teacher leads a discussion about the Engineering Design Process. The teacher will provide students with the Design Process sheet which they will use as a guide for all projects in the course.

The teacher also introduces the Engineering Notebook. The concept is explained as well as the requirement that students record everything they do related to solving the problem. The rest of the week is used to describe and experience the design process. Teachers should guide student teams to record information from this important first project in their Engineering Notebooks to establish a procedure of proper entries.

The students are given the scenario and the teacher informs the teams that they begin solving the problem using the Engineering Design Process. The students are given the problem; keeping a sheet of paper in the air longer than the other teams. The teachers have the student teams discuss the problem and record their initial thoughts in their Engineering Notebooks.

The teacher provides the vocabulary list for the projects and teams divide the work to discover the definitions of the words. The teacher reinforces the connection of the vocabulary to the design process and notes to students the importance of speaking the language of the Engineering Design Process.

The student teams should reword the initial problem statement so it reflects a more focused problem. Provide students with the document on the Problem Statement and have each team create and share their rewritten problem statement.

Have students reflect upon the day in their Engineering Notebooks.

Day 2
Key Question: How should we gather information about solving our problem?

The teacher guides student teams with the process of organizing their teams. Teams discuss necessary roles and individual responsibilities. Teams review the management plan and apply it to their needs. Students identify the activities that will be required. Teams identify what they will need to know in order to solve this problem.

The teacher reinforces the process of recording information in the Engineering Notebook. Students conduct online research to answer the key questions identified when they prepared the management plan. The teacher reviews the proper method of citing research sources in the Engineering Notebook.

The teacher explains the design brief and leads a discussion with students about how it can be applied to this project. Student teams are given ten minutes to draft a design brief. Students write a reflection in their Engineering Notebook.

Day 3
Key Question:

The teacher begins the day with a review of the design process and gathers from each team their progress so far. The teacher introduces the rules for brainstorming. Student teams begin the brainstorming process recording information in their Engineering Notebooks.

Student teams examine and discuss the document on the testing protocol. Teams begin the process of developing a testing protocol used to evaluate their design solution.

Once teams have recorded their testing protocol they begin the process of evaluating the brainstormed ideas. This is a step that begins narrowing the number of suggestions.

Individual students select one idea to quickly develop. Once everyone on the team has developed one idea the team meets to discuss which solution the team should pursue. Students should end the day with a reflection about their accomplishments and issues in their Engineering Notebooks.

Day 4
Key Question: How can we develop and evaluate our solution.

The teacher begins the class by reviewing the design process and determining where student teams currently are in the process. Teams are given time to discuss and identify the solution they will develop as a team. Teams that are having difficulty determining which solution to develop should be allowed to discuss further, but the teacher might ask how they could objectively make the decision. The teacher points out that a decision matrix is often used as a tool to make decisions.

Teams create their initial prototypes using the information collected in the research process. Once the initial prototype is created the teams can begin testing them according to the testing protocol. It is important that the teacher insists the protocol be used. It was the team's definition of what was important at the beginning of the process.

Teams analyze the data gathered during the initial testing process. Items identified will generate both positive and negative comments. Teams propose improvements and then modify or recreate their prototype to incorporate the selected changes. The teams repeat the testing process.

Teams finish the day with reflections in their Engineering Notebooks.

Day 5
Key Question: How do we communicate the elements of our design to other people?

The teacher introduces the Engineering Report. Teams are instructed to create just the outline of the report. Students will be asked to stand in front of the class and present the outline information that will be included in the report. It is important to remind students that this step is a simplified version of what students will develop in the future where each project will concentrate on a different part of the design process. The goal is to have students be comfortable with the entire process. Teams divide up the sections of the engineering report and each team member creates the outline for their section. All research used must be documented in the report.

Teams take a few minutes to present their design and provide the results of their testing.

The teacher reviews the process with students and points out the value of the Engineering Notebook. Students write a reflection about the design process including what was learned about areas of improvement.

Vocabulary:

Brainstorming
Constraints
Criteria
Design Process
Engineering Design Process
Engineering Notebook
Iterative
Matrix
Optimal
Specifications
Testing protocol

Resources:

Engineering Design Process

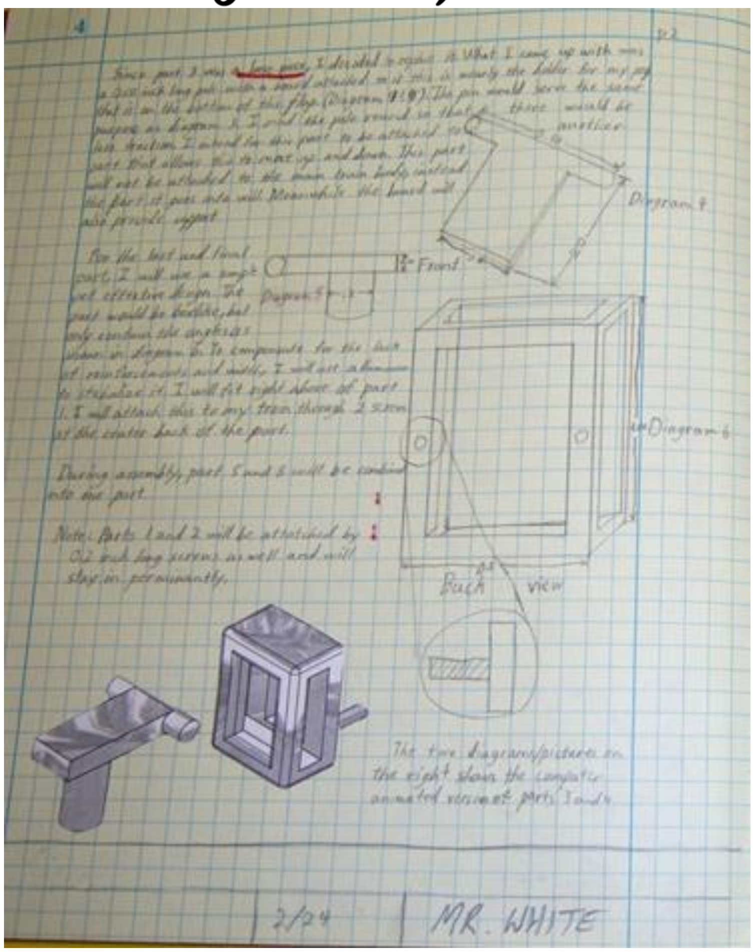
- https://www.nasa.gov/audience/foreducators/best/edp.html
- https://www.pbslearningmedia.org/resource/phy03.sci.engin.design.desprocess/what-is-the-engineering-design-process/en/
- https://www.teachengineering.org/k12engineering/designprocess
- http://www.asfa.k12.al.us/ourpages/auto/2014/8/25/41576897/Engineering%20Design%20Process%20-%2010%20stages%20-%20PRESENT%20THIS.pdf
- https://www.khanacademy.org/partner-content/49ers-steam/49ers-gridiron-eng/49ers-innovations-equipment/v/engineering-design-process

Engineering Notebook:

- http://www.wisegeek.com/what-is-an-engineering-notebook.htm
- https://www.firstinspires.org/sites/default/files/uploads/resource_library/ftc/engineering-notebook-guidelines.pdf
- https://www.asme.org/career-education/articles/early-career-engineers/my-engineers-notebook-jenn-t-dandrea

Engineering Reports

- http://web.mit.edu/me-ugoffice/communication/technical-writing.pdf
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/writing_engineering_reports.html
- https://www.youtube.com/playlist?list=PLDAAF7A8FD5CD582C&feature=plcp
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/mechanical_engineering_writing_enhancement_program/report_writing.html
- https://owl.purdue.edu/owl/subject_specific_writing/professional_technical_writing/technical_reports_and_report_abstracts/reports_proposals_and_technical_papers.html



Project: Sketching and Documentation

Introduction:

A sketch is a quick way to communicate an idea. Typically we utilize a pencil and paper. The object is to create an easily recognizable graphic image that conveys the desired message. Designers often joke about designs sketched on napkins or envelopes but in reality, when there is a need to communicate quickly any surface will do.

Purpose of the Project:

The purpose of this project unit is to introduce students to basic sketching and documentation techniques utilized as the primary mode of communication in the initial stages of the design process. This project focuses on some of the fundamental skills used in freehand sketching. Students will become familiar with types of lines and what they represent. They will explore the design process and the role of sketching in that process. During this course, students will frequently use sketching techniques to convey their design ideas. All sketches will be documented in the students' Engineering Notebook.

The research and learning activities are designed to help students:

- Explain the role of sketching in the design process
- Create sketches utilizing basic shapes such as lines, circles, and ellipses
- Communicate ideas to a group through the use of sketches and other documentation
- Understand the difference between isometric and orthographic sketches
- Utilize sketching techniques to aid in the design process

Concepts:

- Sketches are used to aid in creative thinking and to communicate ideas
- Sketching is frequently used to document original thought for future reference
- Design is an iterative process and there are many methods used to create and document ideas
- Lines forming shape, value, color, texture, and space are all utilized to communicate and collaborate

Outline:

- Documentation
    - Engineering Notebook
    - Documenting computer programs
    - Documenting research
- Sketching
    - Line types
    - Isometric
    - Orthographic
    - Dimensioning

Standards:

Career and Technical Standards

Engineering Design Process

- Create sketches utilizing basic shapes such as lines, circles, and ellipses.
- Communicate ideas to a group through the use of sketches and other documentation.
- Apply isometric and orthographic sketches to add clarity to design.
- Create necessary sketches to communicate basic ideas during the design process.

College and Career Readiness Math Standards

Geometric Measurement and Dimension G-GMD

Explain volume formulas and use them to solve problems

1. Give an informal argument for the formulas for the circumference of a circle, area of a circle, volume of a cylinder, pyramid, and cone. *Use dissection arguments, Cavalieri's principle, and informal limit arguments.*
3. Use volume formulas for cylinders, pyramids, cones, and spheres to solve problems.

Modeling with Geometry G-MG

Apply geometric concepts in modeling situations

1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).
2. Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot).
3. Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).

Reading Standards for Literacy in History/Social Studies 9-10

Key Ideas and Details

1. Cite specific textual evidence to support analysis of primary and secondary sources, attending to such features as the date and origin of the information.
3. Analyze in detail a series of events described in a text; determine whether earlier events caused later ones or simply preceded them.

Integration of Knowledge and Ideas

7. Integrate quantitative or technical analysis (e.g., charts, research data) with qualitative analysis in print or digital text.
9. Compare and contrast treatments of the same topic in several primary and secondary sources.

Range of Reading and Level of Text Complexity

10. By the end of grade 10, read and comprehend science/technical texts in the grades 9–10 text complexity band independently and proficiently.

Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 9-10

Text Types and Purposes

1. Write arguments focused on *discipline-specific content.*
2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

Production and Distribution of Writing

4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Research to Build and Present Knowledge

7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.

Range of Writing

10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Next Generation Science Standards

The projects engage students in the scientific and engineering practices taken from the National Research Council's Framework for K-12 Science Education, Practices, Crosscutting Concepts, and Core Ideas. This is the document upon which the NGSS are based.

These practices are used for two reasons: 1) they parallel the design process utilized in each project, and 2) they serve as the foundation of the NGSS.

The eight science and engineering practices are:

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Standards for Technological Literacy

Standard 3

Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Standard 4

Students will develop an understanding of the cultural, social, economic, and political effects of technology.

Standard 7

Students will develop an understanding of the influence of technology on history.

Standard 8
Students will develop an understanding of the attributes of design.

Standard 9
Students will develop an understanding of engineering design.

Standard 10
Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Standard 11
Students will develop the abilities to apply the design process.

Standard 12
Students will develop the abilities to use and maintain technological products and systems.

Standard 13
Students will develop the abilities to assess the impact of products and systems.

Standard 17
Students will develop an understanding of and be able to select and use information and communication technologies.

Standard 19
Students will develop an understanding of and be able to select and use manufacturing technologies.

Assessment:

Assessment is both formative and summative. It is an integral part of quality instruction. During the course of each project, one of the teacher's main functions is to work with student groups, keeping track of progress and providing formative assessment in the form of feedback and promoting reflection on the part of students. The focus should be on promoting lifetime learning and 21st century skills. The goal of instruction is to promote abilities in research, problem solving, designing, experimenting, testing, collecting and analyzing data.

Rubrics are used in the assessment process to communicate expectations of quality of a task. Rubrics should be shared with students at the beginning of each project so they can understand the learning expectations before beginning work. They can then build the skills and gather knowledge to solve the problem presented to the level of excellence described.

General Rubrics for Literacy tasks:
Argumentative_Pursuasive
Informational_Explanatory

Individual Project Rubric:
Sketching and Documentation Rubric

Essential Question:

How do I document an original idea so I can communicate with others effectively?

Student Scenario:

You are a design engineer working for the Fischertechnik Company. The Fischertechnik Company manufactures a system of components, blocks, gears, wheels, links, sensors, switches, etc., that can be used to assemble working models of real operating systems such as amusement park rides, assembly lines, vehicles and so on.

The company has asked you to work with a client who needs some specialty parts created that can be used with the Fischertechnik system. In the first phase, your supervisor would like to see several ideas for a proposed design for a new system building block. Your supervisor has asked you to sketch some possible design options and present them to a design team of upper management for review.

"Your team is responsible for selecting a part for the kit that doesn't exist and create several sketches to show how the new component connects with the rest of the fischertechnik system, recommend the material for the component and propose a suggested color for the component."

You will be responsible for a short presentation which will provide a review of your research, your design options, and the reasons for your suggested material and color choices.

Daily Plan:

Day 1

Key Question: What are the expectations for this sketching and documentation project?

Introduce students to the project by providing them with the Essential Question and the scenario.

Review and discuss with your students the design process, Engineering Notebook and design documentation requirements. Discuss the problem statement, design brief, testing protocol and management plan. Review the elements of a good engineering report with the students. These were all covered in the first project titled *Introduction to the Engineering Design Process* but should be reinforced on a regular basis. All projects depend on the design process and student activities should relate directly.

Have the students form teams of two. Allow the students five minutes to discuss the problem. Students begin by brainstorming ideas in their Engineering Notebooks. The teacher will provide a list of vocabulary terms that students will need to research on their own. The teams can divide the list of terms among team members and share their definitions. All team members are responsible to know all definitions.

Day 2
Key Question: What are elements of design and how can we communicate our ideas quickly.

The teacher leads a discussion of how an object that the students are familiar with might be designed. Students break into groups and spend 10 minutes in discussion and then create a quick diagram of their process.
Students view the webpage:
https://www.nasa.gov/audience/foreducators/best/edp.html#.V_bDoODR-Uk and explore the seven videos.

Once the students have viewed the page they return to their groups and compare their results with what NASA designed.
Students discuss how to visualize a design.

Day 3-4
Key Question: How do we properly communicate with sketching?

The teacher reviews the design process from first project focusing on generating ideas through sketching.
The teacher demonstrates how isometric sketches are created. The teacher can use resources found by a computer search for isometric sketching or use the ones in the resource section at the end of the project.
The teacher will review drawing in isometric views. The teacher can use isometric graph paper to help student visualize what the sketch should look like. The template for isometric graph paper can be downloaded from http://www.printfreegraphpaper.com/.
The teacher gives each group of students a die from a set of dice.
The teacher has the students draw an isometric sketch of the die including the dots on each face. Students save the sketch in their Engineering Notebooks.

Day 5-7
Key Question: How can I show detail on a surface?

The teacher reviews what the students had drawn.
The teacher introduces the orthographic sketching concepts. The teacher can use resources found by a computer search for orthographic sketching or use the ones in the resource section at the end of the project.

The teacher will introduce the sketching activity and then have each student sketch a fischertechnik 30 mm building block in their Engineering Notebook. The sketches should have notes and any other necessary descriptors. Students should show the teacher when completed and insert into their Engineering Notebook.

Day 8-9
Key Question: How much information is really necessary to include in a sketch.

The teacher begins by reviewing various sketching techniques the students have learned. Students discuss other information that should be included in sketches.

The teacher introduces the communication activity. The teacher should have prepared several objects made from different fischertechnik pieces before the students arrive. (an alternative is to have each student team build a model of miscellaneous parts that will be given to a second team to sketch, and reconstructed by a third team.) All the objects should be different. An object created from several different fischertechnik pieces is hidden behind a screen so that only the team working on the sketch will be able to see it. Teams will have 20 minutes to view the object and sketch out as much information as they can without removing the object. Partners must each create their own sketch.

Student teams are not allowed to look at the object again. The student teams utilize the drawings they each prepared to create one sketch that will be given to another team who will then have to recreate the object without asking questions or seeing the original model. The new models are compared to the original to see how accurate the process was.

The students should comment in their Engineering Notebooks about the information that they needed in their sketch to solve the issue. Students should also comment on what they wish had been included on the sketch they used.

Day 10-11
Key Question: How do we organize our presentation outline to the client?

The teacher will review the project scenario. Each team should brainstorm a part they would like to design. Each student team at this point will have a prepare a design brief where they will outline what they will be designing and what their process will be.

Students will examine some fischertechnik blocks and see how they interconnect.

The teams of students will decide on their new designs. Students should discuss how the block will attach to the system. Students begin sketching their ideas. The teacher should encourage different sketching techniques and annotations. Students also sketch how their new block will link to existing blocks.

Day 12
Key Question: How do we convey our ideas to our clients?

The teacher outlines the options students have for their presentations. Teams decide how to best present their material.
Students present their solutions to the class one at a time. At the end, students reflect on their work and how they would have improved their designs

Vocabulary:

Annotated Sketch
Brainstorming
Center Line
Design Process
Engineering Notebook
Hidden Line
Isometric Sketch
Isometric Graph Paper
Iterative Process
Multi-view Sketch
Object Line
Orthographic

Resources:

Engineering Notebook:

- http://www.wisegeek.com/what-is-an-engineering-notebook.htm

Engineering Sketching:

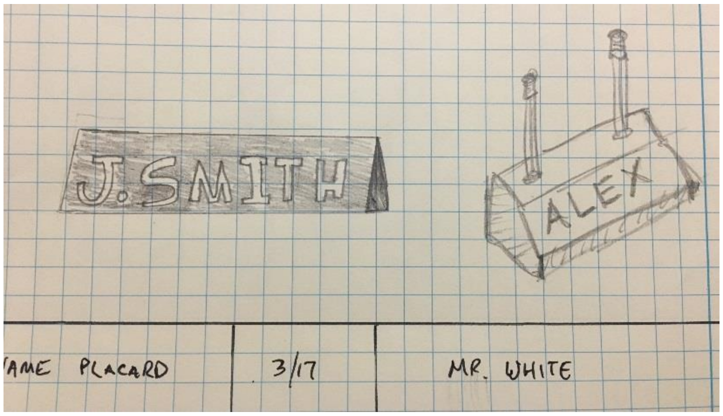
- http://www.me.umn.edu/courses/me2011/handouts/drawing/blanco-tutorial.html#isodrawing
- http://www.youtube.com/watch?v=KN7281MUp_U
- http://www.youtube.com/watch?v=ZBuhGaGPYfQ
- http://www.technologystudent.com/designpro/isocube1.htm

Department of Labor:

- http://www.bls.gov/bls/topicsaz.htm

Engineering Reports

- http://web.mit.edu/me-ugoffice/communication/technical-writing.pdf
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/writing_engineering_reports.html
- https://www.youtube.com/playlist?list=PLDAAF7A8FD5CD582C&feature=plcp
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/mechanical_engineering_writing_enhancement_program/report_writing.html
- https://owl.purdue.edu/owl/subject_specific_writing/professional_technical_writing/technical_reports_and_report_abstracts/reports_proposals_and_technical_papers.html



Project: Name Plate Holder

Introduction:

A name plate holder is an easily recognizable object in a typical office setting usually found on a desk, is rectangular in shape, and has many possible styles and sizes. It usually contains information such as the person's proper name and title. It may contain a graphic or company logo. Name plates are engraved, where material is removed from the original piece.

The Engineering Report for this project will be completed by students in an outline format except for the section where students describe the design. Students will include graphics from the design process and describe the process used. Remind students to include their reflections about their design process in the Engineering Notebook.

Purpose of the Project:

Students will model a fully customized name plate holder. Students will gain an understanding of the software commands and software workflow. At the end of the project, the students will present their custom name plate holder to the class. This project will be printed and displayed.

Concepts:

- CAD software can create 3D models as well as 2D drawings.
- CAD modeling is often used but not limited to electrical, mechanical, civil, aerospace, and automotive engineering.

- Creating a virtual prototype is a major advantage of using a 3D modeling software.
- In parametric modeling, changes can be made to the part while maintaining geometric relationships.

Outline:

Documentation
- Engineering Notebook
- Documentation of object to be designed

Modeling
- Creation of 3D models

Communication
- Presentation of design solutions
- 3D print of design

Standards:

Career and Technical Standards

Engineering Design Process

- Create and maintain an Engineering Notebook for daily reflections, research and prototype creation documentation

Sketching

- Create sketches utilizing basic shapes such as lines, circles, and ellipses.
- Communicate ideas to a group through the use of sketches and other documentation.
- Create necessary sketches to communicate basic ideas during the design process.

3D Solid Modeling

- Apply geometric relationships between lines and shapes to create a mathematical database to describe design ideas
- Create solid models utilizing concepts of Parametric Modeling

College and Career Readiness Math Standards

Modeling with Geometry G-MG

Apply geometric concepts in modeling situations

1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).
2. Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot).
3. Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).

Reading Standards for Literacy in History/Social Studies 9-10
Key Ideas and Details

1. Cite specific textual evidence to support analysis of primary and secondary sources, attending to such features as the date and origin of the information.
3. Analyze in detail a series of events described in a text; determine whether earlier events caused later ones or simply preceded them.

Integration of Knowledge and Ideas

7. Integrate quantitative or technical analysis (e.g., charts, research data) with qualitative analysis in print or digital text.
9. Compare and contrast treatments of the same topic in several primary and secondary sources.

Range of Reading and Level of Text Complexity

10. By the end of grade 10, read and comprehend science/technical texts in the grades 9–10 text complexity band independently and proficiently.

Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 9-10

Text Types and Purposes

1. Write arguments focused on *discipline-specific content.*
2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

Production and Distribution of Writing

4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Research to Build and Present Knowledge

7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.

Range of Writing

10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Next Generation Science Standards
The projects engage students in the scientific and engineering practices taken from the National Research Council's Framework for K-12 Science Education, Practices, Crosscutting Concepts, and Core Ideas. This is the document upon which the NGSS are based.

These practices are used for two reasons: 1) they parallel the design process utilized in each project, and 2) they serve as the foundation of the NGSS.

The eight science and engineering practices are:
1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Standards for Technological Literacy

Standard 1
Students will develop an understanding of the characteristics and scope of technology.

Standard 2
Students will develop an understanding of the core concepts of technology.

Standard 4
Students will develop an understanding of the cultural, social, economic, and political effects of technology.

Standard 7
Students will develop an understanding of the influence of technology on history.

Standard 8
Students will develop an understanding of the attributes of design.

Standard 9
Students will develop an understanding of engineering design.

Standard 10
Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Standard 11
Students will develop the abilities to apply the design process.

Standard 12
Students will develop the abilities to use and maintain technological products and systems.

Standard 13
Students will develop the abilities to assess the impact of products and systems.

Standard 17
Students will develop an understanding of and be able to select and use information and communication technologies.

Standard 19
Students will develop an understanding of and be able to select and use manufacturing technologies.

Standard 20
Students will develop an understanding of and be able to select and use construction technologies.

Assessment:

Assessment is both formative and summative. It is an integral part of quality instruction. During the course of each project, one of the teacher's main functions is to work with student groups, keeping track of progress and providing formative assessment in the form of feedback and promoting reflection on the part of students. The focus should be on promoting lifetime learning and 21st century skills. The goal of instruction is to promote abilities in research, problem solving, designing, experimenting, testing, collecting and analyzing data.

Rubrics are used in the assessment process to communicate expectations of quality. Rubrics should be shared with students at the beginning of a project to clarify any misconceptions before beginning their work. Students can then build the skills and gather knowledge to solve the problem presented to the expectations of excellence described.

General Rubrics for Literacy tasks:
Argumentative_Pursuasive
Informational_Explanatory

Individual Project Rubric:
Name Plate Holder Project Rubric

Essential Question:

How can a 3-D model be used to display a student name and store two pencils?

Student Scenario:

Employees who work at a desk generally have a name plate to indicate their name and title. Your task is to create a design for a name plate displaying a name and holding two pencils. This project will be customized by name and then created with a 3D printer personalizing the product for individual users.

Deliverables include:

- Engineering Notebook
- CAD model
- 3D printed model
- Outline of an Engineering Report that includes graphics and 3D images
- Presentation of the development process

.

Daily Plan:

Day 1
Key Question: What are the expectations of the project?

Introduce students to the project by providing them with the Essential Question and the scenario.

Review and discuss with your students the design process, Engineering Notebook and design documentation requirements. Discuss the problem statement, design brief, testing protocol and management plan. Review the elements of a good engineering report with the students. These were all covered in the first project titled *Introduction to the Engineering Design Process* but should be reinforced on a regular basis. All projects depend on the design process and student activities should relate directly.

Have the students form teams of two. Allow the students five minutes to discuss the problem. Students begin by brainstorming ideas in their Engineering Notebooks. The teacher will provide a list of vocabulary terms that students will need to research on their own. The teams can divide the list of terms among team members and share their definitions. All team members are responsible to know all definitions.

Day 2-4
Key Question: How do we get started with the design process?

Allow student teams to meet and discuss what they want to create. Students should prepare a list of what they need to know to utilize a CAD system. Students should be refining their sketches in the Engineering Notebook. They also should be researching examples and recording their findings in their Engineering Notebook. The teacher will introduce the Solid Edge user interface to students to become familiar with the look and feel of the software.

The teacher will provide access to the following video tutorials that will provide students with information about the user interface, sketching, constraining and basic 3D commands. Students should explore the following video tutorials and experiment with the interface to learn to navigate the software. They can also access Siemens Solid Edge Video Resources for further information on the topics.

Basic Introduction

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-quick-start/Ey8QWFP7d/chapters/solid-edge-quick-start/Nk1aTuvXd?topic=0

View Orientation

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=2

Sketching Tools

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=3

Simple Sketch

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=4

Geometric Relationships

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=5

Geometric Constraints

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=6

Intellisketch

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=8

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=9

Sketch Angle Box

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=10

Trim

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=18

Line Constraints

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/introduction-to-solid-edge-2-d-geometry/414vCOk6P/chapters/chapter-01-constraints-and-relationships/VkJ3kKy6w?topic=1

Text

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-18-practice/E1CNFc96w?topic=0

Basic Shapes

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=1

Day 5
Key Question: How do we get started using a CAD system?

The teacher will begin the day with a discussion of sketches and how they define shapes. Students should recognize that shapes are created from the geometric relationship of the components of the sketch. The student teams are expected to support their teammates during the learning exercises. These exercises are a component of the research phase of the design process. The students begin with the tutorial Creating Sketches Sketch 1.

Day 6
Key Question: How do we fully describe sketch geometry?

The teacher leads a discussion about the importance of the sketch prior to creating a solid model. The teacher should continue to check student's CAD sketches. Once students finish with Sketching Exercise 1 they continue with tutorial Creating Sketches Sketch 2

Day 7
Key Question: How do we turn a sketch into a solid model?

The teacher reviews sketching with teams. Once teams are comfortable with creating sketches, students then create a 3D object following the instructions from tutorial Creating and Printing the Triangle.

Day 8
Key Question: How do we create a design for our name plate holder?

The teacher begins the day demonstrating the Help system to find out how the software accomplishes basic features. The students are shown https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index enabling students to enter terms and view a tutorial on creating certain features. The teacher will also show students the Siemens Solid Edge Video Resources to allow students to discover further elements to help their designs. Student teams discuss the criteria and constraints for their design project and define their testing protocol. Individual team members create a sketch of their name plate holder and discuss the merits of their designs. Team members begin the process of creating the CAD model. Student teams continue printing their triangle sample.

Day 9
Key Question: How do we create the model of the name plate holder?

The teacher should review with students any initial design problems with the name plate holder. Students will finalize their models making sure they are properly rendered and hold the required pencils or pens. Students continue developing their solid model of the name plate holder. The teacher will approve each student design prior to printing the name plate holder.

Day 10
Key Question: How do we organize a presentation of the name plate holder design?

The teacher will discuss with students how to effectively present their ideas to the class. The deliverables should include a pictorial representation and/or a rapid (3D printed) prototype. Students will also be prepared to justify any design enhancements incorporated in the name plate holder. Students prepare the outline of the Engineering Report. The first section describes the process of creating the 3D model. It should be a fully written narrative describing the design and how it was created. All other sections should be formatted as outlines.

Day 12
Key Question: How do we convey our ideas?

The teacher will describe the options students have for making a presentation. Students will select their presentation option and make their presentation one at a time. To conclude, students will reflect on their work and provide feedback to each other about possible improvements to each design.

Vocabulary:

2D
3D
CAD
Chamfer
Emboss
Engrave
Extrude
Fillet
Font
Hole
Round
Sketch
Text Profile
Thin Wall

Resources:

CAD Tutorials

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012412/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012413/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012414/index.html
  https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012415/index.html

Engineering Reports

- http://web.mit.edu/me-ugoffice/communication/technical-writing.pdf
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/writing_engineering_reports.html
- https://www.youtube.com/playlist?list=PLDAAF7A8FD5CD582C&feature=plcp
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/mechanical_engineering_writing_enhancement_program/report_writing.html
- https://owl.purdue.edu/owl/subject_specific_writing/professional_technical_writing/technical_reports_and_report_abstracts/reports_proposals_and_technical_papers.html

Name Plate Holder Examples:

- http://www.plaquemaker.com/Catalog/desk-name-plates_42
- http://www.officesigncompany.com/desktop-sign-nameplates.aspx
- http://www.mynameplates.com/
- https://www.youtube.com/watch?v=rKk0wMQNJR4
- https://www.youtube.com/watch?v=qz0yIwhOQI4

- https://www.youtube.com/watch?v=vn0W373f9d4

Solid Edge Instructional Videos

Basic Introduction

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-quick-start/Ey8QWFP7d/chapters/solid-edge-quick-start/Nk1aTuvXd?topic=0

Controls and View Orientation

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-01-fundamentals-of-3-d-modelling/E1NPKx5pP?topic=2

Work Environment

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-03-user-interface/4kozzZqTv?topic=1

Quick View Cube

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=2

Steering Wheel

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=34
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-01-fundamentals-of-3-d-modelling/E1NPKx5pP?topic=12
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-01-fundamentals-of-3-d-modelling/E1NPKx5pP?topic=13

Sketching

Introduction

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=3
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=4

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=9
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=10

Draw Commands

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-01-fundamentals-of-3-d-modelling/E1NPKx5pP?topic=4

Trim

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=18

Extend to Next

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/introduction-to-solid-edge-2-d-geometry/414vCOk6P/chapters/chapter-01-constraints-and-relationships/VkJ3kKy6w?topic=22

Line Sketch

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-01-fundamentals-of-3-d-modelling/E1NPKx5pP?topic=5

Selecting Keypoints

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-01-fundamentals-of-3-d-modelling/E1NPKx5pP?topic=11
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/introduction-to-solid-edge-2-d-geometry/414vCOk6P/chapters/chapter-03-creating-shapes-and-patterns/Vyb071ZpP?topic=0

Intellisketch

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=7

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=8

Using the Sketch Lock

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=12

Fillet

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/introduction-to-solid-edge-2-d-geometry/414vCOk6P/chapters/chapter-03-creating-shapes-and-patterns/Vyb071ZpP?topic=19

Constraining Sketches

Geometric Relationships and Constraints

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=5
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=6
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-quick-start/Ey8QWFP7d/chapters/solid-edge-quick-start/Nk1aTuvXd?topic=3
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-quick-start/Ey8QWFP7d/chapters/solid-edge-quick-start/Nk1aTuvXd?topic=4

Base Features

Base Features introduction

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-quick-start/Ey8QWFP7d/chapters/solid-edge-quick-start/Nk1aTuvXd?topic=2
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-01-fundamentals-of-3-d-modelling/E1NPKx5pP?topic=16

Project: Sport Drink Container

Introduction:
Consumers have many choices today when it comes to picking a personal beverage container. The containers come in all colors, shapes, and sizes. Most workers take one from home, into the car, and then to their job. We are tasked with designing a beverage container that will hold a specific volume and fit the standard cup holder in a vehicle.

Purpose of the Project:
The purpose of this project is to design a container using a mathematical formula to calculate volume. Students will calculate the dimensions of the container from the specified volume given to them by the teacher. Students will utilize the design process during the progression of this container.

This project introduces students to 3D modeling concepts using many different features found in the current software. Students will become familiar with a variety of commands as well as the workflow of the CAD program. Throughout this course, students will frequently utilize many of the techniques developed in this lesson.

This project allows students to act as designers. Each group will interview a “client” and design a sport drink container to meet the client’s needs. Students will interview the client and develop a design brief. Student groups will create sketches for the client and design the beverage container after they receive approval from the teacher. NOTE: The teacher will decide how the “client” and the client’s needs for the project are represented.

Concepts:

- Design is an iterative process and there are many methods used to create and document ideas.
- The design process is a common tool used to gather ideas, refine them and then communicate them.
- Many products are made to certain standardized increments and sizes.
- Engineers utilize mathematical formulas frequently when designing products.

Outline:

- Documentation
    - Engineering Notebook
    - Documentation of beverage container types
    - Documentation of different volume formulas
- Modeling
    - Creation of 3D model
    - Verification of 3D model
- Communication
    - Documentation of design
    - 3D print of design

Standards:

Career and Technical Standards

Engineering Design Process

- Create and maintain an Engineering Notebook for daily reflections, research and prototype creation documentation.
- Apply the design and problem solving process as an iterative process incorporating sciences, mathematics and engineering to optimally convert resources to meet a stated objective.
- Communicate solutions utilizing technical writing skills including correct spelling, proper grammar and dependent vocabulary.

Sketching

- Apply isometric and orthographic sketches to add clarity to design.
- Create necessary sketches to communicate basic ideas during the design process.

3D Solid Modeling

- Apply geometric relationships between lines and shapes to create a mathematical database to describe design ideas
- Create solid models utilizing concepts of Parametric Modeling
- Analyze models for appropriate engineering design features needed

College and Career Readiness Math Standards

Modeling with Geometry G-MG

Apply geometric concepts in modeling situations

1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).
2. Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot).
3. Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).

Create equations that describe numbers or relationships CED

A.4. Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.

Reading Standards for Literacy in History/Social Studies 9-10
Key Ideas and Details

1. Cite specific textual evidence to support analysis of primary and secondary sources, attending to such features as the date and origin of the information.

3. Analyze in detail a series of events described in a text; determine whether earlier events caused later ones or simply preceded them.

Integration of Knowledge and Ideas

7. Integrate quantitative or technical analysis (e.g., charts, research data) with qualitative analysis in print or digital text.

9. Compare and contrast treatments of the same topic in several primary and secondary sources.

Range of Reading and Level of Text Complexity

10. By the end of grade 10, read and comprehend science/technical texts in the grades 9–10 text complexity band independently and proficiently.

Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 9-10

Text Types and Purposes

1. Write arguments focused on *discipline-specific content.*
2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

Production and Distribution of Writing

4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Research to Build and Present Knowledge

7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow

or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.

Range of Writing

10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Next Generation Science Standards

The projects engage students in the scientific and engineering practices taken from the National Research Council's Framework for K-12 Science Education, Practices, Crosscutting Concepts, and Core Ideas. This is the document upon which the NGSS are based.

These practices are used for two reasons: 1) they parallel the design process utilized in each project, and 2) they serve as the foundation of the NGSS.

The eight science and engineering practices are:

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Standards for Technological Literacy

Standard 1

Students will develop an understanding of the characteristics and scope of technology.

Standard 2

Students will develop an understanding of the core concepts of technology.

Standard 7

Students will develop an understanding of the influence of technology on history.

Standard 8

Students will develop an understanding of the attributes of design.

Standard 9
Students will develop an understanding of engineering design.

Standard 10
Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Standard 11
Students will develop the abilities to apply the design process.

Standard 12
Students will develop the abilities to use and maintain technological products and systems.

Standard 13
Students will develop the abilities to assess the impact of products and systems.

Standard 17
Students will develop an understanding of and be able to select and use information and communication technologies.

Standard 19
Students will develop an understanding of and be able to select and use manufacturing technologies.

Standard 20
Students will develop an understanding of and be able to select and use construction technologies.

Assessment:

Assessment is both formative and summative. It is an integral part of quality instruction. During the course of each project, one of the teacher's main functions is to work with student groups, keeping track of progress and providing formative assessment in the form of feedback and promoting reflection on the part of students. The focus should be on promoting lifetime learning and 21st century skills. The goal of instruction is to promote abilities in research, problem solving, designing, experimenting, testing, collecting and analyzing data.

Rubrics are used in the assessment process to communicate expectations of quality of a task. Rubrics should be shared with students at the beginning of a project so they can clarify any misconceptions before beginning their work. They can then build the skills and gather knowledge to solve the problem presented to the expectations of excellence described.

General Rubrics for Literacy tasks:
Argumentative_Pursuasive
Informational_Explanatory

Individual Project Rubric:
Sport Drink Container Project Rubric

Essential Question:
How do we design a modern and practical beverage container that will hold a specified volume?

Student Scenario:
You are a package designer that must submit plans for a product line consisting of stackable beverage containers that could be made from several different materials. The container must hold a specified volume in fluid ounces.

You will interview your client to discover their needs. You will create a design brief to share with your client to obtain approval before beginning work on the final design. After conducting research on container styles and sizes, select a design that meets the desired requirements. Create the solid model and verify its characteristics. You will also be responsible for giving a short presentation about your container design, highlighting your favorite characteristics.

The research and learning activities are designed to help students:

- Create sketches to communicate to a group
- Use mathematical formulas to aid in the design of a product
- Utilize specific software features to create a solid model of their idea.
- Communicate their solution to their peers.

Deliverables include:

- Engineering Notebook
- CAD model
- 3D printed model
- Outline of an Engineering Report that includes 3D images and working drawing
- Presentation of the development process

Daily Plan:

Day 1
Key Question: What are the expectations of the project?

Introduce students to the project by providing them with the Essential Question and the scenario.

Review and discuss with your students the design process, Engineering Notebook and design documentation requirements. Discuss the problem statement, design brief, testing protocol and management plan. Review the elements of a good engineering report with the students. These were all covered in the first project titled *Introduction to the Engineering Design Process* but should be reinforced on a regular basis. All projects depend on the design process and student activities should relate directly.

Have the students form teams of two. Allow the students five minutes to discuss the problem. Students begin by brainstorming ideas in their Engineering Notebooks. The teacher will provide a list of vocabulary terms that students will need to research on their own. The teams can divide the list of terms among team members and share their definitions. All team members are responsible to know all definitions.

Day 2-4
Key Question: How do we get started in the design process?

The teacher should specify that teams will be responsible for researching the characteristics of the beverage container. Student teams should research the requirements of a container as pertains to cup holders in vehicles and kitchen storage. Student teams should spend some time interviewing the client to establish the desired characteristics. Students begin sketching in the Engineering Notebook.

The teacher reminds students about the help system to find out how the software accomplishes basic features they might want to incorporate. https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index Students can enter terms and view a tutorial for creating certain features. Students can reference specific terms from the vocabulary list for specific commands to be used in the design of the container. The teacher will also show students the Siemens Solid Edge Video Resources to allow students to discover further elements to help their designs. Other tutorials in the Resources section are available for use if students struggle.

Student teams discuss the specifications of the container. Students list the criteria and constraints of the problem they are solving. The teacher can specify a certain fluid ounce range the container must hold. (around 20 oz. as a starting point) Also the radius or the height could be a predetermined value determined by the students after researching standard cup holder sizes in cars. The teams will use a formula for the volume to be used to dictate the shape of the container. Students should be refining their sketches in the Engineering Notebook. Teams should research how to convert fluid ounces to cubic inches. They also should be applying the necessary volume formula(s) to their design.

Remind students to record research notes and sources as well as reflections on the day in the Engineering Notebook.

The teacher will provide access to the following video tutorials that will provide students with information about basic 3D commands, constraining, editing and developing 3D designs. They can also access Siemens Solid Edge Video Resources for further information on the topics.

Command Finder

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-03-user-interface/4kozzZqTv?topic=2

Feature Tree

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-03-user-interface/4kozzZqTv?topic=3

Prompt Bar

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-03-user-interface/4kozzZqTv?topic=4

Axis in the Center

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-

certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=15

Selecting Keypoints

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-01-fundamentals-of-3-d-modelling/E1NPKx5pP?topic=11

Project to Sketch

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=24

Offset

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-09-bullseye/4ySXy7qTD?topic=1

Mirror

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=21

Extrusion

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-06-cube-cutouts/EJu1wW96D?topic=0

Round Command

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-07-rounding/EJl7pZ5TD?topic=0

Thin Wall

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-12-thinwall/Ny6wHXcaw?topic=0

Loft

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-14-loft/Ektxjm9Tv?topic=0

Revolve

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-

certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=29

Sweep

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-17-sweep/VydMvq5aw?topic=0

Pattern

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=28

Working Drawings

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=26

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-quick-start/Ey8QWFP7d/chapters/solid-edge-quick-start/Nk1aTuvXd?topic=7

Day 5-7
Key Question: How do we get started on our design?

Teams can decide which sketches and calculations will be used to create their designs. Student teams finish creating their isometric sketches and create a design brief to include with their sketch. They then meet with the client. The client will need to sign off on the design proposal before beginning solid modeling. Teams might select one design or elements of multiple designs to combine into their final design. Once the students have verified their dimensions and design, they begin solid modeling on the software to convey their ideas. Students can reference specific terms from the vocabulary list for specific commands to be used in the design of the container. Students can begin solid modeling on the software to convey their ideas. Students can reference Basic 3D Commands and Creating Drawing Views for specific commands to use in their beverage container designs.

Day 8-9
Key Question: What can we do to enhance our design?

Teams discuss the container and how to progress to the next step given the approved sketch. They work together to design the container and divide the work of creating the 3D solid model of the components of the container. They utilize the division of work in the creation of their project management plan.

Teams are reminded to continually check their solid models for accuracy to assure the correct sizes are created.

Students can review tutorials as necessary. Students record sketches and reflections in the Engineering Notebook. Once the students feel they have a container solution that meets the requirements, they should consider practical enhancements. Their container design could incorporate features like lids, handles, and the ability to stack.

Day 10-11
Key Question: How can we put the finishing touches on our designs?

Students will continue to model using the software. Students 3D print samples of the container. Groups finalize their designs.

Day 12
Key Question: How do we organize a presentation to the client?

Students discuss the types of things to include in the presentation to the client. They decide on the types of graphics to include. Students should prepare an engineering report about the process of designing the container. They should be required write the introduction, results including graphics, conclusion and include the acknowledgement sections reporting where their information came from. The rest can be in outline format.

Day 13
Key Question: How do we convey our ideas?

Students can present their solutions to the class one at a time. In the end, all students can reflect on their work by giving and receiving feedback on how they could possibly improve their designs.

Vocabulary:

Chamfer
Constraints
Conversion
Cut
Ergonomics
Extrusion
Feature Tree
Fillet
Hole
Intellisketch
Join
Keypoints
Loft

Mirror
Nest
Offset
Pattern
Reference Plane
Revolve
Round
Sketch Lock
Sweep
Thin Wall
Trim
Volume

Resources:

Container Designs:

- http://news.thomasnet.com/companystory/amcor-rigid-plastics-captures-golden-a-design-award-for-redesign-of-toni-s-profit-sports-beverage-container-30006385
- http://www.thedieline.com/blog/2010/6/8/redesigning-the-coffee-cup.html
- http://redesignreport.com/keepcup-a-well-designed-coffee-mug/
- http://thesweethome.com/reviews/best-travel-mug/
- https://www.behance.net/gallery/3738073/Self-conducted-project-Speedo-water-bottle-redesign

Volume Formulas:

- http://www.calculator.net/volume-calculator.html

Converting Cubic Inches to Fluid Ounces

- http://www.metric-conversions.org/volume/cubic-inches-to-us-ounces.htm

CAD Tutorials

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012412/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012413/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012414/index.html
  https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012415/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012416/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012417/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012430/index.html

Engineering Reports

- http://web.mit.edu/me-ugoffice/communication/technical-writing.pdf
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/writing_engineering_reports.html
- https://www.youtube.com/playlist?list=PLDAAF7A8FD5CD582C&feature=plcp
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/mechanical_engineering_writing_enhancement_program/report_writing.html
- https://owl.purdue.edu/owl/subject_specific_writing/professional_technical_writing/technical_reports_and_report_abstracts/reports_proposals_and_technical_papers.html

Solid Edge Instructional Videos

Using the Sketch Lock

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=12

Project to Sketch

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=24

Offset

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-09-bullseye/4ySXy7qTD?topic=1

Crosshatch and Color

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=16

Copy and Rotate

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=27

Fillet

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/introduction-to-solid-edge-2-d-geometry/414vCOk6P/chapters/chapter-03-creating-shapes-and-patterns/Vyb071ZpP?topic=19

Mirror

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-

certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=21

Creating Reference Planes

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=17

Visualization: Creating Parts from Engineering Sketches

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-10-engineering-drawings/4yIO-mcaP?topic=0

Extrusion

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-06-cube-cutouts/EJu1wW96D?topic=0

Round Command

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-07-rounding/EJl7pZ5TD?topic=0

Thin Wall

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-12-thinwall/Ny6wHXcaw?topic=0

Loft

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-14-loft/Ektxjm9Tv?topic=0

Revolve

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=29

Sweep

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-17-sweep/VydMvq5aw?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-17-sweep/VydMvq5aw?topic=1

Pattern

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=28

Area

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=20

Mass Properties

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=23

Basic modify

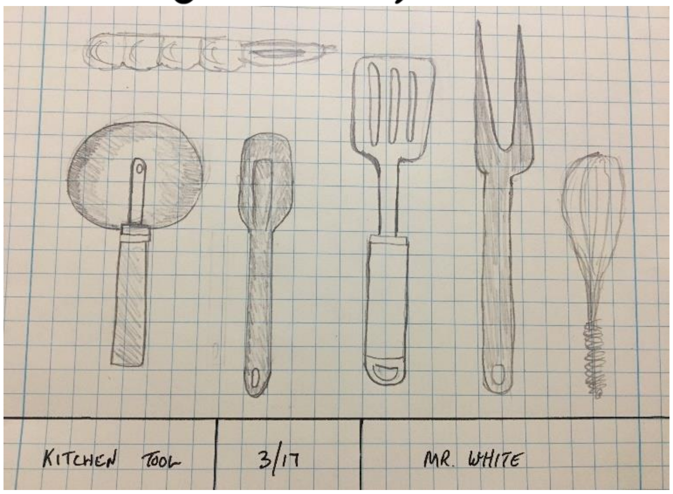
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-01-fundamentals-of-3-d-modelling/E1NPKx5pP?topic=3

Design Intent

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-09-bullseye/4ySXy7qTD?topic=0

Working Drawings

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=26
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-quick-start/Ey8QWFP7d/chapters/solid-edge-quick-start/Nk1aTuvXd?topic=7



Project: Kitchen Tool Design

Introduction:
We all have or have seen a wide variety of tools in our kitchens. People who are working in a kitchen need specific tools for certain applications. These tools generally serve a single purpose and should be easily accessible to the user. What if we could possibly combine or add to some of these common tools to make it easier for the user?

Purpose of the Project:
The purpose of this project is to go through the design process and have students brainstorm, sketch, model, and present an innovative practical kitchen tool that could be used in preparing food.

This project introduces students to 3D modeling concepts. The project will utilize many different features found in the current software. Students will become familiar with a variety of commands as well as the workflow of the CAD program. Throughout this course students will frequently utilize many of the techniques developed in this lesson.

This project allows students to act as designers. Each group will interview a “client” and design a kitchen tool to meet their needs. Students will interview the client and develop a design brief to identify the type of tool and what it should do. Student groups will create sketches for the client and design the tool after they receive approval.

Concepts:

- Analyze models for appropriate engineering design features that are needed.
- Develop strategies for the building of solid models for the rapid creation of design solutions.
- Communicate ideas to a group through the use of sketches and other documentation.
- Create a drawing to communicate design ideas and engineering principles to an audience.

Outline:

Documentation
    Engineering Notebook
    Documentation of possible objects to be designed
Modeling
    Creation of 3D models
Communication
    Presentation of design solutions

Standards:

Career and Technical Standards

Engineering Design Process

- Create and maintain an Engineering Notebook for daily reflections, research and prototype creation documentation.
- Apply the design and problem solving process as an iterative process incorporating sciences, mathematics and engineering to optimally convert resources to meet a stated objective.
- Communicate solutions utilizing technical writing skills including correct spelling, proper grammar and dependent vocabulary.

Sketching

- Apply isometric and orthographic sketches to add clarity to design.
- Create necessary sketches to communicate basic ideas during the design process.

3D Solid Modeling

- Apply geometric relationships between lines and shapes to create a mathematical database to describe design ideas
- Create solid models utilizing concepts of Parametric Modeling
- Analyze models for appropriate engineering design features needed

College and Career Readiness Math Standards

Modeling with Geometry G-MG

Apply geometric concepts in modeling situations

1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).
2. Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot).
3. Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).

Create equations that describe numbers or relationships CED

A.4. Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.

Reading Standards for Literacy in History/Social Studies 9-10

Key Ideas and Details

1. Cite specific textual evidence to support analysis of primary and secondary sources, attending to such features as the date and origin of the information.

3. Analyze in detail a series of events described in a text; determine whether earlier events caused later ones or simply preceded them.

Integration of Knowledge and Ideas

7. Integrate quantitative or technical analysis (e.g., charts, research data) with qualitative analysis in print or digital text.

9. Compare and contrast treatments of the same topic in several primary and secondary sources.

Range of Reading and Level of Text Complexity

10. By the end of grade 10, read and comprehend science/technical texts in the grades 9–10 text complexity band independently and proficiently.

Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 9-10

Text Types and Purposes

1. Write arguments focused on *discipline-specific content.*
2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

Production and Distribution of Writing

4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Research to Build and Present Knowledge

7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow

or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.

Range of Writing

10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Next Generation Science Standards

The projects engage students in the scientific and engineering practices taken from the National Research Council's Framework for K-12 Science Education, Practices, Crosscutting Concepts, and Core Ideas. This is the document upon which the NGSS are based.

These practices are used for two reasons: 1) they parallel the design process utilized in each project, and 2) they serve as the foundation of the NGSS.

The eight science and engineering practices are:

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Standards for Technological Literacy

Standard 1

Students will develop an understanding of the characteristics and scope of technology.

Standard 2

Students will develop an understanding of the core concepts of technology.

Standard 7

Students will develop an understanding of the influence of technology on history.

Standard 8

Students will develop an understanding of the attributes of design.

Standard 9
Students will develop an understanding of engineering design.

Standard 10
Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Standard 11
Students will develop the abilities to apply the design process.

Standard 12
Students will develop the abilities to use and maintain technological products and systems.

Standard 13
Students will develop the abilities to assess the impact of products and systems.

Standard 17
Students will develop an understanding of and be able to select and use information and communication technologies.

Standard 19
Students will develop an understanding of and be able to select and use manufacturing technologies.

Standard 20
Students will develop an understanding of and be able to select and use construction technologies.

Assessment:

Assessment is both formative and summative. It is an integral part of quality instruction. During the course of each project, one of the teacher's main functions is to work with student groups, keeping track of progress and providing formative assessment in the form of feedback and promoting reflection on the part of students. The focus should be on promoting lifetime learning and 21st century skills. The goal of instruction is to promote abilities in research, problem solving, designing, experimenting, testing, collecting and analyzing data.

Rubrics are used in the assessment process to communicate expectations of quality. Rubrics should be shared with students at the beginning of a project to clarify any misconceptions before beginning their work. Students can then build the skills and gather knowledge to solve the problem presented to the expectations of excellence described.

General Rubrics for Literacy tasks:
[Argumentative_Pursuasive](#)
[Informational_Explanatory](#)

Individual Project Rubric:
[Kitchen Tool Design Project Rubric](#)

Essential Question:
How can we make a new and improved tool to perform a kitchen task that is routinely done by hand?

Student Scenario:
There are many tools found in all of our kitchens that serve a particular purpose. Your team has been given the task by a large kitchen appliance company. You must take an ordinary manual hand held kitchen tool and innovate it.

You will interview your client to discover their needs. After conducting research on styles, characteristics, and sizes, you will select a design that meets the desired requirements. You will create a design brief to share with your clients giving a short presentation about your design, highlighting your favorite characteristics. Obtain the client's approval before beginning work on the final design. You will create the solid model and verify its characteristics by printing and building a prototype. NOTE: The teacher will decide how the "client" and the client's needs for the project are to be represented.

The research and learning activities are designed to help students:
- Create sketches to communicate to a group
- Use mathematical formulas to aid in the design of a product
- Utilize specific software features to create a solid model of their idea
- Communicate their solution to their peers

Deliverables include:
- Engineering Notebook
- CAD model
- 3D printed model
- Outline of an Engineering Report that includes 3D images and working drawing
- Presentation of the development process

Daily Plan:
Day 1
Key Question: What are the expectations of the project?

Introduce students to the project by providing them with the Essential Question and the scenario.

Review and discuss with your students the design process, Engineering Notebook and design documentation requirements. Discuss the problem statement, design brief, testing protocol and management plan. Review the elements of a good engineering report with the students. These were all covered in the first project titled *Introduction to the Engineering Design Process* but should be reinforced on a regular basis. All projects depend on the design process and student activities should relate directly.

Have the students form teams of two. Allow the students five minutes to discuss the problem. Students begin by brainstorming ideas in their Engineering Notebooks. The teacher will provide a list of vocabulary terms that students will need to research on their own. The teams can divide the list of terms among team members and share their definitions. All team members are responsible to know all definitions.

Day 2-4
Key Question: How do we get started in the design process?

The teacher should specify that the teams will be responsible for researching the characteristics and specifications of the kitchen tool. The client should specify the characteristics of the tool. The tool should be easy to use and an improvement over what can be purchased today.

NOTE: The teacher will decide how the "client" and the client's needs for the project are to be represented.

Student teams should spend some time interviewing the client to establish the desired characteristics. Students begin sketching in the Engineering Notebook.

The teacher reminds students about the help system to find out how the software accomplishes basic features they might want to incorporate.
https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index

Students can enter terms to view a tutorial for creating certain features. Students can reference specific terms from the vocabulary list for specific commands to be used in the design of the kitchen tool. The teacher will also show students the Siemens Solid Edge Video Resources to allow students to discover further elements to help their designs. Other tutorials in the Resources section are available for use if students struggle.

Student teams research the types of kitchen tools available and basic ergonomics. Student teams discuss the specifications of the tool. Students list the criteria and constraints of the problem they are solving. Teams research the existing kitchen tools and discover information about ergonomics. The teams will use formulas to calculate data needed based on the shape of the tool. Students should be refining their sketches in the Engineering Notebook.

Remind students to record research notes and sources as well as reflections on the day in the Engineering Notebook.

The teacher will provide access to the following video tutorials that will provide students with information about basic 3D commands, constraining, editing and developing 3D designs. They can also access Siemens Solid Edge Video Resources for further information on the topics.

Command Finder

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-03-user-interface/4kozzZqTv?topic=2

Feature Tree

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-03-user-interface/4kozzZqTv?topic=3

Prompt Bar

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-03-user-interface/4kozzZqTv?topic=4

Axis in the Center

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=15

Selecting Keypoints

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-01-fundamentals-of-3-d-modelling/E1NPKx5pP?topic=11

Project to Sketch

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=24

Offset

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-09-bullseye/4ySXy7qTD?topic=1

Mirror

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=21

Extrusion

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-06-cube-cutouts/EJu1wW96D?topic=0

Round Command

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-07-rounding/EJl7pZ5TD?topic=0

Thin Wall

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-12-thinwall/Ny6wHXcaw?topic=0

Loft

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-14-loft/Ektxjm9Tv?topic=0

Revolve

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=29

Sweep

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-17-sweep/VydMvq5aw?topic=0

Pattern

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=28

Working Drawings

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=26

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-quick-start/Ey8QWFP7d/chapters/solid-edge-quick-start/Nk1aTuvXd?topic=7

Day 5-7
Key Question: How do we get started on our individual designs?

Student teams finish creating their isometric sketches and create a design brief to include with their sketch. They then meet with the client who will need to sign off on the design proposal before beginning the solid model. Once the design has been verified and permission given, students can begin solid modeling on the software to convey their ideas. Students can reference Basic 3D Commands and Creating Drawing Views for specific commands to use in the kitchen tool design.

Day 8-9
Key Question: How can we model efficiently?

Teams discuss their tool and how to achieve the design given the approved sketch they presented. They work together to design the tool and divide the work of creating the 3D solid model of the pieces they are responsible for. They utilize the division of work in the creation of their project management plan.

Teams are reminded to continually check their solid models for accuracy to ensure the correct sizes are created.

Students can review tutorials as necessary. Students record sketches and reflections in the Engineering Notebook. Once the students feel they have a kitchen tool solution that meets the requirements, they should consider practical enhancements.

Day 10
Key Question: How can we finalize our designs?

The teacher should review the design process with the class and check with teams to see where they are in the design process along with any known or perceived problems with kitchen tool designs encountered.

Students will finish modeling using the software and tutorials as necessary.

Day 11
Key Question: How does one plan and deliver a presentation to the class?

The teacher will discuss with the students how to optimally present their ideas to the class. Students should also be prepared to justify any design enhancements incorporated into the kitchen tool. Students will continue to refine the model using the Solid Edge. Students will use the 3D printer to prepare samples of the kitchen tool. Teams finalize their designs.

Students discuss the items needed in their presentation to their clients. The team decides on the types of graphics to include. Students should prepare an Engineering Report about the process of designing the kitchen tool. They should be required to write the introduction, provide results including graphics, a conclusion and include the acknowledgement sections reporting the source of the information. The rest of the report can be in outline format.

Day 12
Key Question: How do we convey our ideas?

Students can present their solutions to the class one at a time. In the end, all students can reflect on their work by giving and receiving feedback on how they could possibly improve their designs.

Vocabulary:

Chamfer
Constraints
Conversion
Cut
Ergonomics
Extrusion
Feature Tree
Fillet
Hole
Intellisketch
Join
Keypoints
Loft
Mirror
Nest
Offset
Pattern
Reference Plane
Revolve
Round
Sketch Lock
Sweep
Thin Wall
Trim
Volume

Resources:

Kitchen Tool Examples:

- https://www.aliexpress.com/cheap/cheap-handheld-gadgets.html
- https://www.aliexpress.com/hand-cheese-grater_reviews.html
- http://www.dillards.com/c/home-kitchen-kitchen-utensils-gadgets-tools

- https://visual.ly/tag/kitchen-tools

CAD Tutorials
- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012412/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012413/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012414/index.html
https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012415/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012416/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012417/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012430/index.html

Engineering Reports
- http://web.mit.edu/me-ugoffice/communication/technical-writing.pdf
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/writing_engineering_reports.html
- https://www.youtube.com/playlist?list=PLDAAF7A8FD5CD582C&feature=plcp
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/mechanical_engineering_writing_enhancement_program/report_writing.html
- https://owl.purdue.edu/owl/subject_specific_writing/professional_technical_writing/technical_reports_and_report_abstracts/reports_proposals_and_technical_papers.html

Solid Edge Instructional Videos

Using the Sketch Lock
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=12

Project to Sketch
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=24

Offset
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-09-bullseye/4ySXy7qTD?topic=1

Crosshatch and Color

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=16

Copy and Rotate

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=27

Fillet

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/introduction-to-solid-edge-2-d-geometry/414vCOk6P/chapters/chapter-03-creating-shapes-and-patterns/Vyb071ZpP?topic=19

Mirror

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=21

Creating Reference Planes

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=17

Visualization: Creating Parts from Engineering Sketches

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-10-engineering-drawings/4yIO-mcaP?topic=0

Extrusion

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-06-cube-cutouts/EJu1wW96D?topic=0

Round Command

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-07-rounding/EJl7pZ5TD?topic=0

Thin Wall

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-12-thinwall/Ny6wHXcaw?topic=0

Loft

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-14-loft/Ektxjm9Tv?topic=0

Revolve

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=29

Sweep

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-17-sweep/VydMvq5aw?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-17-sweep/VydMvq5aw?topic=1

Pattern

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=28

Area

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=20

Mass Properties

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=23

Basic modify

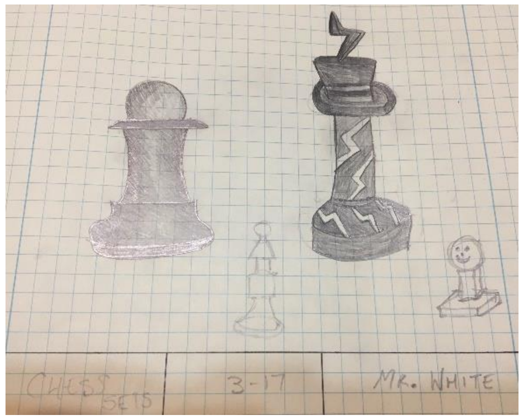
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-01-fundamentals-of-3-d-modelling/E1NPKx5pP?topic=3

Design Intent

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-09-bullseye/4ySXy7qTD?topic=0

Working Drawings

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=26
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-quick-start/Ey8QWFP7d/chapters/solid-edge-quick-start/Nk1aTuvXd?topic=7



Project: Chess Set

Introduction:
The game of Chess has been played for well over 1000 years all over the world. Many Chess sets are usually very similar in style and not always appealing to newer or younger players.

Purpose of the Project:
The purpose of this project is to introduce students to 3D modeling concepts. The Chess set project will utilize many different features found in the current software. Students will become familiar with a variety of commands as well as the workflow of the CAD program. Throughout this course, students will frequently use many of the techniques developed in this lesson.

This project allows students to act as designers. Each group will interview a “client” and design a Chess set to meet their needs. Students will interview the client and develop a design brief to identify the theme of the set. Student groups will create sketches for their client and design a “themed” Chess set after they receive approval from the teacher. NOTE: The teacher will decide how the “client” and the client’s needs for the project are to be represented.

Concepts:
- Design is an iterative process requiring many methods to create and document ideas.

- The design process is a common tool used to gather ideas, refine them, and then communicate them.
- Many products are made to certain standardized increments and sizes.
- Certain products can evolve as customer trends change.
- Designing and creating a model using additive manufacturing technology-is sometimes called rapid prototyping.
- Analyze models for appropriate engineering design features.

Outline:

- Documentation
  - Engineering Notebook
  - Documentation of Chess regulations
  - Documentation of Chess set styles
- Modeling
  - Creation of 3D solid models
  - Assembly of 3D solid models
- Communication
  - Documentation of design
  - 3D print of design

Standards:

Career and Technical Standards

Engineering Design Process

- Create and maintain an Engineering Notebook for daily reflections, research and prototype creation documentation.
- Apply the design and problem solving process as an iterative process incorporating sciences, mathematics and engineering to optimally convert resources to meet a stated objective.
- Communicate solutions utilizing technical writing skills including correct spelling, proper grammar and dependent vocabulary.

Sketching

- Apply isometric and orthographic sketches to add clarity to design.
- Create necessary sketches to communicate basic ideas during the design process.

3D Solid Modeling

- Apply geometric relationships between lines and shapes to create a mathematical database to describe design ideas
- Create solid models utilizing concepts of Parametric Modeling
- Analyze models for appropriate engineering design features needed

College and Career Readiness Math Standards

Modeling with Geometry G-MG

Apply geometric concepts in modeling situations

1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).
2. Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot).
3. Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).

Reading Standards for Literacy in History/Social Studies 9-10

Key Ideas and Details

1. Cite specific textual evidence to support analysis of primary and secondary sources, attending to such features as the date and origin of the information.

3. Analyze in detail a series of events described in a text; determine whether earlier events caused later ones or simply preceded them.

Integration of Knowledge and Ideas

7. Integrate quantitative or technical analysis (e.g., charts, research data) with qualitative analysis in print or digital text.

9. Compare and contrast treatments of the same topic in several primary and secondary sources.

Range of Reading and Level of Text Complexity

10. By the end of grade 10, read and comprehend science/technical texts in the grades 9–10 text complexity band independently and proficiently.

Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 9-10

Text Types and Purposes

1. Write arguments focused on *discipline-specific content.*
2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

Production and Distribution of Writing

4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Research to Build and Present Knowledge

7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.

Range of Writing

10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Next Generation Science Standards

The projects engage students in the scientific and engineering practices taken from the National Research Council's Framework for K-12 Science Education, Practices, Crosscutting Concepts, and Core Ideas. This is the document upon which the NGSS are based.

These practices are used for two reasons: 1) they parallel the design process utilized in each project, and 2) they serve as the foundation of the NGSS.

The eight science and engineering practices are:

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Standards for Technological Literacy

Standard 1

Students will develop an understanding of the characteristics and scope of technology.

Standard 2

Students will develop an understanding of the core concepts of technology.

Standard 7

Students will develop an understanding of the influence of technology on history.

Standard 8

Students will develop an understanding of the attributes of design.

Standard 9

Students will develop an understanding of engineering design.

Standard 10
Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Standard 11
Students will develop the abilities to apply the design process.

Standard 12
Students will develop the abilities to use and maintain technological products and systems.

Standard 13
Students will develop the abilities to assess the impact of products and systems.

Standard 17
Students will develop an understanding of and be able to select and use information and communication technologies.

Standard 19
Students will develop an understanding of and be able to select and use manufacturing technologies.

Standard 20
Students will develop an understanding of and be able to select and use construction technologies.

Assessment:

Assessment is both formative and summative. It is an integral part of quality instruction. During the course of each project, one of the teacher's main functions is to work with student groups, keeping track of progress and providing formative assessment in the form of feedback and promoting reflection on the part of students. The focus should be on promoting lifetime learning and 21st century skills. The goal of instruction is to promote abilities in research, problem solving, designing, experimenting, testing, collecting and analyzing data.

Rubrics are used in the assessment process to communicate expectations of quality. Rubrics should be shared with students at the beginning of a project to clarify any misconceptions before beginning their work. Students can then build the skills and gather knowledge to solve the problem presented to the expectations of excellence described.

General Rubrics for Literacy tasks:
Argumentative_Pursuasive
Informational_Explanatory

Individual Project Rubric:
Chess set Project Rubric

Essential Question:
How can we design a themed Chess set to attract new players?

Student Scenario:
Your development team has been hired by a board game company for the introduction of an exciting new themed Chess set that will be sold all over the United States. This Chess set will be in a theme consistent with the client's needs and comply with tournament Chess regulations.

After conducting research on regulation Chess sets and styles, you will interview your client and create a design that meets the desired requirements. You will create the solid model and verify its characteristics. You will also be responsible for giving a short presentation about your Chess set design, highlighting your favorite characteristics.

The research and learning activities are designed to help students:

- Create sketches to communicate to a group
- Use mathematical formulas to aid in the design of a product
- Utilize specific software features to create a solid model of their idea.
- Communicate their solution to their peers.

Deliverables include:

- Engineering Notebook
- CAD model
- 3D printed model
- Outline of an Engineering Report that includes 3D images and working drawing
- Presentation of the development process

Daily Plan:
Day 1
Key Question: What are the expectations of the project?

Introduce students to the project by providing them with the Essential Question and the scenario.

Review and discuss with your students the design process, Engineering Notebook and design documentation requirements. Discuss the problem statement, design brief, testing protocol and management plan. Review the elements of a good engineering report with the students. These were all covered in the first project titled *Introduction to the Engineering Design Process* but should be reinforced on a regular basis. All projects depend on the design process and student activities should relate directly.

Have the students form teams of two. Allow the students five minutes to discuss the problem. Students begin by brainstorming ideas in their Engineering Notebooks. The teacher will provide a list of vocabulary terms that students will need to research on their own. The teams can divide the list of terms among team members and share their definitions. All team members are responsible to know all definitions.

Day 2-4
Key Question: How do we get started with the design process?

The teacher will lead a group discussion on the expectations and the specifications of the themed Chess set. The teacher should specify that the teams will be responsible for researching the characteristics the Chess set including the requirements of a Chess set pertaining to size and number of pieces. Students should begin sketching in their Engineering Notebook. They also should be researching rules of tournament Chess sets and record any findings in their Engineering Notebooks. Students should end the day with a reflection in their Engineering Notebook.

The teacher will provide access to the following video tutorials that will provide students with information about basic 3D commands, constraining, editing and developing 3D designs. They can also access Siemens Solid Edge Video Resources for further information on the topics.

Command Finder

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-03-user-interface/4kozzZqTv?topic=2

Feature Tree

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-03-user-interface/4kozzZqTv?topic=3

Prompt Bar

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-03-user-interface/4kozzZqTv?topic=4

Axis in the Center

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=15

Selecting Keypoints

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-01-fundamentals-of-3-d-modelling/E1NPKx5pP?topic=11

Project to Sketch

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=24

Offset

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-09-bullseye/4ySXy7qTD?topic=1

Mirror

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=21

Extrusion

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-06-cube-cutouts/EJu1wW96D?topic=0

Round Command

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-07-rounding/EJl7pZ5TD?topic=0

Thin Wall

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-12-thinwall/Ny6wHXcaw?topic=0

Loft

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-14-loft/Ektxjm9Tv?topic=0

Revolve

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=29

Sweep

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-17-sweep/VydMvq5aw?topic=0

Pattern

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=28

Working Drawings

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=26

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-quick-start/Ey8QWFP7d/chapters/solid-edge-quick-start/Nk1aTuvXd?topic=7

Day 5
Key Question: How do we get started with the design?

Student teams finish creating their isometric sketches and create a design brief to be included with their sketch. They then meet with the client. The client will need to sign off on the design proposal before they begin solid modeling. Once the students have verified the model and have permission from the teacher, they can begin solid modeling using Solid Edge to convey their ideas. The teacher reminds students about the help system to find out how the software accomplishes basic features they might want to incorporate.
https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index

Students can enter specific terms to view a tutorial for creating certain features. Students can reference specific terms from the vocabulary list for specific commands to be used in the design of the Chess set. The teacher will also show students the Siemens Solid Edge Video Resources to allow students to discover further elements to help their designs. Other tutorials in the Resources section are available for use if students struggle. Students can reference Basic 3D Commands and Creating Drawing Views for specific commands to use in the chess set design.

Day 6-7
Key Question: What can be done to enhance the design?

Teams discuss the Chess set design thus far. They identify areas for improvement and make design adjustments. Students work together to divide the work of designing the Chess set creating the 3D solid models of the pieces. They utilize the division of work in the creation of their project management plan.

Teams are reminded to continually check their solid models for accuracy to assure the correct sizes are created.

The students should pace themselves and try to create one Chess piece in one class period (2 Chess pieces in a double period block schedule) so the team can have the Chess set completed on time. Students can review tutorials as necessary. Students record sketches and reflections in the Engineering Notebook.

Day 8-9
Key Question: Are we on track with our designs?

The teacher should review any known or perceived problems with the Chess set designs so far. The teacher reminds the teams about the one piece per class period output so the Chess set is completed on time. Students continue to produce 3D models using Solid Edge. When the Chess set is completed, students use the 3D printer to produce models of the Chess set.

Day 10
Key Question: How can we prepare our designs to look professional for presentation?

Students discuss the items needed in their presentation to their client. The teams decide on the types of graphics to include. Students should prepare an Engineering Report about the process of designing the Chess set. They should be required to write the introduction, results including graphics, conclusion and include the acknowledgement sections reporting where their information came from. The rest of the report can be in outline format.

Day 11
Key Question: How are ideas conveyed?

Students can present their solutions to the class one at a time. In the end, all students can reflect on their work by giving and receiving feedback on how they could possibly improve their designs.

Vocabulary:

Chamfer
Constraints
Conversion
Cut
Ergonomics
Extrusion
Feature Tree

Fillet
Hole
Intellisketch
Join
Keypoints
Loft
Mirror
Offset
Pattern
Reference Plane
Revolve
Round
Sketch Lock
Sweep
Thin Wall
Trim
Volume

Resources:

Chess Rules:

- https://www.Chess.com/learn-how-to-play-Chess
- http://www.usChess.org/content/view/7864/221/
- http://www.Chessusa.com/tournament-Chess-size.html

Custom Designed Chess Sets:

- http://www.home-designing.com/2014/04/30-unique-home-Chess-sets
- https://www.pinterest.com/jama3marion/cool-Chess-sets/

CAD Tutorials

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012412/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012413/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012414/index.html
  https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012415/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012416/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012417/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012430/index.html

Engineering Reports

- http://web.mit.edu/me-ugoffice/communication/technical-writing.pdf

- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/writing_engineering_reports.html
- https://www.youtube.com/playlist?list=PLDAAF7A8FD5CD582C&feature=plcp
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/mechanical_engineering_writing_enhancement_program/report_writing.html
- https://owl.purdue.edu/owl/subject_specific_writing/professional_technical_writing/technical_reports_and_report_abstracts/reports_proposals_and_technical_papers.html

Solid Edge Instructional Videos

Using the Sketch Lock

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=12

Project to Sketch

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=24

Offset

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-09-bullseye/4ySXy7qTD?topic=1

Crosshatch and Color

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=16

Copy and Rotate

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=27

Fillet

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/introduction-to-solid-edge-2-d-geometry/414vCOk6P/chapters/chapter-03-creating-shapes-and-patterns/Vyb071ZpP?topic=19

Mirror

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=21

Creating Reference Planes

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=17

Visualization: Creating Parts from Engineering Sketches

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-10-engineering-drawings/4yIO-mcaP?topic=0

Extrusion

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-06-cube-cutouts/EJu1wW96D?topic=0

Round Command

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-07-rounding/EJl7pZ5TD?topic=0

Thin Wall

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-12-thinwall/Ny6wHXcaw?topic=0

Loft

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-14-loft/Ektxjm9Tv?topic=0

Revolve

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=29

Sweep

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-17-sweep/VydMvq5aw?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-17-sweep/VydMvq5aw?topic=1

Pattern

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=28

Area

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=20

Mass Properties

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=23

Basic modify

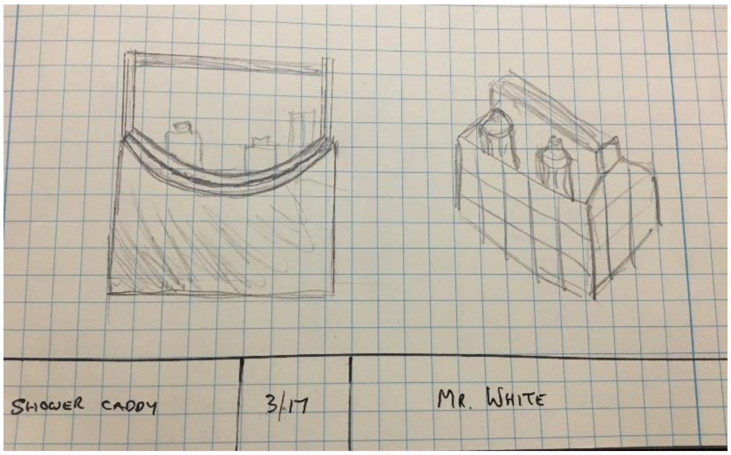
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-01-fundamentals-of-3-d-modelling/E1NPKx5pP?topic=3

Design Intent

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-09-bullseye/4ySXy7qTD?topic=0

Working Drawings

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=26
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-quick-start/Ey8QWFP7d/chapters/solid-edge-quick-start/Nk1aTuvXd?topic=7



Project: Shower Caddy Rendering

Introduction:

There are many instances where several people must share a bathroom. In this situation it would be convenient, for the people affected, if common toiletries could be stored and transported quickly and safely.

Purpose of the Project:

The purpose of this project is to have students use the design process and brainstorm, sketch, model, and present a practical shower caddy to hold a number of items that will be safe, lightweight, and water resistant. The students will model the caddy using the Solid Edge software and prepare a rendering to be used during presentations.

The project introduces students to the rendering engine available with the Solid Edge software. Students will become familiar with the various functions available to them in the creation of photo-realistic renderings. The ability to create renderings is a valuable addition to students' presentations. This project allows student teams to become freelance product designers. Each student team will discuss, brainstorm, plan, and design a shower caddy. Teams will create a photo-realistic rendering to be used in a marketing effort aimed at gaining approval of the general public for the design.

Concepts:

- Renderings are images with color, texture, and shading added.to create a proposed final appearance.
- Many rendered drawings are used to emphasize certain characteristics of a model.
- Presentations are used to display a topic or an idea to an audience.
- The design process is a series of steps that engineers use to come up with solutions to problems.

Outline:

- Documentation
  - Engineering Notebook
  - Documentation object to be designed
- Modeling
  - Creation of 3D models
  - Creation of presentation/rendering/working drawings
- Communication
  - Presentation of rendered designs

Standards:

Career and Technical Standards

Engineering Design Process

- Create and maintain an Engineering Notebook for daily reflections, research and prototype creation documentation.
- Apply the design and problem solving process as an iterative process incorporating sciences, mathematics and engineering to optimally convert resources to meet a stated objective.
- Communicate solutions utilizing technical writing skills including correct spelling, proper grammar and dependent vocabulary.

Sketching

- Apply isometric and orthographic sketches to add clarity to design.
- Create necessary sketches to communicate basic ideas during the design process.

3D Solid Modeling

- Apply geometric relationships between lines and shapes to create a mathematical database to describe design ideas
- Create solid models utilizing concepts of Parametric Modeling
- Analyze models for appropriate engineering design features needed
- Access, generate, process, and transfer information using appropriate technologies.
- Design and create a model using additive manufacturing technology sometimes called a rapid prototyping system.

Renderings/Working Drawings/ Design Presentations

- Create renderings to communicate design ideas and engineering principles to the general public.
- Generate an image from a model utilizing light, texture and shading to create a proposed final appearance of a product.
- Apply rendering techniques to create presentations of design for a non-technical audience.

College and Career Readiness Math Standards

Modeling with Geometry G-MG

Apply geometric concepts in modeling situations

1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).
2. Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot).
3. Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).

Create equations that describe numbers or relationships CED

A.4. Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.

Reading Standards for Literacy in History/Social Studies 9-10

Key Ideas and Details

1. Cite specific textual evidence to support analysis of primary and secondary sources, attending to such features as the date and origin of the information.

3. Analyze in detail a series of events described in a text; determine whether earlier events caused later ones or simply preceded them.

Integration of Knowledge and Ideas

7. Integrate quantitative or technical analysis (e.g., charts, research data) with qualitative analysis in print or digital text.

9. Compare and contrast treatments of the same topic in several primary and secondary sources.

Range of Reading and Level of Text Complexity

10. By the end of grade 10, read and comprehend science/technical texts in the grades 9–10 text complexity band independently and proficiently.

Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 9-10

Text Types and Purposes

1. Write arguments focused on *discipline-specific content.*
2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

Production and Distribution of Writing

4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Research to Build and Present Knowledge

7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.

Range of Writing

10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Next Generation Science Standards

The projects engage students in the scientific and engineering practices taken from the National Research Council's Framework for K-12 Science Education, Practices, Crosscutting Concepts, and Core Ideas. This is the document upon which the NGSS are based.

These practices are used for two reasons: 1) they parallel the design process utilized in each project, and 2) they serve as the foundation of the NGSS.

The eight science and engineering practices are:

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Standards for Technological Literacy

Standard 7

Students will develop an understanding of the influence of technology on history.

Standard 8
Students will develop an understanding of the attributes of design.

Standard 9
Students will develop an understanding of engineering design.

Standard 10
Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Standard 11
Students will develop the abilities to apply the design process.

Standard 12
Students will develop the abilities to use and maintain technological products and systems.

Standard 13
Students will develop the abilities to assess the impact of products and systems.

Standard 17
Students will develop an understanding of and be able to select and use information and communication technologies.

Standard 19
Students will develop an understanding of and be able to select and use manufacturing technologies.

Assessment:

Assessment is both formative and summative. It is an integral part of quality instruction. During the course of each project, one of the teacher's main functions is to work with student groups, keeping track of progress and providing formative assessment in the form of feedback and promoting reflection on the part of students. The focus should be on promoting lifetime learning and 21st century skills. The goal of instruction is to promote abilities in research, problem solving, designing, experimenting, testing, collecting and analyzing data.

Rubrics are used in the assessment process to communicate expectations of quality. Rubrics should be shared with students at the beginning of a project to clarify any misconceptions before beginning their work. Students can then build the skills and gather knowledge to solve the problem presented to the expectations of excellence described.

General Rubrics for Literacy tasks:
Argumentative_Pursuasive
Informational_Explanatory

Individual Project Rubric:
Shower Caddy Rendering Project Rubric

Essential Question:
How can we design and communicate a design to safely store and efficiently move certain bathroom necessities from one room to another?

Student Scenario
In certain living situations, several people must share a bathroom. An example of this can be found in a college dormitory setting.

You are a designer that works for a home goods retail store and are given the task of designing a bathroom caddy to carry certain objects to and from a shared bathroom. Practical users would be large families, college students, travelers, and anyone with a shared bathroom space.

The research and learning activities are designed to help students:
- Create photorealistic renderings to present a product
- Use mathematical formulas to aid in the design of a product
- Utilize specific software features to present renderings and animations of their idea.
- Communicate their solution to their peers.

Deliverables include:
- Engineering Notebook
- CAD model
- 3D printed model
- Outline of an Engineering Report that includes 3D images and working drawing
- Presentation of the development process

Daily Plan:
Day 1
Key Question: What are the expectations of the project?

Introduce students to the project by providing them with the Essential Question and the scenario.

Review and discuss with your students the design process, Engineering Notebook and design documentation requirements. Discuss the problem statement, design brief, testing protocol and management plan. Review the elements of a good engineering report with the students. These were all covered in the first project titled *Introduction to the Engineering Design Process* but should be reinforced on a regular basis. All projects depend on the design process and student activities should relate directly.

Have the students form teams of two. Allow the students five minutes to discuss the problem. Students begin by brainstorming ideas in their Engineering Notebooks. The teacher will provide a list of vocabulary terms that students will need to research on their own. The teams can divide the list of terms among team members and share their definitions. All team members are responsible to know all definitions.

Day 2-4
Key Question: How do we get started in the design process?

The teacher should review the following:

- teams will be responsible for researching the characteristics of the shower caddy,
- teams will research the requirements of the components they wish to store in the shower caddy, standard bottle sizes, items typically needed for showering,
- teams will interview the "potential customers" to establish the desired characteristics, and
- ideas will be documented by sketching in the Engineering Notebook.

NOTE: The teacher will decide how the "client" and the client's needs for the project are to be represented.

The teacher reminds students about the help system to find out how the software accomplishes basic features they might want to incorporate.
https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index

Students can enter specific terms to view a tutorial for creating certain features. Students can reference specific terms from the vocabulary list for specific commands to be used in the design of the shower caddy. Students can reference Basic 3D Commands and Creating Drawing Views for specific commands to use in the shower caddy design.

The teacher will provide access to the following video tutorials that will provide students with information about basic coloring of parts, rendering, applying materials and colors. They can also access Siemens Solid Edge Video Resources for further information on the topics.

Solid Edge Video Renderings

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-quick-start/Ey8QWFP7d/chapters/solid-edge-quick-start/Nk1aTuvXd?topic=10

Adding Color to Models

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-01-fundamentals-of-3-d-modelling/E1NPKx5pP?topic=7

Saving Images

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-03-user-interface/4kozzZqTv?topic=5

Creating Movies

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=3

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=7

Keyshot Tutorial

- https://www.keyshot.com/resources/learning/tutorials/

Day 5-6
Key Question: How do we get started on our individual designs?

Point students to the Rendering with Key Shot activity.

Student teams finish creating their isometric sketches and create a design brief to include with their sketch. They then present their design to a focus group. The focus group will provide feedback on the design proposal before they begin solid modeling using Solid Edge. Once the students have verified their sketches and have permission from the teacher, they can begin solid modeling using Solid Edge to convey their ideas. Students can reference Basic 3D Commands and Creating Drawing Views for specific software commands to be used in the shower caddy design. NOTE: The teacher will decide how the “focus group” for the project is to be represented.

Day 7-8
Key Question: How can we model efficiently?

Teams discuss their shower caddy design and how to achieve the desired look given the approved sketch. Students work together to design the shower caddy and create the 3D solid model of the caddy and other items for the presentation. They utilize the division of work in the creation of their project management plan. Certain features can be eliminated from complex designs if pace becomes a problem. Students can review tutorials as necessary.

Day 9
Key Question: Are we on track with our designs?

The teacher should review any known or perceived problems with the shower caddy designs. The class should also be reminded of the pace of part creation and the requirements necessitated by the design. Students could design some solid models to use in their designs (shampoo bottles, soap, razor, etc.)

Students will continue to model using the software and using tutorials as necessary.

Day 10-11
Key Question: How can we put our new designs together?

The teacher should review the design process with the class and check with teams to see where they are in the design process along with any known or perceived problems with kitchen tool designs.

Students will finish modeling using the Solid Edge and using tutorials as necessary. Once the individual parts are created, the students should assemble the bathroom items into their caddy and verify in the software that the parts fit and work correctly. If time allows, the caddy can be customized to fit a personality. Students should create a rendering of the components in their caddy.

Day 12
Key Question: How does one plan and deliver a presentation to the class?

The teacher will discuss with the students how to optimally present their ideas to the class. Students should also be prepared to justify any design enhancements incorporated into the kitchen tool. Students will continue to refine the model using the Solid Edge. Students will use the 3D printer to prepare samples of the shower caddy. Groups finalize their designs.

Students discuss the items needed in their presentation to their clients. The team decides on the types of graphics to include. Students should prepare an Engineering Report about the process of designing the shower caddy. They should be required to write the introduction, provide results including graphics, and a conclusion including an acknowledgement section reporting the source of the information. The rest of the report can be in outline format

Day 13
Key Question: How do we convey our ideas?

Students can present their solutions to the class one at a time. In the end, all students can reflect on their work by giving and receiving feedback on how they could possibly improve their designs.

Vocabulary:

Caddy
Color
Hue
Image Synthesis
Lighting
Material
Pattern
Photo-realistic
Pixel
Ray tracing
Reflection
Refraction
Rendered image
Resolution
Saturation
Shade
Surface
Texture
Thin Wall
Tote
Wavelengths
Web

Resources:

CAD Tutorials

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012412/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012413/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012414/index.html
  https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012415/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012416/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012417/index.html

Assembly Tutorials

- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012454/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012455/index.html

- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012460/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012451/index.html

Engineering Reports

- http://web.mit.edu/me-ugoffice/communication/technical-writing.pdf
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/writing_engineering_reports.html
- https://www.youtube.com/playlist?list=PLDAAF7A8FD5CD582C&feature=plcp
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/mechanical_engineering_writing_enhancement_program/report_writing.html
- https://owl.purdue.edu/owl/subject_specific_writing/professional_technical_writing/technical_reports_and_report_abstracts/reports_proposals_and_technical_papers.html

Rendering Example Video

- https://www.khanacademy.org/partner-content/pixar/rendering/rendering1/v/overview-rendering
- https://www.keyshot.com/resources/learning/tutorials/
- https://www.youtube.com/watch?v=siHzOVvAIW0
- https://www.youtube.com/watch?v=WNrtRc10GXA
- https://www.youtube.com/watch?v=JXe5CK6lPaY&feature=youtu.be&hd=1&fs=1&autoplay=1&rel=0
- https://www.keyshot.com/resources/learning/tutorials
- https://www.youtube.com/watch?v=NLBNfYx5ze0
- https://www.youtube.com/watch?v=1oVREdyD40g

Shower Caddy Examples

- https://www.bedbathandbeyond.com/store/product/2-in-1-interlocking-shower-tote
- http://www.target.com/p/plastic-shower-caddy-earth-gray-room-essentials
- https://www.amazon.com/Hanging-Toiletry-Organizer-Storage-Compartments

Items that Could Be Included in the Caddy

- https://www.bustle.com/articles/104534-15-shower-caddy-essentials-you-absolutely-need-for-your-dorm-room
- http://www.popsugar.com/beauty/What-Do-I-Need-My-Shower-Caddy-35436012

Solid Edge Instructional Videos

Renderings

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-quick-start/Ey8QWFP7d/chapters/solid-edge-quick-start/Nk1aTuvXd?topic=10

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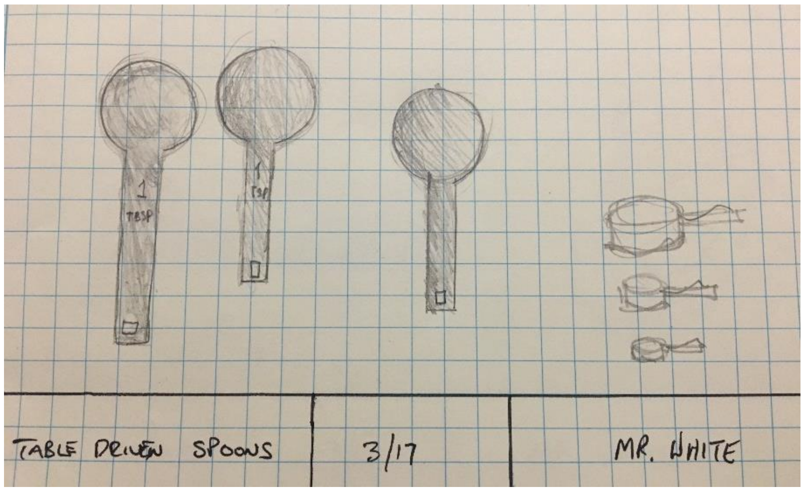
Ingenuity for life



Project: Table Driven Kitchen Measuring Instruments

Introduction:

Designers will often create a complete set of a particular product. Each set item looks very similar but each varies in scale. Some examples are a mechanics sockets set, dumbbells of different weights, drill bits of different sizes, or measuring cups or spoons holding different volumes. Each example shares common characteristics which may include color, texture, and ratio of their sizes. When a product set has multiple items with only scale being different, manufacturers can utilize a table of dimensions to control model sizes. An example of this can be found in product catalogs where a letter gives a dimension and the customer can look up the dimension for the letter to select the desired product size. In 3D modeling, this allows us to save design time.

Purpose of the Project:

The purpose of this project is to introduce the concept of designing with formulas. The solid model of the part is created where all measurements are linked to a table. This allows a designer to select a row from an Excel table automatically resizing the part. When one or more dimensions are changed, the outcome is a very similar part just slightly larger or smaller in size in almost no time at all!

Concepts:

- Apply geometric relationships between lines and shapes to create a mathematical database describing design ideas.

- Table driven functionality allows the creation of similar parts with variations very quickly.
- Parametric modeling uses many concepts such as geometric and dimensional constraints to define a part.
- The volume of a cylinder depends on relationship of radius and height in calculations.
- The mathematical database that describes a 3D model. The original parameters may be modified at any time. The result is an updated model with the latest dimensions.
- Working drawings contain enough views, dimensions, and notes to fully describe the part.

Outline:

Documentation
  - Engineering Notebook
  - Documentation object to be designed

Modeling
  - Creation of 3D model
  - Creation of table to enter data
  - Design renderings and working drawings
  - 3D print of design

Communication
  - Presentation of design solutions

Standards:

Career and Technical Standards

Engineering Design Process

- Create and maintain an Engineering Notebook for daily reflections, research and prototype creation documentation.
- Apply the design and problem solving process as an iterative process incorporating sciences, mathematics and engineering to optimally convert resources to meet a stated objective.
- Communicate solutions utilizing technical writing skills including correct spelling, proper grammar and dependent vocabulary.
- Assume and carry out a role in the smooth running of a team working toward the solution of a problem.

Sketching

- Create sketches utilizing basic shapes such as lines circles and ellipses.
- Communicate ideas to a group through the use of sketches and other documentation.
- Apply isometric and orthographic sketches to add clarity to design.
- Create necessary sketches to communicate basic ideas during the design process.

3D Solid Modeling/Fabrication and 3-D Printing

- Apply geometric relationships between lines and shapes to create a mathematical database to describe design ideas.
- Create solid models utilizing concepts of Parametric Modeling.
- Analyze models for appropriate engineering design features needed.
- Develop strategies for the creation of solid models for the rapid creation of design solutions.
- Apply the concepts of digital prototyping to accelerate the time frame between ideation and completed project.

Renderings/Working Drawings/ Design Presentations

- Create renderings to communicate design ideas and engineering principles to the general public.
- Generate an image from a model utilizing light, texture and shading to create a proposed final appearance of a product.
- Apply rendering techniques to create presentations of design for a non-technical audience.

College and Career Readiness Math Standards

Creating Equations A -CED

- Create equations that describe numbers or relationships

Reasoning with Equations and Inequalities A-REI

- Interpret the structure of expressions
- Write expressions in equivalent forms to solve problems

Modeling with Geometry G-MG

Apply geometric concepts in modeling situations

- Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).
- Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot).
- Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).

Create equations that describe numbers or relationships CED

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Text Types and Purposes

1. Write arguments focused on *discipline-specific content.*
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7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

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2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Standards for Technological Literacy

Standard 1
Students will develop an understanding of the characteristics and scope of technology.

Standard 2
Students will develop an understanding of the core concepts of technology.

Standard 3
Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Standard 7
Students will develop an understanding of the influence of technology on history.

Standard 8
Students will develop an understanding of the attributes of design.

Standard 9
Students will develop an understanding of engineering design.

Standard 10
Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Standard 11
Students will develop the abilities to apply the design process.

Standard 12
Students will develop the abilities to use and maintain technological products and systems.

Standard 13
Students will develop the abilities to assess the impact of products and systems.

Standard 17
Students will develop an understanding of and be able to select and use information and communication technologies.

Standard 19
Students will develop an understanding of and be able to select and use manufacturing technologies.

Standard 20
Students will develop an understanding of and be able to select and use construction technologies.

Assessment:

Assessment is both formative and summative. It is an integral part of quality instruction. During the course of each project, one of the teacher's main functions is to work with student groups, keeping track of progress and providing formative assessment in the form of feedback and promoting reflection on the part of students. The focus should be on promoting lifetime learning and 21st century skills. The goal of instruction is to promote abilities in research, problem solving, designing, experimenting, testing, collecting and analyzing data.

Rubrics are used in the assessment process to communicate expectations of quality. Rubrics should be shared with students at the beginning of a project to clarify any misconceptions before beginning their work. Students can then build the skills and gather knowledge to solve the problem presented to the expectations of excellence described.

General Rubrics for Literacy tasks:
Argumentative_Pursuasive
Informational_Explanatory

Individual Project Rubric:
Table Driven Kitchen Measuring Instruments Project Rubric

Essential Question:
How do we create a set of measuring instruments that look similar but hold different specified amounts?

Student Scenario:
Many items we purchase come in a set and often they are the same shape but only larger or smaller in scale. Your client, a kitchen supply company, is asking your team to design a set of measuring implements for household and commercial kitchen settings. This will require designing the implements using tables. Doing this will permit the required variations in the set of implements and to assure they can nest one inside the other. You will develop the necessary table and tie the table to the variable table in Solid Edge to allow quick manipulation of the model. You will need to calculate the volume for each size so the table will create the 3D model correctly.

The research and learning activities are designed to help students:
- Discover the uses of table driven parts
- Use mathematical formulas to aid in the design of a product
- Design an Excel spreadsheet to control a series of parts
- Utilize specific software features to create a solid model of their idea
- Communicate their solution to their peers

Deliverables include:
- Engineering Notebook
- CAD model
- 3D printed model
- Excel spreadsheet
- Engineering Report that includes 3D images and working and assembly drawings
- Presentation of the development process

Daily Plan:
Day 1
Key Question: What are the expectations of the project?

Introduce students to the project by providing them with the Essential Question and the scenario.

Review and discuss with your students the design process, Engineering Notebook and design documentation requirements. Discuss the problem statement, design brief, testing protocol and management plan. Review the elements of a good engineering report with the students. These were all covered in the first project titled *Introduction to the Engineering Design Process* but should be reinforced on a regular basis. All projects depend on the design process and student activities should relate directly.

Have the students form teams of two. Allow the students five minutes to discuss the problem. Students begin by brainstorming ideas in their Engineering Notebooks. The teacher will provide a list of vocabulary terms that students will need to research on their own. The teams can divide the list of terms among team members and share their definitions. All team members are responsible to know all definitions.

Day 2-4
Key Question: How do we get started with the design process?

The teacher should review the following:

- teams will be responsible for researching the characteristics and specifications of the set of measuring implements
- teams will research the requirements of a measuring implements so they are easy to use and contain the proper amount,
- teams will interview the “client” to establish the desired characteristics, and
- students will prepare sketches and enter them in their Engineering Notebook.

NOTE: The teacher will decide how the “client” and the client’s needs for the project are to be represented.

The teacher reminds students about the help system to find out how the software accomplishes basic features they might want to incorporate.
https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index
Students can enter specific terms to view a tutorial for creating certain features. Students can reference specific terms from the vocabulary list for specific commands to be used in the design of the measuring instruments. Other tutorials in the Resources section are available for use if students struggle.

Student teams discuss the specifications of the creation of the measuring set. Students list the criteria and constraints of the problem they are solving. Teams research the existing kitchen measuring implements and discover information about ergonomics. The teams will use formulas as needed related to the shape of the implements. Students should be refining their sketches in the Engineering Notebook.

Teams should discuss how the implements will nest.

Remind students to record research notes and sources as well as reflections on the day in the Engineering Notebook.

The teacher will provide access to the following video tutorials that will provide students with information about area and mass properties.

Area

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-11-area/VkAAEQ9Tw?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-11-area/VkAAEQ9Tw?topic=1

Mass Properties

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=23
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-18-practice/E1CNFc96w?topic=4

Using Variables in Part Models Tutorial

- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/seppcvt/index.html

Day 5-7
Key Question: How do we get started on our individual designs?

The teacher directs the students to the tutorial Dimensioning with Equations and Variables. Students plan how they will reuse the drawing by changing the dimensions. Student teams finish creating their isometric sketches and create a design brief to include with their sketch. They then meet with the client. The client will need to sign off on the design proposal before they begin solid modeling. Once the design has been verified and permission given by the client, students can begin solid modeling with Solid Edge to convey their ideas. Students can reference Basic 3D Commands and Creating Drawing Views for specific commands to use in the design of their measuring implements. NOTE: The teacher will decide how the "client" and the client's needs for the project are to be represented.

Day 8-9
Key Question: How can we begin to make our nesting implements?

Teams discuss their implements and how to achieve the design given the approved sketch they presented. They work together to design the implements and divide the work of creating the 3D solid model of the pieces they are responsible for. They utilize the division of work in the creation of their project management plan.

Teams are reminded to continually check their solid models for accuracy with team mates to assure the correct sizes are created.

Students record sketches and reflections in the Engineering Notebook. The students should start by making just one measuring spoon in the set. (The largest or smallest one in the set would be preferential) Students can review tutorials as necessary and prepare an Excel spreadsheet to drive the remaining elements in the set.

Day 10-12
Key Question: What is the most efficient way to create the set of implements?

The teacher should review the design process with the class and check with teams to see where they are in the design process along with any known or perceived problems with the measuring implements. Student teams create the basic design and calculate the various values necessary for the Excel table.

Day 13
Key Question: How does one plan and deliver a presentation to the class?

The teacher will discuss with the students how to optimally present their ideas to the class. Students should also be prepared to justify any design enhancements they incorporated into the measuring implements. Students will continue to model using Solid Edge. Students print samples of the implements. Groups finalize their designs.

Students discuss the items needed in their presentation to their clients. The team decides on the types of graphics to include. Students should prepare an Engineering Report about the process of designing the kitchen tool. They should be required to write the introduction, provide results including graphics, and a conclusion including the acknowledgement section reporting the source of information. The rest of the report can be in outline format.

Day 14
Key Question: How do we convey our ideas?

Students can present their solutions to the class one at a time. In the end, all students can reflect on their work by giving and receiving feedback on how they could possibly improve their designs.

Vocabulary:

Dimension
Excel
Formulas
Nest
Parametric modeling

Proportion
Scale
Shell
Table
Uniform
Variables
Volume
Working drawing

Resources:

Examples of Sets

- http://www.sears.com/home-kitchen-bakeware-measuring-cups-spoons/b-1348744864
- http://www.independentliving.com/prodinfo.asp?number=182387
- https://www.aliexpress.com/cheap/cheap-kitchen-measure.html
- http://www.houzz.com/photos/traditional/measuring-cups/features_measuring_cup--Set

Common Sizes Found in Sets

- http://www.cooksinfo.com/measuring-spoons

CAD Tutorials

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012412/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012413/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012414/index.html
https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012415/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012416/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012417/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012430/index.html

Assembly Tutorials

- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012454/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012455/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012460/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012451/index.html

Formulas in Solid Edge

- https://www.youtube.com/watch?v=HU78K7FCo9I
- https://grabcad.com/tutorials/tutorial-how-to-drive-a-solid-edge-model-from-excel

Engineering Reports

- http://web.mit.edu/me-ugoffice/communication/technical-writing.pdf
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/writing_engineering_reports.html
- https://www.youtube.com/playlist?list=PLDAAF7A8FD5CD582C&feature=plcp
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/mechanical_engineering_writing_enhancement_program/report_writing.html
- https://owl.purdue.edu/owl/subject_specific_writing/professional_technical_writing/technical_reports_and_report_abstracts/reports_proposals_and_technical_papers.html

Solid Edge Instructional Videos

Copy and Rotate

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=27

Polygons

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/introduction-to-solid-edge-2-d-geometry/414vCOk6P/chapters/chapter-01-constraints-and-relationships/VkJ3kKy6w?topic=17

Pattern

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=28

Area

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-11-area/VkAAEQ9Tw?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-11-area/VkAAEQ9Tw?topic=1

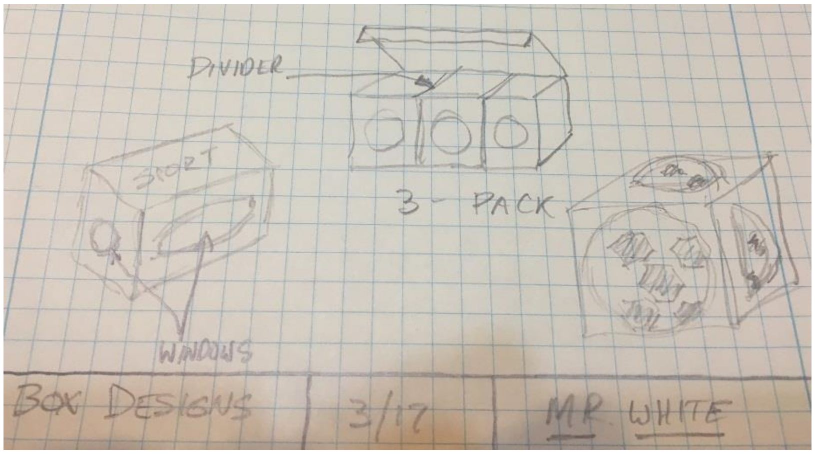
Mass Properties

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=23

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-18-practice/E1CNFc96w?topic=4

Working Drawings

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=26
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-quick-start/Ey8QWFP7d/chapters/solid-edge-quick-start/Nk1aTuvXd?topic=7



Project: Package Design

Introduction:
Consumers often buy a product because of a certain style, appearance, or name. Packaging designers often design packages to appeal to these characteristics which can be an integral factor in a successful new product launch. Many times, the package can be the most important factor in a customer's purchase decision.

Purpose of the Project:
The purpose of this project is to introduce students to packaging design and product advertising. The intent of this project is to provide product protection and advertising through package design. Students will use Solid Edge to develop the package.

This project introduces students to 3D modeling concepts. The project will utilize many different features found in Solid Edge. Students will become familiar with a variety of commands as well as the workflow of the CAD program. Throughout this course students will frequently utilize many of the techniques developed in this lesson.

This project allows students to act as designers. Each group will interview a "client" and design a package to meet the client's needs. Students will interview the client and develop a design brief. Student groups will create sketches for the client and design the package after they receive approval from the teacher. NOTE: The teacher will decide how the “client” and the client’s needs for the project are to be represented.

Concepts:

- Design is an iterative process requiring many methods to create and document ideas.
- The design process is a common tool used to gather ideas, refine them and then communicate them.
- Create a solid model using the concepts of parametric modeling.
- Analyze models for appropriate engineering design features.

Outline:

- Documentation
    - Engineering Notebook
    - Documentation of general packaging designs
    - Documentation of sporting goods packaging designs
- Modeling
    - Creation of 3D model
    - Print and construction of 3D model
- Communication
    - Display of design

Standards:

Career and Technical Standards

Engineering Design Process

- Create and maintain an Engineering Notebook for daily reflections, research and prototype creation documentation.
- Apply the design and problem solving process as an iterative process incorporating sciences, mathematics and engineering to optimally convert resources to meet a stated objective.
- Communicate solutions utilizing technical writing skills including correct spelling, proper grammar and dependent vocabulary.

Sketching

- Apply isometric and orthographic sketches to add clarity to design.
- Create necessary sketches to communicate basic ideas during the design process.

3D Solid Modeling

- Apply geometric relationships between lines and shapes to create a mathematical database to describe design ideas
- Create solid models utilizing concepts of Parametric Modeling
- Analyze models for appropriate engineering design features

College and Career Readiness Math Standards

Modeling with Geometry G-MG

Apply geometric concepts in modeling situations

1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).
2. Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot).
3. Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).

Create equations that describe numbers or relationships CED

A.4. Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.

Reading Standards for Literacy in History/Social Studies 9-10

Key Ideas and Details

1. Cite specific textual evidence to support analysis of primary and secondary sources, attending to such features as the date and origin of the information.

3. Analyze in detail a series of events described in a text; determine whether earlier events caused later ones or simply preceded them.

Integration of Knowledge and Ideas

7. Integrate quantitative or technical analysis (e.g., charts, research data) with qualitative analysis in print or digital text.

9. Compare and contrast treatments of the same topic in several primary and secondary sources.

Range of Reading and Level of Text Complexity

10. By the end of grade 10, read and comprehend science/technical texts in the grades 9–10 text complexity band independently and proficiently.

Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 9-10

Text Types and Purposes

1. Write arguments focused on *discipline-specific content.*
2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

Production and Distribution of Writing

4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Research to Build and Present Knowledge

7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow

or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.

Range of Writing

10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Next Generation Science Standards

The projects engage students in the scientific and engineering practices taken from the National Research Council's Framework for K-12 Science Education, Practices, Crosscutting Concepts, and Core Ideas. This is the document upon which the NGSS are based.

These practices are used for two reasons: 1) they parallel the design process utilized in each project, and 2) they serve as the foundation of the NGSS.

The eight science and engineering practices are:

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Standards for Technological Literacy

Standard 1

Students will develop an understanding of the characteristics and scope of technology.

Standard 2

Students will develop an understanding of the core concepts of technology.

Standard 4

Students will develop an understanding of the cultural, social, economic, and political effects of technology.

Standard 6
Students will develop an understanding of the role of society in the development and use of technology.

Standard 7
Students will develop an understanding of the influence of technology on history.

Standard 8
Students will develop an understanding of the attributes of design.

Standard 9
Students will develop an understanding of engineering design.

Standard 10
Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Standard 11
Students will develop the abilities to apply the design process.

Standard 12
Students will develop the abilities to use and maintain technological products and systems.

Standard 13
Students will develop the abilities to assess the impact of products and systems.

Standard 17
Students will develop an understanding of and be able to select and use information and communication technologies.

Standard 19
Students will develop an understanding of and be able to select and use manufacturing technologies.

Standard 20
Students will develop an understanding of and be able to select and use construction technologies.

Assessment:

Assessment is both formative and summative. It is an integral part of quality instruction. During the course of each project, one of the teacher's main functions is to work with student groups, keeping track of progress and providing formative assessment in the form of feedback and promoting reflection on the part of students. The focus should be on promoting lifetime learning and 21st century skills. The goal of instruction is to

promote abilities in research, problem solving, designing, experimenting, testing, collecting and analyzing data.

Rubrics are used in the assessment process to communicate expectations of quality. Rubrics should be shared with students at the beginning of a project to clarify any misconceptions before beginning their work. Students can then build the skills and gather knowledge to solve the problem presented to the expectations of excellence described.

General Rubrics for Literacy tasks:
Argumentative_Pursuasive
Informational_Explanatory

Individual Project Rubric:
Package Design Project Rubric

Essential Question:

How can we safely secure and display new sporting goods for consumers to review and purchase?

Student Scenario:

You are a packaging engineer and are given the task of designing a folding package that will hold and advertise new sporting goods balls to be sold on store shelves. Because consumers prefer to see and feel the product that they may purchase, the design must be mindful of this fact.

You will interview your client to discover their needs. You will create a design brief to share with your client to get their approval before beginning work on the final design. After conducting research on packaging styles and sizes, you will create a design that meets the desired requirements. You will create the solid model and verify its characteristics by printing and building a prototype. You will also be responsible for giving a short presentation about your packaging design, highlighting your favorite characteristics.

The research and learning activities are designed to help students:

- Create sketches to communicate to a group
- Use mathematical formulas to aid in the design of a product
- Utilize specific software features to create a flat pattern model of their idea
- Communicate their solution to their peers

Deliverables include:

- Engineering Notebook
- CAD model
- 3D printed model
- Outline of an Engineering Report that includes 3D images and flat pattern
- Presentation of the development process

Daily Plan:

Day 1

Key Question: What are the expectations of the project?

Introduce students to the project by providing them with the Essential Question and the scenario.

Review and discuss with your students the design process, Engineering Notebook and design documentation requirements. Discuss the problem statement, design brief, testing protocol and management plan. Review the elements of a good engineering report with the students. These were all covered in the first project titled *Introduction to the Engineering Design Process* but should be reinforced on a regular basis. All projects depend on the design process and student activities should relate directly.

Have the students form teams of two. Allow the students five minutes to discuss the problem. Students begin by brainstorming ideas in their Engineering Notebooks. The teacher will provide a list of vocabulary terms that students will need to research on their own. The teams can divide the list of terms among team members and share their definitions. All team members are responsible to know all definitions.

Day 2-4

Key Question: How do we get started with the design process?

The teacher should explain that the teams will be responsible for researching the characteristics and specifications of the package design. The client should specify a certain sporting good ball that could be contained within the package design. (football, tennis, soccer, golf, etc.…)

The students should pick a type, research sizes of the ball, and choose a package design that will hold the ball stable while advertising it to consumers. Student teams should spend some time interviewing the client to establish desired characteristics. Students begin sketching in the Engineering Notebook. NOTE: The teacher will decide how the “client” and the client’s needs for the project are to be represented.

The teacher reminds students about the help system to find out how the software accomplishes basic features they might want to incorporate.
https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index
Students can enter specific terms to view a tutorial for creating certain features. Students can reference specific terms from the vocabulary list for specific commands to be used in the design of the package.

Student teams discuss the specifications of the package. Students list the criteria and constraints of the problem they are solving. Teams research the ball that was selected to discover the size and volume the ball will require. The teams will use formulas as needed related to the shape and size of the ball to determine the shape and size of the package. Students should be refining their sketches in the Engineering Notebook.

Remind students to record research notes and sources as well as reflections on the day in the Engineering Notebook.

The teacher will provide access to the following video tutorials that will provide students with information about the basics of sheet metal design. They can also access Siemens Solid Edge Video Resources for further information on the topics.

Sheet Metal Tutorial

- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/stssash/index.html

Adding Color to Models

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-01-fundamentals-of-3-d-modelling/E1NPKx5pP?topic=7

Crosshatch and Color

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=16

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=11

Day 5-6
Key Question: How do we get started with the design?

Student teams finish creating their isometric sketches and create a design brief to include with their sketch. They then meet with the client who will need to sign off on the design proposal before they begin solid modeling using Solid Edge. Once the students have verified the sketches and have permission from their client, they can begin solid modeling using Solid Edge to convey their ideas. Students can reference the Drawing Nets for ideas about how shapes can be folded to create a package design. If the students are advanced they can consider using techniques displayed in the Tennis Ball Container.

Day 7-8
Key Question: What can be done to enhance the design?

Teams discuss their package and how to achieve the design given the approved sketch they presented. Students work together to design the package and create the 3D solid model. They utilize the division of work in the creation of their project management plan.

Teams are reminded to continually check their solid models for accuracy with team members to ensure the correctness in details.

Students can review tutorials as necessary. Students record sketches and reflections in the Engineering Notebook. Once the students feel they have a package solution that meets the requirements, they should consider practical enhancements. Their package design could incorporate features like product security, strapping, and the ability to stack.

Day 9
Key Question: Are we on track with our designs?

The teacher should review the design process with the class and check with teams to see where they are in the design process along with any known or perceived problems with the package designs so far.

Students will finish modeling using the Solid Edge and using tutorials as necessary.

Day 10
Key Question: How can designs be prepared to look professional for presentation?

The teacher should facilitate preparing the students to arrange their designs into the final stages. Once the design is finished and the flat pattern created, groups should print their design and fold it to create the 3D package. Teams should consider practical enhancements. Their container design could incorporate features like colorful graphics, endorsements, specific themes, and the ability to stack or nest.

Day 11
Key Question: How does one plan and deliver a good presentation to the class?

Students discuss the types of things to put in their presentation to their clients. They decide on the types of graphics to include. Students should prepare an engineering report about the process of designing the set. They should be required to write the introduction, provide results including graphics, a conclusion, and include the acknowledgement sections, reporting the source of their information. The rest can be in outline format. Students can print, cut out, and assemble their package designs. Students should also be prepared to apply any design enhancements decided by the team.

Day 12
Key Question: How are ideas conveyed?

Students can present their solutions to the class one at a time. In the end, all students can reflect on their work by giving and receiving feedback on how they could possibly improve their designs.

Vocabulary:

Base Feature
Bend
Bend Radius
Bend Relief
Chamfer
Contour Flange
Corner
Cut
Cutouts
Divider
Emboss
Engrave
Flange
Flat Pattern
Fillet
Fold
Gage
Hem
Hole
Join
Loft
Material Tables
Nest
Plate
Tab/flange

Resources:

CAD Tutorials

- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/stssash/index.html
https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012412/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012413/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012414/index.html

- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012415/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012416/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012417/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012431/index.html

Assembly Tutorials

- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012454/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012455/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012460/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012451/index.html

Engineering Reports

- http://web.mit.edu/me-ugoffice/communication/technical-writing.pdf
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/writing_engineering_reports.html
- https://www.youtube.com/playlist?list=PLDAAF7A8FD5CD582C&feature=plcp
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/mechanical_engineering_writing_enhancement_program/report_writing.html
- https://owl.purdue.edu/owl/subject_specific_writing/professional_technical_writing/technical_reports_and_report_abstracts/reports_proposals_and_technical_papers.html

Package Ideas:

- http://www.peekpackaging.com/product-showcase-los-angeles-ca-san-diego-ca-phoenix-az/chipboard-boxes
- http://www.rpconline.com/Chipboard-Products_c_353.html
- http://www.customboxesnow.com/
- http://www.custommadeboxes.com/

Videos:

- https://www.youtube.com/watch?v=d-QGI1EKrlI
- https://www.youtube.com/watch?v=AWWCEdV4ciM

Solid Edge Instructional Videos

Adding Color to Models

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-01-fundamentals-of-3-d-modelling/E1NPKx5pP?topic=7

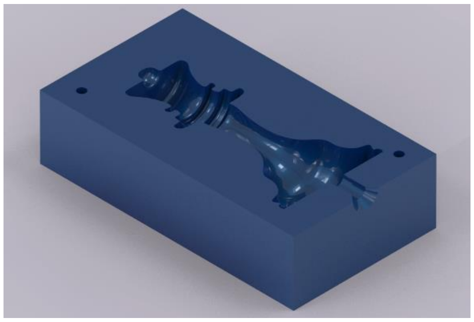
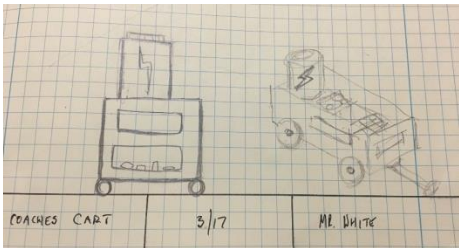
Crosshatch and Color

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=16
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=11

Sheet Metal Tutorial

- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/stssash/index.html

Projects Quarter 2

Assembly Modeling/Documentation/Exploded Assemblies/Bill of materials • 3D Puzzle	
Assembly Modeling/Documentation/Exploded Assemblies/Bill of materials • Mold Design	
Assembly Modeling/Documentation/Exploded Assemblies/Bill of materials Optional Project • Coaches Cart	
Reverse Engineering/Engineering Features/Precision Measurement • Reverse Engineering Project	

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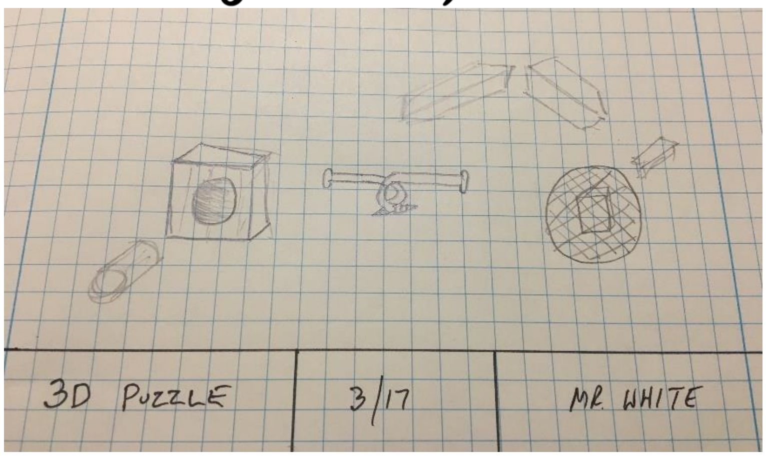

Project: 3D Puzzle

Introduction:

Puzzles are used as brain building exercises that develop problem solving skills. They help with hand eye coordination, both fine and gross motor skills, sharpening memory, and achieving goals. There are many types of puzzles created largely as entertainment for all age groups.

Purpose of the Project:

The purpose of the project is to introduce students to the concepts of assembly modeling and documentation of the assemblies including the bill of materials. By using knowledge of assembly relationship tools to organize the puzzle pieces, students will apply geometric concepts to create the look and organizational structure to multi-part products.

Student teams design and create a physical puzzle that can be used to entertain others. Teams will follow the design process, create individual puzzle parts, and assemble the puzzle in the software. Student teams will present exploded pictorial drawings, renderings, and 3D models.

Concepts:

- Design and create a model using rapid prototyping systems.
- Develop strategies for the creation of solid models for the rapid creation of design solutions.

- Generate an image from a model utilizing light, texture, and shading to create a proposed final appearance of a product.
- Create an exploded view drawing which shows the relationships of parts in an assembly.
- Develop an assembly file which represents components located in a design.

Outline:

Documentation
- Engineering notebook
- Documentation object to be designed

Modeling
- Creation of 3D model
- Creation of puzzle assembly
- Creation of exploded pictorials with bill of materials
- 3D print puzzle design

Communication
- Presentation of design solutions

Standards:

Career and Technical Standards

Engineering Design Process

- Create and maintain an Engineering Notebook for daily reflections, research and prototype creation documentation.
- Apply the design and problem solving process as an iterative process incorporating sciences, mathematics and engineering to optimally convert resources to meet a stated objective.
- Communicate solutions utilizing technical writing skills including correct spelling, proper grammar and dependent vocabulary.
- Assume and carry out a role in the smooth running of a team working toward the solution of a problem.
- Assemble a quantitative plan for successful completion of the project.
- Assume responsibility for leadership roles and responsibility for actions, decisions products and policies in the governance of a project.

Sketching

- Create sketches utilizing basic shapes such as lines circles and ellipses.
- Communicate ideas to a group through the use of sketches and other documentation.
- Apply isometric and orthographic sketches to add clarity to design.
- Create necessary sketches to communicate basic ideas during the design process.

3D Solid Modeling/Fabrication and 3-D Printing

- Apply geometric relationships between lines and shapes to create a mathematical database to describe design ideas.
- Create solid models utilizing concepts of Parametric Modeling.
- Analyze models for appropriate engineering design features needed.
- Develop strategies for the creation of solid models for the rapid creation of design solutions.
- Apply the concepts of digital prototyping to accelerate the time frame between ideation and completed project.
- Access, generate, process, and transfer information using appropriate technologies.
- Design and create a model using additive manufacturing technology sometimes called a rapid prototyping system.
- Apply new principles of more rapid and less costly development and deployment of new materials.

R***enderings/Working Drawings/ Design Presentations***

- Create renderings to communicate design ideas and engineering principles to the general public.
- Generate an image from a model utilizing light, texture and shading to create a proposed final appearance of a product.
- Apply rendering techniques to create presentations of design for a non-technical audience.

Assembly Modeling/Documentation/Exploded Assemblies/Bill of Materials

- Conduct model documentation as the process of recording details such as size, material composition, and instructions for assembling, installation and servicing, analysis, development process that describes a model for the purpose of communication of ideas.
- Create a bill of materials to communicate materials and other information about a design.

College and Career Readiness Math Standards

Modeling with Geometry G-MG

Apply geometric concepts in modeling situations

1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).
2. Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot).
3. Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).

Create equations that describe numbers or relationships CED

A.4. Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.

Reading Standards for Literacy in History/Social Studies 9-10

Key Ideas and Details

1. Cite specific textual evidence to support analysis of primary and secondary sources, attending to such features as the date and origin of the information.

3. Analyze in detail a series of events described in a text; determine whether earlier events caused later ones or simply preceded them.

Integration of Knowledge and Ideas

7. Integrate quantitative or technical analysis (e.g., charts, research data) with qualitative analysis in print or digital text.

9. Compare and contrast treatments of the same topic in several primary and secondary sources.

Range of Reading and Level of Text Complexity

10. By the end of grade 10, read and comprehend science/technical texts in the grades 9–10 text complexity band independently and proficiently.

Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 9-10

Text Types and Purposes

1. Write arguments focused on *discipline-specific content.*

2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

Production and Distribution of Writing

4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Research to Build and Present Knowledge

7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.

Range of Writing

10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Next Generation Science Standards

The projects engage students in the scientific and engineering practices taken from the National Research Council's Framework for K-12 Science Education, Practices, Crosscutting Concepts, and Core Ideas. This is the document upon which the NGSS are based.

These practices are used for two reasons: 1) they parallel the design process utilized in each project, and 2) they serve as the foundation of the NGSS.

The eight science and engineering practices are:

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Standards for Technological Literacy

Standard 1

Students will develop an understanding of the characteristics and scope of technology.

Standard 2

Students will develop an understanding of the core concepts of technology.

Standard 3

Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Standard 7

Students will develop an understanding of the influence of technology on history.

Standard 8

Students will develop an understanding of the attributes of design.

Standard 9

Students will develop an understanding of engineering design.

Standard 10
Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Standard 11
Students will develop the abilities to apply the design process.

Standard 12
Students will develop the abilities to use and maintain technological products and systems.

Standard 13
Students will develop the abilities to assess the impact of products and systems.

Standard 17
Students will develop an understanding of and be able to select and use information and communication technologies.

Standard 19
Students will develop an understanding of and be able to select and use manufacturing technologies.

Standard 20
Students will develop an understanding of and be able to select and use construction technologies.

Assessment:

Assessment is both formative and summative. It is an integral part of quality instruction. During the course of each project, one of the teacher's main functions is to work with student groups, keeping track of progress and providing formative assessment in the form of feedback and promoting reflection on the part of students. The focus should be on promoting lifetime learning and 21st century skills. The goal of instruction is to promote abilities in research, problem solving, designing, experimenting, testing, collecting and analyzing data.

Rubrics are used in the assessment process to communicate expectations of quality. Rubrics should be shared with students at the beginning of a project to clarify any misconceptions before beginning their work. Students can then build the skills and gather knowledge to solve the problem presented to the expectations of excellence described.

General Rubrics for Literacy tasks:
Argumentative_Pursuasive
Informational_Explanatory

Individual Project Rubric:
[3D Puzzle Project Rubric]

Essential Question:

How can we create a challenging 3D puzzle for a particular age group and appropriate difficulty level? The following graphic is an example.

Student Scenario:

People enjoy puzzles as a way to challenge themselves. A large office supply company asks your team to design and build a 3D puzzle for distribution in their nationwide chain of stores. These puzzles will be displayed on a desk or table as a promotion item for the company.

Students will interview the “office supply client” to discover the needs of the company. A design brief will be created to share with the clients for their approval before beginning work on the final design. After conducting research on puzzle styles and sizes, teams will decide on a design that meets the desired requirements. Design teams will create a solid model and verify its characteristics by printing and building a prototype. Teams will prepare and deliver a short presentation about your packaging design, highlighting your favorite characteristics. NOTE: The teacher will decide how the “client” and the client’s needs for the project are to be represented.

The research and learning activities are designed to help students:

- Discover the elements of a good puzzle
- Use mathematical formulas to aid in the design of a product

- Utilize specific software features to create a solid model of an idea
- Communicate their solution

Deliverables include:

- Engineering Notebook
- CAD model
- 3D printed model
- Engineering Report that includes 3D images and working and assembly drawings
- Presentation of the development process

Daily Plan:

Day 1

Key Question: What are the expectations of the project?

Introduce students to the project by providing them with the Essential Question and the scenario.

Review and discuss with your students the design process, Engineering Notebook and design documentation requirements. Discuss the problem statement, design brief, testing protocol and management plan. Review the elements of a good engineering report with the students. These were all covered in the first project titled *Introduction to the Engineering Design Process* but should be reinforced on a regular basis. All projects depend on the design process and student activities should relate directly.

Have the students form teams of two. Allow the students five minutes to discuss the problem. Students begin by brainstorming ideas in their Engineering Notebooks. The teacher will provide a list of vocabulary terms that students will need to research on their own. The teams can divide the list of terms among team members and share their definitions. All team members are responsible to know all definitions.

Day 2-4

Key Question: How do we get started in the design process?

The teams will be responsible for researching the characteristics and specifications of the 3D puzzle. The teams will decide the form and difficulty of the 3D puzzle design.

Student teams should spend some time interviewing the client to establish the desired characteristics. Students begin sketching in their engineering notebooks.

NOTE: The teacher will decide how the “client” and the client’s needs for the project are to be represented.

The teacher reminds students about the help system to find out how the software accomplishes basic features they might want to incorporate. https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index Students can enter terms to view a tutorial for creating certain features. Students can reference specific terms from the vocabulary list for specific commands to be used in the design of the puzzle.

Student teams discuss the specifications of the puzzle. Students list the criteria and constraints of the problem they are solving. Teams research the existing 3D puzzles and discover information about which features are important to customers. The teams will use formulas to calculate volume formula and dictate the shape of the puzzle. Students should be refining their sketches in the engineering notebook.

Remind students to record research notes and sources as well as reflections on the day in the Engineering notebook.

The teacher will provide access to the following video tutorials that will provide students with information about the basics of assembly design. They can also access Siemens Solid Edge Video Resources for further information on the topics. Groups should view the Assembly Modeling Videos and then decide which others will support their work.

Measure Minimum Distance

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=38

Assembly Modeling

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=35
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=36
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=37
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-quick-start/Ey8QWFP7d/chapters/solid-edge-quick-start/Nk1aTuvXd?topic=6

Assembly Example-Rowboat Video Collection

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/rowboat-mechanism-in-solid-edge/EJaWFRQRP

Assembly Tutorial

- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012447/index.html

Day 5-8
Key Question: How do we get started on our individual designs?

Student teams finish creating their isometric sketches and create a design brief to include with their sketch. They then meet with the client who will need to sign off on the design proposal before beginning solid modeling. Once the design has been verified and permission given, students can begin solid modeling on the software to convey their ideas.

The teacher should introduce students to the Assembly Modeling tutorials. Students can reference Basic 3D Commands and Creating Drawing Views for specific commands to use in the puzzle design.

Day 9-10
Key Question: How can we begin to make our puzzles?

Teams discuss their puzzle and how to achieve the design given the approved sketch presented. Teams work together to design the puzzle and divide the work of creating the 3D solid model of the pieces they are responsible for, utilizing the division of work in the creation of their project management plan.

Teams are reminded to continually check their solid models for accuracy to ensure the correct sizes are created.

Students can review tutorials as necessary. Students record sketches and reflections in the Engineering Notebook. Once the students feel they have a puzzle solution that meets the requirements, additional practical enhancements can be considered. (i.e. logo, name, etc.)

Day 11-12
Key Question: How do we put our puzzles together?

The teacher will review assembly methods so students will be able to virtually solve their puzzles in the software. The teacher should review the design process with the class and check with teams to see where they are in the design process along with any known or perceived problems with puzzle designs so far.

Students will finish modeling using the software and using tutorials as necessary.

Once all of the parts are created, then they can start to assemble their puzzle designs. Students can review Assembly Modeling as necessary.
Students should be 3D printing their puzzles as they complete them.

Day 13
Key Question: How can we check our designs?

Once the assemblies are together, completed and verified, the students can create an exploded drawing of the assembly. The teacher should help the students gather the design into the final stage for the presentation drawings. Students analyze their parts and check for collisions. Students assemble puzzle parts they have printed and check for fit.

Day 14
Key Question: How do we organize our thoughts in a presentation to the class?

The teacher will discuss with the students how to optimally present their ideas to the class. Students should also be prepared to justify any design enhancements they incorporated into the puzzle. Students will continue to model using the software. Students finish the 3D print samples of the puzzle. Groups finalize their designs.

Students discuss the types of items for the presentation to the client. The deliverables could be in the form of a dimensioned working drawing pictorial representation with balloons and bill of materials and/or a 3D printed prototype. Students should also be prepared to justify any design enhancements they incorporated into their puzzles. They decide on the types of graphics to include. Students should prepare an engineering report about the process of designing the puzzle. They should be required write the introduction, provide results including graphics, and a conclusion including the acknowledgement section reporting the source of information. Students decide how to divide the work so they can create a team report.

Day 15
Key Question: How do we convey our ideas?

Students can present their solutions to the class one at a time. In the end, all students can reflect on their work by giving and receiving feedback on how they could possibly improve their designs.

Vocabulary:

Animation
Assembly
Assembly Relationships
Degrees of Freedom

Exploded Assembly View
Gear Relationship
Ground Relationship
Interlocking
Library of Parts
Offset Value
Path Relationship
Pictorial
Presentation Views
Rotational Motor

Resources:

Puzzle Examples:

- https://www.fatbraintoys.com/toys/toy_categories/puzzles/3_d_puzzles/
- http://www.eureka-puzzle.eu/eureka/index.php/eureka-3D-products
- http://kubiyagames.com/3D-puzzles.html
- http://www.puzzledinc.com/3D-wooden-puzzles-s/1832.htm
- https://www.seriouspuzzles.com/brain-teasers.html

Videos:

- https://www.youtube.com/watch?v=gSi8E3XZNfg
- https://www.youtube.com/watch?v=TCuXp53qVYY

CAD Tutorials

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012424/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012420/index.html
- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1323753:index_assemble_parts
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012430/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012447/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012454/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012455/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012420/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012460/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012430/index.html

Assembly Tutorials

- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012454/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012455/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012460/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012451/index.html

Parts for Assembly Tutorials

- https://drive.google.com/open?id=0B_7sFhPxnoaXd3N3bGc5OUZzOEU

Assembly Tutorials

- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012424/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012454/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012455/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012460/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012451/index.html

Bill of materials

- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012445/index.html?goto=as_reports_act_01_02.html

Engineering Reports

- http://web.mit.edu/me-ugoffice/communication/technical-writing.pdf
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/writing_engineering_reports.html
- https://www.youtube.com/playlist?list=PLDAAF7A8FD5CD582C&feature=plcp
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/mechanical_engineering_writing_enhancement_program/report_writing.html
- https://owl.purdue.edu/owl/subject_specific_writing/professional_technical_writing/technical_reports_and_report_abstracts/reports_proposals_and_technical_papers.html

Exploded Assemblies

- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012454/id1608066.html

Solid Edge Instructional Videos

Measure Minimum Distance

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-

certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=38

Assembly Modeling

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=35
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=36
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=37
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-quick-start/Ey8QWFP7d/chapters/solid-edge-quick-start/Nk1aTuvXd?topic=6

Working Drawings

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=26
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-quick-start/Ey8QWFP7d/chapters/solid-edge-quick-start/Nk1aTuvXd?topic=7

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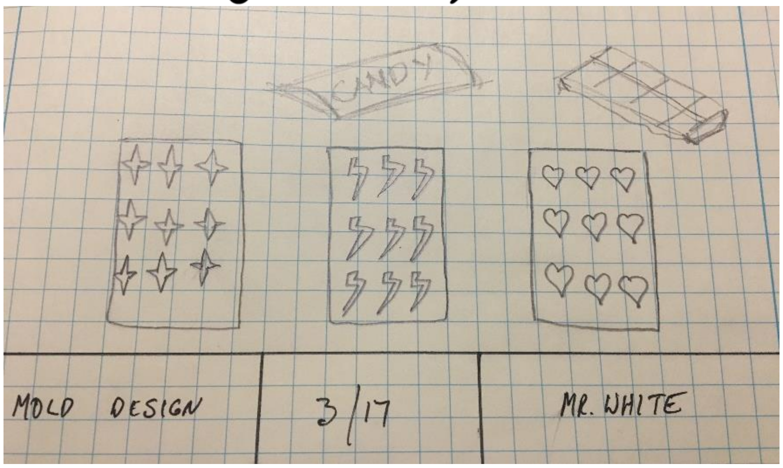

Project: Mold Design

Introduction:

Mold makers create hollowed out shapes in blocks which are called molds. These molds are used by filling the mold cavity to produce a product. This process is called casting and it has existed for thousands of years. Molds for casting are often used by professions to create sculptures, textures, patterns, and even toys. Molds are also used in the food industry. Reproducing parts and products becomes very easy once the mold is made. A simple example of a mold is the ice tray used to create ice cubes.

Purpose of the Project:

The purpose of this project is to introduce students to the concept of mold making and casting. Students will design their own candy bar and will produce it using a mold. Students will apply Boolean subtraction, create the reverse image in the mold, and use a 3D printer to produce the mold. The mold will be used to cast the final product. Students will use volume calculations to predict the final weight of candy bar.

Concepts:

- Apply parametric modeling to the creation of solid models.
- Analyze models for appropriate engineering design features needed.
- Utilize rapid prototyping to create a complex part created in a CAD system.
- Apply concepts of casting and mold making to create a custom product.
- Create a new part by subtracting one solid from another solid.

Outline:

- Documentation
  - Engineering Notebook
  - Documentation object to be designed
- Modeling
  - Creation of 3D model
  - Design renderings and working drawings
- Product Creation
  - Building the part on a 3D printer
  - Casting custom part
- Communication
  - Presentation of design solutions

Standards:

Career and Technical Standards

Engineering Design Process

- Create and maintain an Engineering Notebook for daily reflections, research and prototype creation documentation.
- Apply the design and problem solving process as an iterative process incorporating sciences, mathematics and engineering to optimally convert resources to meet a stated objective.
- Communicate solutions utilizing technical writing skills including correct spelling, proper grammar and dependent vocabulary.
- Assume and carry out a role in the smooth running of a team working toward the solution of a problem.
- Assemble a quantitative plan for successful completion of the project.
- Assume responsibility for leadership roles and responsibility for actions, decisions products and policies in the governance of a project.
- Evaluate the need for and costs of resources necessary for the completion of a project.

Sketching

- Create sketches utilizing basic shapes such as lines circles and ellipses.
- Communicate ideas to a group through the use of sketches and other documentation.
- Apply isometric and orthographic sketches to add clarity to design.
- Create necessary sketches to communicate basic ideas during the design process.

3D Solid Modeling/Fabrication and 3-D Printing

- Apply geometric relationships between lines and shapes to create a mathematical database to describe design ideas.
- Create solid models utilizing concepts of Parametric Modeling.
- Analyze models for appropriate engineering design features needed.

- Develop strategies for the creation of solid models for the rapid creation of design solutions.
- Apply the concepts of digital prototyping to accelerate the time frame between ideation and completed project.
- Access, generate, process, and transfer information using appropriate technologies.
- Design and create a model using additive manufacturing technology sometimes called a rapid prototyping system.
- Utilize rapid prototyping/additive manufacturing to create highly complex parts designed in a CAD system.

Renderings/Working Drawings/ Design Presentations

- Create renderings to communicate design ideas and engineering principles to the general public.
- Generate an image from a model utilizing light, texture and shading to create a proposed final appearance of a product.
- Apply rendering techniques to create presentations of design for a non-technical audience.

Assembly Modeling/Documentation/Exploded Assemblies/Bill of Materials

- Conduct model documentation as the process of recording details such as size, material composition, and instructions for assembling, installation and servicing, analysis, development process that describes a model for the purpose of communication of ideas.
- Create a bill of materials to communicate materials and other information about a design.

College and Career Readiness Math Standards

Modeling with Geometry G-MG

Apply geometric concepts in modeling situations

1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).
2. Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot).
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Create equations that describe numbers or relationships CED

A.4. Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.

Reading Standards for Literacy in History/Social Studies 9-10

Key Ideas and Details

1. Cite specific textual evidence to support analysis of primary and secondary sources, attending to such features as the date and origin of the information.
3. Analyze in detail a series of events described in a text; determine whether earlier events caused later ones or simply preceded them.

Integration of Knowledge and Ideas

7. Integrate quantitative or technical analysis (e.g., charts, research data) with qualitative analysis in print or digital text.
9. Compare and contrast treatments of the same topic in several primary and secondary sources.

Range of Reading and Level of Text Complexity

10. By the end of grade 10, read and comprehend science/technical texts in the grades 9–10 text complexity band independently and proficiently.

Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 9-10

Text Types and Purposes

1. Write arguments focused on *discipline-specific content.*
2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

Production and Distribution of Writing

4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Research to Build and Present Knowledge

7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.

Range of Writing

10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Next Generation Science Standards
The projects engage students in the scientific and engineering practices taken from the National Research Council's Framework for K-12 Science Education, Practices, Crosscutting Concepts, and Core Ideas. This is the document upon which the NGSS are based.

These practices are used for two reasons: 1) they parallel the design process utilized in each project, and 2) they serve as the foundation of the NGSS.

The eight science and engineering practices are:
1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Standards for Technological Literacy

Standard 1
Students will develop an understanding of the characteristics and scope of technology.

Standard 2
Students will develop an understanding of the core concepts of technology.

Standard 4
Students will develop an understanding of the cultural, social, economic, and political effects of technology.

Standard 7
Students will develop an understanding of the influence of technology on history.

Standard 8
Students will develop an understanding of the attributes of design.

Standard 9
Students will develop an understanding of engineering design.

Standard 10
Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

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Students will develop the abilities to apply the design process.

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Students will develop the abilities to use and maintain technological products and systems.

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Students will develop an understanding of and be able to select and use information and communication technologies.

Standard 19
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Standard 20
Students will develop an understanding of and be able to select and use construction technologies.

Assessment:

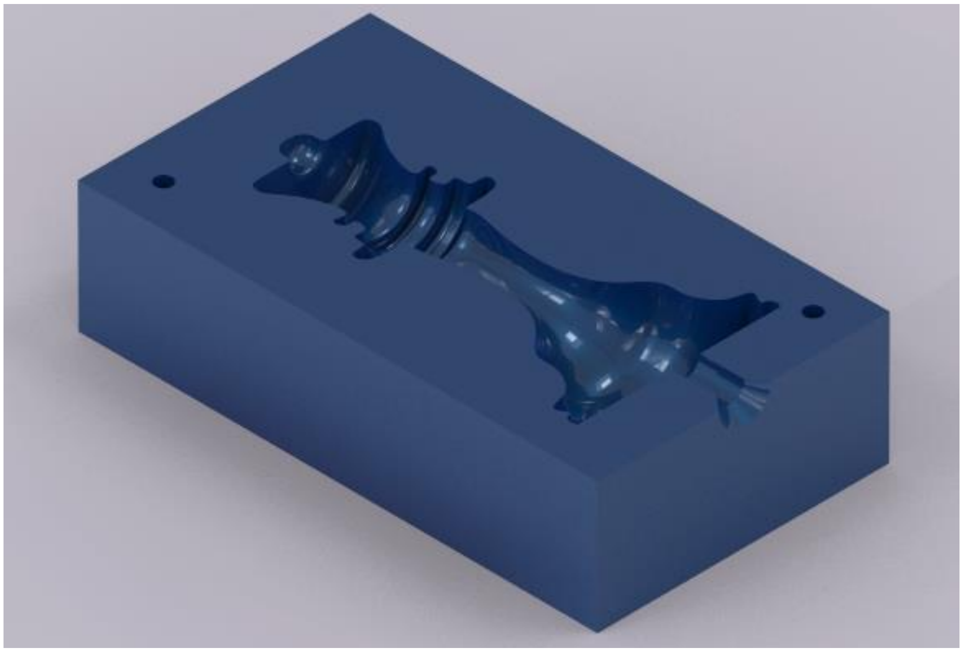
Assessment is both formative and summative. It is an integral part of quality instruction. During the course of each project, one of the teacher's main functions is to work with student groups, keeping track of progress and providing formative assessment in the form of feedback and promoting reflection on the part of students. The focus should be on promoting lifetime learning and 21st century skills. The goal of instruction is to promote abilities in research, problem solving, designing, experimenting, testing, collecting and analyzing data.

Rubrics are used in the assessment process to communicate expectations of quality. Rubrics should be shared with students at the beginning of a project to clarify any misconceptions before beginning their work. Students can then build the skills and gather knowledge to solve the problem presented to the expectations of excellence described.

General Rubrics for Literacy tasks:
Argumentative_Pursuasive
Informational_Explanatory

Individual Project Rubric:
Mold Design Project Rubric

Essential Question:
How can we design a unique mold cavity to produce a chocolate candy bar of exact weight?



Student Scenario:
Around many major holidays and celebrations, people like to order personalized or themed chocolates. You have been charged with designing a unique mold for a candy company. This mold will be used for making distinctive chocolate bars or any other candy product with a low melting temperature.

You will interview your client to discover their needs. Write a design brief to share with your client for approval before beginning work on the final design of the candy bar. After conducting research on candy bar styles and sizes, create a design that meets the desired requirements. Prepare the solid model and verify its characteristics by printing and building a prototype. You will also be responsible for giving a short presentation about your design, highlighting your favorite characteristics.

The research and learning activities are designed to help students:
- Discover the elements of a mold
- Use mathematical formulas to aid in the design of a product
- Utilize specific software features to create a solid model of the idea
- Communicate their solution to their peers

Deliverables include:
- Engineering Notebook
- CAD model

- 3D printed mold
- Engineering Report that includes 3D images and working and assembly drawings
- Presentation of the development process
- Final candy bar

Daily Plan:

Day 1
Key Question: What are the expectations of the project?

Introduce students to the project by providing them with the Essential Question and the scenario.

Review and discuss with your students the design process, Engineering Notebook and design documentation requirements. Discuss the problem statement, design brief, testing protocol and management plan. Review the elements of a good engineering report with the students. These were all covered in the first project titled *Introduction to the Engineering Design Process* but should be reinforced on a regular basis. All projects depend on the design process and student activities should relate directly.

Have the students form teams of two. Allow the students five minutes to discuss the problem. Students begin by brainstorming ideas in their Engineering Notebooks. The teacher will provide a list of vocabulary terms that students will need to research on their own. The teams can divide the list of terms among team members and share their definitions. All team members are responsible to know all definitions.

Day 2-4
Key Question: How do we get started in the design process?

The teams will be responsible for researching the characteristics and specifications of the candy bar mold. The client specifies the characteristics of the candy bar. The teams will decide the form and weight of the candy bar design.

NOTE: The teacher will decide how the "client" and the client's needs for the project are to be represented.

Student teams should spend some time interviewing the client as needed. Students begin sketching in their Engineering Notebooks.

The teacher reminds students about the help system to find out how the software accomplishes basic features they might want to incorporate.
https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index
Students can enter terms and view a tutorial for creating certain features.
Students can reference specific terms from the vocabulary list for specific

commands to be used in the design candy mold. Other tutorials in the Resources section are available for use if students struggle.

Student teams discuss the specifications of the mold design. Students list the criteria and constraints of the problem they are solving. Teams research the existing candy bar designs, molds, and casting process to discover which features are important to customers. The teams will use formulas to calculate volume and dictate the shape of the mold to be created. Students should be refining their sketches in the Engineering Notebook.

Remind students to record research notes and sources as well as reflections on the day in the Engineering Notebook.

Student groups discuss the specifications of the mold design. The teacher should specify or limit the amount of material contained in the mold. Students should also research what existing molds look like and the ratio of the shapes and sizes. Students record findings in their notebooks.

The teacher will provide access to the following video tutorials that will provide students with information about the basics of assembly design. They can also access Siemens Solid Edge Video Resources for further information on the topics. Groups should view the Assembly Modeling Videos and then decide which others will support their work.

Measure Minimum Distance

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=38

Assembly Modeling

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=35

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=36

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=37

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-quick-start/Ey8QWFP7d/chapters/solid-edge-quick-start/Nk1aTuvXd?topic=6

Assembly Example-Rowboat Video Collection

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/rowboat-mechanism-in-solid-edge/EJaWFRQRP

Assembly Tutorial

- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012447/index.html

Day 5-7
Key Question: How do we get started on our individual designs?

Student teams finish creating their isometric sketches and create a design brief to include with their sketch prior to meeting with the client. The client will sign off on the design proposal before beginning solid modeling. Once the design has been verified and permission given, begin solid modeling on the software.

The teacher should introduce students to the Working with Bodies tutorials. Students can reference Basic 3D Commands, Creating Drawing Views and Assembly Modeling for specific commands to use in the mold design.

Day 8
Key Question: How can we begin to make our candy bar??

Teams discuss their candy bar and how to achieve the design of the mold given the approved sketch they presented. They work together to design the candy bar, mold, and divide the work of creating the 3D solid model of the pieces for which they are responsible. Utilize division of work in the creation of the project management plan.

Teams are reminded to continually check their solid models to assure creation of accurate sizes.

Students can review tutorials as necessary. Students record sketches and reflections in the Engineering Notebook. Once the students feel they have a puzzle solution that meets the requirements, consider practical enhancements.

Students should start by modeling the candy bar design, staying within the volume parameters specified by the teacher. Include fillets and proper draft angles in the designs.

Day 9-11
Key Question: What is the most efficient way to create the mold?

The teacher will review assembly methods. Students will be able to virtually create their candy bar design and mold in the software. The teacher should review the design process with the class and check with teams to assess progress with design process. Determine if there any known or perceived problems with candy bar and mold design.
The teacher should explain the concept of Boolean subtraction in the creation of the mold cavity if necessary.

Day 12
Key Question: How can we put our new designs together?

Once the assemblies are together, completed, and verified, the students can create an explosion of the assembly. The teacher should help the students gather the design into the final stage for the presentation drawings. Students analyze their parts and check draft angles.

Students should be 3D printing their mold cavities and finishing assembly modeling, renderings working drawings or other media for their presentations.

Day 13
Key Question: How do we organize our thoughts in a presentation to the class?

The teacher will discuss with the students how to optimally present their ideas to the class. Students should also be prepared to justify any design enhancements they incorporated into the candy bar and mold. Students will continue to model using the software. Students finish the 3D print of their mold. Groups finalize their designs.

Students discuss the types of things to put in their presentation to their clients. The deliverables could be in the form of a dimensioned working drawing pictorial representation with balloons and bill of materials and/or a 3D printed prototype. Students should also be prepared to justify any design enhancements they incorporated into their candy bar and mold. They decide on the types of graphics to include. Students should prepare an engineering report about the process of designing the candy bar and mold. They should be required write the introduction, results including graphics, conclusion and include the acknowledgement sections reporting the source of their information. Students decide how to divide the work to create a team report. Students should also be prepared to justify any design ideas they used on their candy bar.

Day 14
Key Question: How do we convey our ideas and obtain our candy bars?

Students can present their solutions to the class one at a time. In the end, all students can reflect on their work by giving and receiving feedback on how they

could possibly improve their designs. As time allows the teacher can facilitate the melting of chocolate and pouring into the student molds. Once cooled, the teacher and students can share in enjoying the results.
Students can present their solutions to the class one at a time.

Vocabulary:

Assembly
Boolean subtraction
Casting
Cavity
Core
Demold
Draft
Ejector pins
Gates
Mold
Pattern
Release agent
Riser
Runner
Shrinkage
Sprue
Volume

Resources:

Bill of materials

- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012445/index.html?goto=as_reports_act_01_02.html

Videos:

- https://www.youtube.com/watch?v=o3XaBdRaejc
- https://www.youtube.com/watch?v=E0AeidS699s

Mold design Information:

- http://www.makeyourownmolds.com/
- https://www.chocoley.com/molds/
- https://www.candylandcrafts.com/Catalog/
- https://www.youtube.com/watch?v=QRmAsxlizMk&t=1795s
- https://www.youtube.com/watch?v=j_7bwaHP5MQ&t=687s
- http://thekidshouldseethis.com/post/plastic-injection-molding

CAD Tutorials

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012424/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012420/index.html

- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012430/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012447/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012454/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012455/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012420/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012460/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012430/index.html

Assembly Tutorials

- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012424/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012454/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012455/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012460/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012451/index.html

Exploded Assemblies

- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012454/id1608066.html

Part Splitting

- https://www.youtube.com/watch?v=CXJfvyZFHrI
- https://www.youtube.com/watch?v=b1U9W4iNDiQ

Engineering Reports

- http://web.mit.edu/me-ugoffice/communication/technical-writing.pdf
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/writing_engineering_reports.html
- https://www.youtube.com/playlist?list=PLDAAF7A8FD5CD582C&feature=plcp
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/mechanical_engineering_writing_enhancement_program/report_writing.html
- https://owl.purdue.edu/owl/subject_specific_writing/professional_technical_writing/technical_reports_and_report_abstracts/reports_proposals_and_technical_papers.html

Solid Edge Instructional Videos

Measure Minimum Distance

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=38

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- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=37
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-quick-start/Ey8QWFP7d/chapters/solid-edge-quick-start/Nk1aTuvXd?topic=6

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Working Drawings

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=26
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-quick-start/Ey8QWFP7d/chapters/solid-edge-quick-start/Nk1aTuvXd?topic=7

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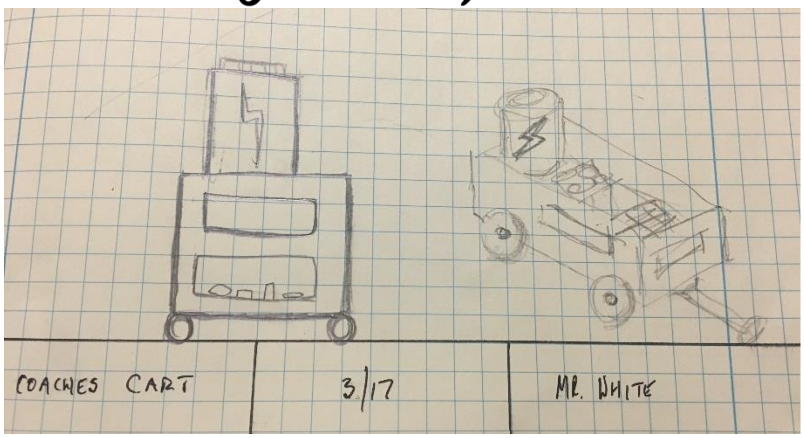
Ingenuity for life



Project: Coaches' Cart

Introduction:

There are many supplies and various pieces of equipment needed for a typical high school sporting event. You can observe the athletes as well as coaches take several trips to bring these items great distances for each match or game. Wouldn't it make everyone's life easier if you could centralize these items and have an easy way to transport them on a daily basis?

Purpose of the Project:

The purpose of this project is to apply knowledge of assembly and part creation in the design of a cart that their school could use to transport objects back and forth from the building to the fields. Students will model parts, assemble the cart and then present their ideas as exploded pictorials with a bill of materials.

Concepts:

- Apply rendering techniques to create presentations of a design to a non-technical audience.
- Maintain an accurate list of required components in an assembly by using a Bill of Materials.
- Utilize the concepts of top down and bottom up assemblies.
- Apply assembly techniques to create a virtual working model.
- Demonstrate ability to edit parts in assembly to address any issues related to fit.

Outline:

- Documentation
  - Engineering Notebook
  - Documentation object to be designed
- Modeling
  - Creation of 3D models
  - Creation of assembly
  - Create exploded pictorial drawings
- Communication
  - Presentation of design solutions

Standards:

Career and Technical Standards

Engineering Design Process

- Create and maintain an Engineering Notebook for daily reflections, research and prototype creation documentation.
- Apply the design and problem solving process as an iterative process incorporating sciences, mathematics and engineering to optimally convert resources to meet a stated objective.
- Communicate solutions utilizing technical writing skills including correct spelling, proper grammar and dependent vocabulary.
- Assume and carry out a role in the smooth running of a team working toward the solution of a problem.
- Assemble a quantitative plan for successful completion of the project.
- Assume responsibility for leadership roles and responsibility for actions, decisions products and policies in the governance of a project.
- Evaluate the need for and costs of resources necessary for the completion of a project.

Sketching

- Create sketches utilizing basic shapes such as lines circles and ellipses.
- Communicate ideas to a group through the use of sketches and other documentation.
- Apply isometric and orthographic sketches to add clarity to design.
- Create necessary sketches to communicate basic ideas during the design process.

3D Solid Modeling/Fabrication and 3-D Printing

- Apply geometric relationships between lines and shapes to create a mathematical database to describe design ideas.
- Create solid models utilizing concepts of Parametric Modeling.
- Analyze models for appropriate engineering design features needed.
- Develop strategies for the creation of solid models for the rapid creation of design solutions.

- Apply the concepts of digital prototyping to accelerate the time frame between ideation and completed project.
- Access, generate, process, and transfer information using appropriate technologies.
- Design and create a model using additive manufacturing technology sometimes called a rapid prototyping system.
- Utilize rapid prototyping/additive manufacturing to create highly complex parts designed in a CAD system.

Renderings/Working Drawings/ Design Presentations

- Create renderings to communicate design ideas and engineering principles to the general public.
- Generate an image from a model utilizing light, texture and shading to create a proposed final appearance of a product.
- Apply rendering techniques to create presentations of design for a non-technical audience.

Assembly Modeling/Documentation/Exploded Assemblies/Bill of Materials

- Conduct model documentation as the process of recording details such as size, material composition, and instructions for assembling, installation and servicing, analysis, development process that describes a model for the purpose of communication of ideas.
- Create a bill of materials to communicate materials and other information about a design.

College and Career Readiness Math Standards

Modeling with Geometry G-MG

Apply geometric concepts in modeling situations

1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).
2. Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot).
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Create equations that describe numbers or relationships CED

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Reading Standards for Literacy in History/Social Studies 9-10

Key Ideas and Details

1. Cite specific textual evidence to support analysis of primary and secondary sources, attending to such features as the date and origin of the information.

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Text Types and Purposes

1. Write arguments focused on *discipline-specific content.*
2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

Production and Distribution of Writing

4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

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Rubrics are used in the assessment process to communicate expectations of quality. Rubrics should be shared with students at the beginning of a project to clarify any misconceptions before beginning their work. Students can then build the skills and gather knowledge to solve the problem presented to the expectations of excellence described.

General Rubrics for Literacy tasks:
Argumentative_Pursuasive
Informational_Explanatory

Individual Project Rubric:
Coaches' Cart Project Rubric

Essential Question:

How can we design a method to safely and efficiently transport certain materials from inside a school building to an athletic field for coaches and players to use?

Student Scenario:

During a routine school athletic match or game, many items are needed near the field for the players and coaches. A sporting goods chain has hired you to design a portable cart that will transport and hold all of the necessary equipment and supplies for a high school sporting event. The cart should be able to be handled by one person and contain just enough equipment for an event.

You will interview your clients to discover their needs. You will create a design brief to share with your clients to get their approval before beginning work on the final design of the candy bar. After conducting research on candy bar styles and sizes, you will create a design that meets the desired requirements. You will create the solid model and verify its characteristics by printing and building a prototype. You will also be responsible for giving a short presentation about your packaging design, highlighting your favorite characteristics.

The research and learning activities are designed to help students:

- Discover the elements of a mold
- Use mathematical formulas to aid in the design of a product
- Utilize specific software features to create a solid model of the idea.
- Communicate their solution to their peers.

Deliverables include:

- Engineering Notebook
- CAD model
- Engineering Report that includes 3D images and working and assembly drawings
- Presentation of the development process
- Rendering of the finished design

Daily Plan:

Day 1
Key Question: What are the expectations of the project?

Introduce students to the project by providing them with the Essential Question and the scenario.

Review and discuss with your students the design process, Engineering Notebook and design documentation requirements. Discuss the problem statement, design brief, testing protocol and management plan. Review the elements of a good engineering report with the students. These were all covered in the first project titled *Introduction to the Engineering Design Process* but should be reinforced on a regular basis. All projects depend on the design process and student activities should relate directly.

Have the students form teams of two. Allow the students five minutes to discuss the problem. Students begin by brainstorming ideas in their Engineering Notebooks. The teacher will provide a list of vocabulary terms that students will need to research on their own. The teams can divide the list of terms among team members and share their definitions. All team members are responsible to know all definitions.

Day 2-4
Key Question: How do we get started in the design process?

The teams will be responsible for researching the characteristics and specifications of the coaches' cart. The client will describe their requirements of the cart. The teams will decide the layout and accessories for the cart design.

NOTE: The teacher will decide how the "client" and the client's needs for the project are to be represented.

Student teams should spend some time interviewing the client as necessary. Students begin sketching in their Engineering Notebooks.

The teacher reminds students about the help system to find out how the software accomplishes basic features they might want to incorporate.
https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index
Students can enter terms to view a tutorial for creating certain features. Students can reference specific terms from the vocabulary list for specific commands to be used in the design of the cart.

Student teams discuss the specifications of the cart. Students list the criteria and constraints of the problem they are solving. Teams research the existing cart designs available, wheels, necessary equipment sizes and discover important features to customers. The teams explore physics terms such as rolling resistance, plough resistance, and vectors. The teams will use formulas to calculate volume and the layout needed to hold all necessary items. Students should be refining their sketches in the Engineering Notebook.

Remind students to record research notes and sources as well as reflections on the day in the Engineering Notebook.

Student groups discuss and agree on the specifications of the cart and what it should hold. They should be recording findings in their notebooks.

The teacher will provide access to the following video tutorials that will provide students with information about the basics of assembly design. They can also access Siemens Solid Edge Video Resources for further information on the topics. Groups should view the Assembly Modeling Videos and then decide which others will support their work.

Measure Minimum Distance

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=38

Assembly Modeling

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=35
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=36
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=37
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-quick-start/Ey8QWFP7d/chapters/solid-edge-quick-start/Nk1aTuvXd?topic=6

Assembly Example-Rowboat Video Collection

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/rowboat-mechanism-in-solid-edge/EJaWFRQRP

Assembly Tutorial

- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012447/index.html

Day 5

Key Question: How do we get started on our individual designs?

Student teams finish creating their isometric sketches and create a design brief to include with their sketch prior to meeting with the client. The client will need to sign off on the design proposal before solid modeling can begin. Once the design has been verified and permission given, students begin solid modeling on the software to convey their ideas.

The teacher should introduce students to the tutorials. Students can reference Basic 3D Commands, Creating Drawing Views, Assembly Modeling and Working with Bodies for specific commands to be used in the design of the coaches' cart.

Day 6-8

Key Question: How can we begin to make our cart designs?

Teams discuss their cart design and how to achieve the design of the cart to satisfy the approved sketch they presented. They work together to design the cart and contents and divide the work of creating the 3D solid model of the pieces for which they are responsible. They utilize the division of work in the creation of their project management plan.

Teams are reminded to continually check their solid models to assure the accurate sizes are created.

Students can review tutorials as necessary. Students record sketches and reflections in the Engineering Notebook. Once the students feel they have a cart solution that meets the requirements, they can consider practical enhancements.

The students should start by modeling the cart design they want staying within the constraints listed earlier in the process.

Day 9-10
Key Question: How can we put our new designs together?

The teacher should work with student groups helping them find tutorials to model needed components of the cart design. Students should consider adding the school logo to the cart. Students will create an assembly of the coaches' cart with some of the supplies and equipment included in the assembly model to allow the client to see how the cart design has met with their proposal.

Day 11
Key Question: How do we organize our thoughts in a presentation to the class?

Once the assemblies are together, completed and verified, the students can create an exploded drawing of the assembly. The teacher should help the students gather the design into the final stage for the presentation drawings. Students analyze their parts and check draft angles.

The teacher will discuss how to optimally present ideas to the class. Students should also be prepared to justify any design enhancements incorporated into the coaches' cart. Students will continue to model using the software. Groups finalize their designs.

Students discuss the outline of their presentation to the client. The deliverables could be in the form of a dimensioned working drawing pictorial representation with balloons, bill of materials, and renderings. Students should also be prepared to justify any design enhancements incorporated into their cart. The teams decide on the types of graphics to include. Students should prepare an engineering report about the process of designing the cart. Student teams plan their engineering report including the introduction, results including graphics, conclusion, including an acknowledgement sections citing sources of information. Students decide how to divide the work of creating a team report. Students should also be prepared to justify any design ideas used on their cart.

Day 12
Key Question: How do we convey our ideas?

Students can present their solutions to the class one at a time. In the end, all students can reflect on their work by giving and receiving feedback on how they could possibly improve their designs

Local coaches could be asked to judge ideas as time allows.

Vocabulary:

Articulate
Axle
Force
Payload
Pounds per Square Inch
Rolling Resistance
Surface Area
Vector
Volume
Wheel

Resources:

Bill of materials

- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012445/index.html?goto=as_reports_act_01_02.html

Cart Ideas

- http://www.dunriteplaygrounds.com/store/22719-1342543-Foldable-Coaches-Cart
- http://www.mansionathletics.com/brute-teaching-cart-325-001057002-tennis-ball-hoppers-baskets.html
- https://www.palossports.com/store/proddetail.cfm/ItemID/7945/CategoryID/42/SubCatID/31/file.htm
- http://soccer.epicsports.com/prod/75066/index.html
- http://www.multibriefs.com/briefs/cb-pivotal-ae/cb-pivotal-ae061015.php
- https://www.youtube.com/watch?v=duFAlIdZTF8

CAD Tutorials

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012424/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012420/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012430/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012447/index.html

- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012454/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012455/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012420/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012460/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012430/index.html

Assembly Tutorials

- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012424/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012454/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012455/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012460/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012451/index.html

Engineering Reports

- http://web.mit.edu/me-ugoffice/communication/technical-writing.pdf
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/writing_engineering_reports.html
- https://www.youtube.com/playlist?list=PLDAAF7A8FD5CD582C&feature=plcp
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/mechanical_engineering_writing_enhancement_program/report_writing.html
- https://owl.purdue.edu/owl/subject_specific_writing/professional_technical_writing/technical_reports_and_report_abstracts/reports_proposals_and_technical_papers.html

Exploded Assemblies

- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012454/id1608066.html

Physics

- https://phet.colorado.edu/

Solid Edge Instructional Videos

Measure Minimum Distance

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=38

Assembly Modeling

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=35
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=36
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=37
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-quick-start/Ey8QWFP7d/chapters/solid-edge-quick-start/Nk1aTuvXd?topic=6

Assembly Example-Rowboat Video Collection

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/rowboat-mechanism-in-solid-edge/EJaWFRQRP

Working Drawings

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=26
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-quick-start/Ey8QWFP7d/chapters/solid-edge-quick-start/Nk1aTuvXd?topic=7

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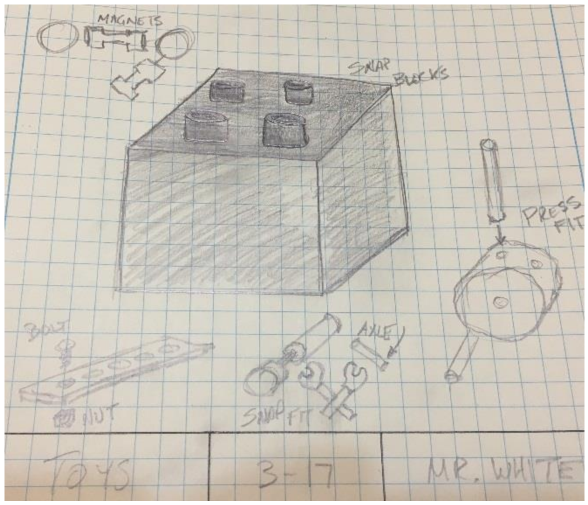
Ingenuity for life



Project: Reverse Engineering

Introduction:

The reverse engineering process is used by industry to study a product, its components, and the process to produce it. This is called produce analysis. A company may choose to conduct a reverse engineering process to see how a competitor’s product works or to create a set of working drawings should they not exist. One goal of reverse engineering is to understand how and why a current design has come to be. Designers and engineers perform this process as the first step in the redesign or improvement of a product.

Purpose of the Project:

The purpose of this project is expose students to the process of reverse engineering. Students will obtain a multiple part product, disassemble it, measure all part, and record the key attributes of each part. Then students will redesign the product with their own ideas for improvement incorporated into the new design. Students learn precision measurement, materials, design features, tolerances, and assembly processes.

Concepts:

- Reverse engineering is the process of disassembly and analysis with the goal of duplicating or improving a device or component.

- Demonstrate the process of reverse engineering using a given object or component and suggest areas of improvement.
- Companies often study existing products in order to create new improved ones.
- Utilize the green principles of design for eventual disassembly and resource recovery.

Outline:

- Documentation
    - Engineering Notebook
    - Documentation object to be reverse engineered
- Modeling
    - Creation of 3D models
    - 3D print of design
- Communication
    - Documentation of designs

Standards:

Career and Technical Standards

Engineering Design Process

- Create and maintain an Engineering Notebook for daily reflections, research and prototype creation documentation.
- Apply the design and problem solving process as an iterative process incorporating sciences, mathematics and engineering to optimally convert resources to meet a stated objective.
- Communicate solutions utilizing technical writing skills including correct spelling, proper grammar and dependent vocabulary.
- Assume and carry out a role in the smooth running of a team working toward the solution of a problem.
- Assemble a quantitative plan for successful completion of the project.
- Assume responsibility for leadership roles and responsibility for actions, decisions products and policies in the governance of a project.
- Evaluate the need for and costs of resources necessary for the completion of a project.

Sketching

- Create sketches utilizing basic shapes such as lines circles and ellipses.
- Communicate ideas to a group through the use of sketches and other documentation.
- Apply isometric and orthographic sketches to add clarity to design.
- Create necessary sketches to communicate basic ideas during the design process.

3D Solid Modeling/Fabrication and 3-D Printing

- Apply geometric relationships between lines and shapes to create a mathematical database to describe design ideas.
- Create solid models utilizing concepts of Parametric Modeling.
- Analyze models for appropriate engineering design features needed.
- Develop strategies for the creation of solid models for the rapid creation of design solutions.
- Apply the concepts of digital prototyping to accelerate the time frame between ideation and completed project.
- Access, generate, process, and transfer information using appropriate technologies.
- Design and create a model using additive manufacturing technology sometimes called a rapid prototyping system.
- Apply new principles of more rapid and less costly development and deployment of new materials.
- Utilize rapid prototyping/additive manufacturing to create highly complex parts designed in a CAD system.

Renderings/Working Drawings/ Design Presentations

- Create renderings to communicate design ideas and engineering principles to the general public.
- Generate an image from a model utilizing light, texture and shading to create a proposed final appearance of a product.
- Apply rendering techniques to create presentations of design for a non-technical audience.

Assembly Modeling/Documentation/Exploded Assemblies/Bill of Materials

- Conduct model documentation as the process of recording details such as size, material composition, and instructions for assembling, installation and servicing, analysis, development process that describes a model for the purpose of communication of ideas.
- Create a bill of materials to communicate materials and other information about a design.

Reverse Engineering/Engineering Features

- Apply the principles of design for manufacturing enabling the efficient and effective production of products.
- Apply the green principles of design for eventual disassembly and resource recovery.
- Investigate activities that a business conducts with the intention of making a discovery that can either lead to the development of new products or procedures, or to improvement of existing products or procedures and to know the new approaches of rapid development and deployment that saves time and is more efficient.

- Disassemble a product into its parts, utilize precision measurement to create sketches, drawings and models of the product and identify the basic processes, systems, designs, and materials used in the manufacture of the product.

College and Career Readiness Math Standards

Modeling with Geometry G-MG

Apply geometric concepts in modeling situations

1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).
2. Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot).
3. Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).

Create equations that describe numbers or relationships CED

A.4. Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.

Reading Standards for Literacy in History/Social Studies 9-10

Key Ideas and Details

1. Cite specific textual evidence to support analysis of primary and secondary sources, attending to such features as the date and origin of the information.

3. Analyze in detail a series of events described in a text; determine whether earlier events caused later ones or simply preceded them.

Integration of Knowledge and Ideas

7. Integrate quantitative or technical analysis (e.g., charts, research data) with qualitative analysis in print or digital text.

9. Compare and contrast treatments of the same topic in several primary and secondary sources.

Range of Reading and Level of Text Complexity

10. By the end of grade 10, read and comprehend science/technical texts in the grades 9–10 text complexity band independently and proficiently.

Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 9-10

Text Types and Purposes

1. Write arguments focused on *discipline-specific content.*
2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

Production and Distribution of Writing

4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Research to Build and Present Knowledge

7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.

Range of Writing

10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Next Generation Science Standards

The projects engage students in the scientific and engineering practices taken from the National Research Council's Framework for K-12 Science Education, Practices, Crosscutting Concepts, and Core Ideas. This is the document upon which the NGSS are based.

These practices are used for two reasons: 1) they parallel the design process utilized in each project, and 2) they serve as the foundation of the NGSS.

The eight science and engineering practices are:

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Standards for Technological Literacy

Standard 2

Students will develop an understanding of the core concepts of technology.

Standard 3

Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Standard 7

Students will develop an understanding of the influence of technology on history.

Standard 8
Students will develop an understanding of the attributes of design.

Standard 9
Students will develop an understanding of engineering design.

Standard 10
Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Standard 11
Students will develop the abilities to apply the design process.

Standard 12
Students will develop the abilities to use and maintain technological products and systems.

Standard 13
Students will develop the abilities to assess the impact of products and systems.

Standard 17
Students will develop an understanding of and be able to select and use information and communication technologies.

Standard 19
Students will develop an understanding of and be able to select and use manufacturing technologies.

Assessment:

Assessment is both formative and summative. It is an integral part of quality instruction. During the course of each project, one of the teacher's main functions is to work with student groups, keeping track of progress and providing formative assessment in the form of feedback and promoting reflection on the part of students. The focus should be on promoting lifetime learning and 21st century skills. The goal of instruction is to promote abilities in research, problem solving, designing, experimenting, testing, collecting and analyzing data.

Rubrics are used in the assessment process to communicate expectations of quality. Rubrics should be shared with students at the beginning of a project to clarify any misconceptions before beginning their work. Students can then build the skills and gather knowledge to solve the problem presented to the expectations of excellence described.

General Rubrics for Literacy tasks:
Argumentative_Pursuasive

[Informational_Explanatory]()

Individual Project Rubric:
[Reverse Engineering Rubric]()

Essential Question:
How can the use of reverse engineering expose key concepts in engineering design?

Student Scenario:
The toy company you work for puts you on a design team that will be reverse engineering a known toy set. The set will be broken down, taken apart, and measured. New functional parts will be designed and created.

After conducting research on reverse engineering, engineering features, and precision measurement you will select a product that meets the desired requirements of the project. You will create sketches in your Engineering Notebook and then produce the necessary solid models. You will also be responsible for giving a short presentation about your reverse engineering design, highlighting your favorite characteristics.

The research and learning activities are designed to help students with:
- Precision measurement
- Assembly and disassembly techniques
- Using mathematical formulas to aid in the design of a product
- Utilizing specific software features to create a solid model of the idea
- Communicating a solution to peers.

Deliverables include:

- Engineering Notebook
- CAD model
- 3D printed replacement parts
- Engineering Report that includes 3D images and working and assembly drawings
- Presentation of the development process
- A presentation of the existing product in an exploded display

Daily Plan:

Day 1

Key Question: What are the expectations of the project?

Introduce students to the project by providing them with the Essential Question and the scenario.

Review and discuss with your students the design process, Engineering Notebook and design documentation requirements. Discuss the problem statement, design brief, testing protocol and management plan. Review the elements of a good engineering report with the students. These were all covered in the first project titled *Introduction to the Engineering Design Process* but should be reinforced on a regular basis. All projects depend on the design process and student activities should relate directly.

Have the students form teams of two. Allow the students five minutes to discuss the problem. Students begin by brainstorming ideas in their Engineering Notebooks. The teacher will provide a list of vocabulary terms that students will need to research on their own. The teams can divide the list of terms among team members and share their definitions. All team members are responsible to know all definitions.

Day 2-4

Key Question: How do we get started in the design process?

The teams will be responsible for researching reverse engineering, precision measurement, engineering design features, and materials.

Student teams should brainstorm what should be disassembled and redesigned. The teacher should discuss the importance of keeping the items selected small with a reasonable number of parts.

The teacher reminds students about the help system to find out how the software accomplishes basic features they might want to incorporate.
https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index
Students can enter terms to view a tutorial for creating certain features. Students can reference specific terms from the vocabulary list for specific commands.

Student teams discuss the specifications of reverse engineering. Students list the criteria and constraints of the problem they are solving. Teams research engineering features, materials and precision measurement. The students should be recording their ideas of reverse engineering products in the Engineering Notebook.

Remind students to record research notes and sources as well as reflections of the day in the Engineering Notebook.

The teacher will provide access to the following video tutorials that will provide students with information about the basics of assembly design. They can also access Siemens Solid Edge Video Resources for further information on the topics. Groups should view the Assembly Modeling Videos and then decide which others will support their work.

Measure Minimum Distance

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=38

Assembly Modeling

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=35
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=36
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=37
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-quick-start/Ey8QWFP7d/chapters/solid-edge-quick-start/Nk1aTuvXd?topic=6

Assembly Example-Rowboat Video Collection

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Assembly Tutorial

- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012447/index.html

Day 5-6
Key Question: How do we get started on our individual designs?

The teacher should review the proper use of dial calipers to gather dimensions of their toy sets. Students should sketch the product as they first find it. They should take pictures and create sketches as they disassemble the parts. Student use the sketches to record dimensions.

The teacher should introduce students to the Working with Bodies tutorials. Students can reference Basic 3D Commands, Creating Drawing Views and Assembly Modeling for specific commands to use in the mold design.

Day 7-10
Key Question: How can we model efficiently?

Teams discuss their product and the various pieces and how to achieve the design of the various parts. They divide the work of creating the 3D solid model of the pieces for which they are responsible. Utilize the division of work in the creation of the project management plan.

Teams are reminded to continually check their solid models to ensure the correct sizes are created and the parts fit together.

Students can review tutorials as necessary. Students record sketches and reflections in the Engineering Notebook. Once all the parts are created, teams discuss the parts they wish to enhance or redesign.

Students create an exploded assembly drawing including Bill of Materials (BOM). Groups work on the redesign of the desired components and print them to include in their exploded part display.

Day 11
Key Question: Are we on track with our designs?

The teacher should review the design process with the class and check with teams to assess progress with the design process. The teacher should review any known or perceived problems encountered with the designs so far. The class should also be reminded of the pace of part creation and the requirements needed of the exploded assemblies.

Students will continue to model using the software and using tutorials as necessary.

Day 12-15
Key Question: How can we put our new designs together?

Once the assemblies are together, completed and verified, the students can create an explosion of the assembly and print pieces for their exploded original product. The teacher should help the students gather the design into the final stage for the presentation drawings

Students start 3D printing the redesigned parts as they finish them.
Students should be 3D printing their redesigned parts and finishing assembly modeling, renderings working drawings, or other media for their presentations.

Day 16-17
Key Question: How does one plan and deliver a presentation to the class?

The teacher will discuss how to optimally present ideas to the class. Students should also be prepared to justify any design enhancements incorporated into the reversed engineered product. Students will continue to model using the software. Students finish the 3D print of their redesigned parts. Groups finalize their designs.

Students discuss the outline of their presentation to their clients. The deliverables could be in the form of a dimensioned working drawing, a pictorial representation with balloons, a bill of materials, with a 3D printed prototype and presentation of the original part totally disassembled. Students should also be prepared to justify any design enhancements they incorporated into their redesign of any parts. Decide on the types of graphics to include. Students should prepare an engineering report about the process of reverse engineering of the parts and information gained from the process. Students should be required to write the introduction, provide results including graphics and a conclusion with an acknowledgement section detailing the source of information. The rest of the report can be in outline format.

Day 18
Key Question: How do we convey our ideas?

Students can present their solutions to the class one at a time. In the end, all students can reflect on their work by giving and receiving feedback on how they could possibly improve their designs

Vocabulary:

Analysis
Assembly modeling
Bill of Materials
Boss
Chamfers

Clips
Dial Calipers
Disassemble
Disassembly and Resource Recovery
Documentation
Dovetail
Fasteners
Fillets
Functionality
Innovation
Invention
Keyway
Knurl
Non-destructive
Observation
Patent
Repurposing
Reverse engineering
Ribs
Rounds
Spline
Spotface
Threads

Resources:

CAD Tutorials

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012424/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012420/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012430/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012447/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012454/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012455/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012420/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012460/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012430/index.html

Assembly Tutorials

- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012424/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012454/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012455/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012460/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012451/index.html

Engineering Reports

- http://web.mit.edu/me-ugoffice/communication/technical-writing.pdf
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/writing_engineering_reports.html
- https://www.youtube.com/playlist?list=PLDAAF7A8FD5CD582C&feature=plcp
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/mechanical_engineering_writing_enhancement_program/report_writing.html
- https://owl.purdue.edu/owl/subject_specific_writing/professional_technical_writing/technical_reports_and_report_abstracts/reports_proposals_and_technical_papers.html

Industry Examples

- https://www.Ice.com/Mechanical-Component-Reverse-Engineering-Project-Examples-328.html
- https://www.asme.org/engineering-topics/articles/modeling-computational-methods/the-rise-of-reverse-engineering
- http://www.npd-solutions.com/remethodology.html
- https://www.asme.org/career-education/early-career-engineers/me-today/reverse-redesigning-everyday-products-leads
- http://slideplayer.com/slide/6084123/

Measuring with Calipers

- http://www.chicagobrand.com/help/dialcaliper.html
- https://www.youtube.com/watch?v=_7-6ALptqQQ
- http://www.aylj.com/en/expertise_dialcaliper.htm
- http://www.tresnainstrument.com/how_to_use_a_dial_caliper.html
- http://www.wikihow.com/Use-and-Read-Dial-Vernier-Caliper

Measuring with Micrometers

- http://www.popsci.com/diy/article/2009-10/basic-skills-micrometer
- https://www.miniphysics.com/how-to-read-a-micrometer-screw-gauge.html
- https://www.youtube.com/watch?v=i_jygJkJujE
- http://www.wikihow.com/Use-and-Read-an-Outside-Micrometer

Solid Edge Instructional Videos

Measure Minimum Distance

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=38

Assembly Modeling

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=35
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=36
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=37
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-quick-start/Ey8QWFP7d/chapters/solid-edge-quick-start/Nk1aTuvXd?topic=6

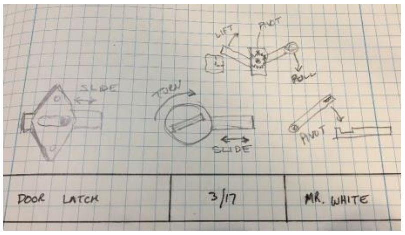
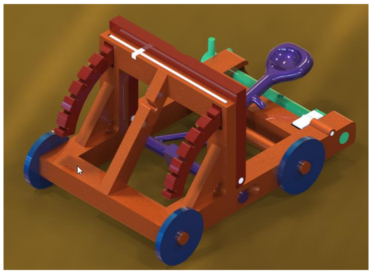
Assembly Example-Rowboat Video Collection

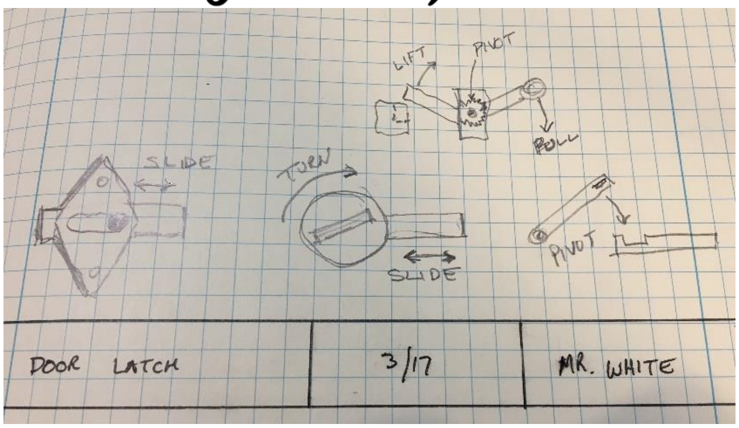
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/rowboat-mechanism-in-solid-edge/EJaWFRQRP

Working Drawings

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=26
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-quick-start/Ey8QWFP7d/chapters/solid-edge-quick-start/Nk1aTuvXd?topic=7

Projects Quarter 3

Simple Machines Select one • Bathroom Door Latch • Nutcracker	
Simple Machines • Ball Launcher	
Mechanical Systems • Differential Gear Design	
Mechanical Systems • Merry-Go-Round	



Project: Bathroom Door Latch

Introduction:

Simple machines have been used since ancient times helping humans in numerous ways to make work easier. All simple machines have a mechanical advantage which can be mathematically calculated and used in the design of products. This project is about designing a device to make it simpler to use by employing different types of simple machines and mechanisms.

Purpose of the Project:

The purpose of this project is to introduce students to the six types of simple machines and how they are used on a daily basis. Simple machines are basic devices used to make work easier. In this activity, the students will research the different types of simple machines and then create a solid model of one or several machines. They will demonstrate their design application of the simple machine(s) to the teacher and the class.

Concepts:

- Utilize mathematical analysis, scientific inquiry, and engineering design to develop solutions to open ended problems.
- Access, generate, process, and transfer information using appropriate technologies.
- Apply the design process in the design of a mechanical system.
- Read and analyze detailed descriptions of machinery and provide a concise summary for documentation purposes.

- Assign mathematical relationships to analyze mechanical advantage.
- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.

Outline:

Documentation

- Engineering Notebook-research of 6 simple machines and terms
- Documentation object to be designed

Modeling

- Creation of 3D model
- Assembly of 3D model
- Exploded drawing of 3D model
- Design renderings and pictorial exploded drawings
- Construct 3D prototype of door latch (if time allows)

Communication

- Presentation of design solutions

Standards:

Career and Technical Standards

Engineering Design Process

- Create and maintain an Engineering Notebook for daily reflections, research and prototype creation documentation.
- Apply the design and problem solving process as an iterative process incorporating sciences, mathematics and engineering to optimally convert resources to meet a stated objective.
- Communicate solutions utilizing technical writing skills including correct spelling, proper grammar and dependent vocabulary.
- Assume and carry out a role in the smooth running of a team working toward the solution of a problem.
- Assemble a quantitative plan for successful completion of the project.
- Assume responsibility for leadership roles and responsibility for actions, decisions products and policies in the governance of a project.
- Evaluate the need for and costs of resources necessary for the completion of a project.

Sketching

- Create sketches utilizing basic shapes such as lines circles and ellipses.
- Communicate ideas to a group through the use of sketches and other documentation.
- Apply isometric and orthographic sketches to add clarity to design.
- Create necessary sketches to communicate basic ideas during the design process.

3D Solid Modeling/Fabrication and 3-D Printing

- Apply geometric relationships between lines and shapes to create a mathematical database to describe design ideas.
- Create solid models utilizing concepts of Parametric Modeling.
- Analyze models for appropriate engineering design features needed.
- Develop strategies for the creation of solid models for the rapid creation of design solutions.
- Apply the concepts of digital prototyping to accelerate the time frame between ideation and completed project.
- Access, generate, process, and transfer information using appropriate technologies.
- Design and create a model using additive manufacturing technology sometimes called a rapid prototyping system.
- Apply new principles of more rapid and less costly development and deployment of new materials.
- Utilize rapid prototyping/additive manufacturing to create highly complex parts designed in a CAD system.

Renderings/Working Drawings/ Design Presentations

- Create renderings to communicate design ideas and engineering principles to the general public.
- Generate an image from a model utilizing light, texture and shading to create a proposed final appearance of a product.
- Apply rendering techniques to create presentations of design for a non-technical audience.

Assembly Modeling/Documentation/Exploded Assemblies/Bill of Materials

- Conduct model documentation as the process of recording details such as size, material composition, and instructions for assembling, installation and servicing, analysis, development process that describes a model for the purpose of communication of ideas.
- Create a bill of materials to communicate materials and other information about a design.

Reverse Engineering/Engineering Features

- Apply the principles of design for manufacturing enabling the efficient and effective production of products.
- Apply the green principles of design for eventual disassembly and resource recovery.
- Investigate activities that a business conducts with the intention of making a discovery that can either lead to the development of new products or procedures, or to improvement of existing products or procedures and to know the new approaches of rapid development and deployment that saves time and is more efficient.

- Disassemble a product into its parts, utilize precision measurement to create sketches, drawings and models of the product and identify the basic processes, systems, designs, and materials used in the manufacture of the product.
-

Simple Machines

- Utilize mathematical analysis, scientific inquiry and engineering design to develop solutions to open ended problems.
- Access, generate, process, and transfer information using appropriate technologies
- Apply the design process in the design of a mechanical system.
- Read and analyze detailed descriptions of machinery and provide a concise summary for documentation purposes.
- Assign mathematical relationships to analyze mechanical advantage.
- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.
- Assign mathematical relationships to analyze mechanical advantage.
- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.

College and Career Readiness Math Standards

Modeling with Geometry G-MG

Apply geometric concepts in modeling situations

1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).
2. Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot).
3. Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).

Create equations that describe numbers or relationships CED

A.4. Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.

Reading Standards for Literacy in History/Social Studies 9-10

Key Ideas and Details

1. Cite specific textual evidence to support analysis of primary and secondary sources, attending to such features as the date and origin of the information.

3. Analyze in detail a series of events described in a text; determine whether earlier events caused later ones or simply preceded them.

Integration of Knowledge and Ideas

7. Integrate quantitative or technical analysis (e.g., charts, research data) with qualitative analysis in print or digital text.

9. Compare and contrast treatments of the same topic in several primary and secondary sources.

Range of Reading and Level of Text Complexity

10. By the end of grade 10, read and comprehend science/technical texts in the grades 9–10 text complexity band independently and proficiently.

Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 9-10

Text Types and Purposes

1. Write arguments focused on *discipline-specific content.*
2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

Production and Distribution of Writing

4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Research to Build and Present Knowledge

7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.

Range of Writing

10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Next Generation Science Standards

The projects engage students in the scientific and engineering practices taken from the National Research Council's Framework for K-12 Science Education, Practices, Crosscutting Concepts, and Core Ideas. This is the document upon which the NGSS are based.

These practices are used for two reasons: 1) they parallel the design process utilized in each project, and 2) they serve as the foundation of the NGSS.

The eight science and engineering practices are:

1. Asking questions and defining problems

2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Standards for Technological Literacy

Standard 1
Students will develop an understanding of the characteristics and scope of technology.

Standard 2
Students will develop an understanding of the core concepts of technology.

Standard 3
Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Standard 4
Students will develop an understanding of the cultural, social, economic, and political effects of technology.

Standard 7
Students will develop an understanding of the influence of technology on history.

Standard 8
Students will develop an understanding of the attributes of design.

Standard 9
Students will develop an understanding of engineering design.

Standard 10
Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Standard 11
Students will develop the abilities to apply the design process.

Standard 12
Students will develop the abilities to use and maintain technological products and systems.

Standard 13
Students will develop the abilities to assess the impact of products and systems.

Standard 17
Students will develop an understanding of and be able to select and use information and communication technologies.

Standard 19
Students will develop an understanding of and be able to select and use manufacturing technologies.

Standard 20
Students will develop an understanding of and be able to select and use construction technologies.

Assessment:

Assessment is both formative and summative. It is an integral part of quality instruction. During the course of each project, one of the teacher's main functions is to work with student groups, keeping track of progress and providing formative assessment in the form of feedback and promoting reflection on the part of students. The focus should be on promoting lifetime learning and 21st century skills. The goal of instruction is to promote abilities in research, problem solving, designing, experimenting, testing, collecting and analyzing data.

Rubrics are used in the assessment process to communicate expectations of quality of a task. Rubrics should be shared with students at the beginning of a project so they can clarify any misconceptions before beginning their work. They can then build the skills and gather knowledge to solve the problem presented to the expectations of excellence described.

General Rubrics for Literacy tasks:
Argumentative_Pursuasive
Informational_Explanatory

Individual Project Rubric:
Bathroom Door Latch Rubric

Essential Question:

How can we design, build, and test a mechanical locking door latch for public bathroom stalls that will indicate if it is occupied or not?

Student Scenario:

When entering a public restroom, it is first necessary to investigate which stalls are occupied and which are not. In many cases this is not always a simple procedure. A plumbing supply contractor has asked your team to design a locking latch mechanism with a built-in indicator for public restroom stall doors. Your prototype should be appropriately sized and use several simple machines so it can be easily operated. The students will choose a design, calculate its mechanical advantage, and then create it using the software. You will create the solid model and verify its characteristics by printing and building a prototype. You will also be responsible for giving a short presentation about your door latch design, highlighting your favorite characteristics.

The research and learning activities are designed to help students:

- Discover the elements of a door latch
- Use mathematical formulas to aid in the design of a product
- Utilize specific software features to create a solid model of their idea.
- Communicate their solution to their peers

Deliverables include:

- Engineering Notebook
- CAD model
- 3D printed model
- Engineering Report that includes 3D images and working and assembly drawings
- Presentation of the development process

Daily Plan:

Day 1
Key Question: What are the expectations of the project?

Introduce students to the project by providing them with the Essential Question and the scenario.

Review and discuss with your students the design process, Engineering Notebook and design documentation requirements. Discuss the problem statement, design brief, testing protocol and management plan. Review the elements of a good engineering report with the students. These were all covered in the first project titled *Introduction to the Engineering Design Process* but should be reinforced on a regular basis. All projects depend on the design process and student activities should relate directly.

Have the students form teams of two. Allow the students five minutes to discuss the problem. Students begin by brainstorming ideas in their Engineering Notebooks. The teacher will provide a list of vocabulary terms that students will need to research on their own. The teams can divide the list of terms among team members and share their definitions. All team members are responsible to know all definitions.

Day 2-4
Key Question: How do we get started in the design process?

The teams will be responsible for researching simple machines and mechanical advantage. Links can be found in the Resources section. The client will specify the necessary characteristics of the door latch.

NOTE: The teacher will decide how the “client” and the client’s needs for the project are to be represented.

The teacher will lead a group discussion on the specifications of the door latch such as the size and what simple machines it might include. Students should be refining their simple machine sketches in their Engineering Notebooks as well as the mechanical advantage calculations associated with each one. Students begin sketching in their Engineering Notebooks. NOTE: The teacher will decide how the “client” and the client’s needs for the project are to be represented.

The teacher reminds students about the help system to find out how the software accomplishes basic features they might want to incorporate.
https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index
Students can enter terms to view a tutorial for creating certain features. Students can reference specific terms from the vocabulary list for specific commands to be used in the design of the door latch.

Student teams discuss the specifications of the door latch. Students list the criteria and constraints of the problem they are solving. Teams research the existing door latches and discover information about which features are important to customers. The teams will use formulas to calculate mechanical advantage and dictate the shape of the latch. Students should be refining their sketches in the Engineering Notebook.

Remind students to record research notes and sources as well as reflections on the day in the Engineering Notebook.

The teacher will provide access to the following video tutorials that will provide students with information about the basics of mechanism design. They can also access Siemens Solid Edge Video Resources to allow students to discover further elements to help their designs.

Solid Edge Instructional Videos

Engineering Reference Command for designing Gears, CAMs Pulleys etc.

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1323753:index_xid718565

Introduction to Mechanisms

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-01-introduction/VJ-5mlGyO?topic=1

CAM and Follower

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=1

Day 5-6
Key Question: How do we get started on our individual designs?

Student teams finish creating their isometric sketches and create a design brief to include with their sketch. Then include measurements and mechanical advantage formulas. They then meet with the client who will need to sign off on the design proposal before solid modeling can begin.

Students can reference Basic 3D Commands, Creating Drawing Views and Assembly Modeling and Working with Bodies for specific commands to use in the door latch design. Students can reference web links, videos, and tutorials at any time during the process of the simple machine design.

Day 7-8
Key Question: How can we begin to make our door latch design?

Teams discuss their door latch and how to achieve the design of the latch using the approved sketch. The students work together to design the latch and then divide the work of creating the 3D solid model of the pieces needed. They utilize the division of work in the creation of their project management plan.

Teams are reminded to continually check their solid models to ensure the sizes are accurate. Student teams also discuss how the various components fit and work together.

Students can review tutorials as necessary. Students record sketches and reflections in the Engineering Notebook. Once the students feel they have a latch solution that meets the requirements, consider how easily someone will be able to tell if the stall is occupied.

The students should start by modeling the components of the latch design, staying within the size parameters specified by the teacher.

Day 9-10
Key Question: How can we put our new designs together?

The teacher will review assembly methods necessary for students to be able to virtually create their latch design and assemble the latch in the software. The teacher should review the design process with the class. Then check in with teams to assess their progress with the design process and any known or perceived problems encountered with the latch designs. Students should animate the assembly to demonstrate how the latch functions by creating a motor to drive the assembly. Students can revisit the assembly modeling document if needed. See the sections on Gear Relationships, Motors and Animating an Assembly in the Introduction to Assemblies Activity.

Day 11
Key Question: How can we use Solid Edge to demonstrate how the new latch design functions?

Once the assemblies are together, completed, and verified, the students can create an exploded drawing of the assembly. The teacher should help the students gather the design into the final stage for the presentation drawings. Students analyze their parts and check animations for collisions.

Students start 3D printing their simple machine designs for the door latch as they finish them. While students are finishing their 3D printing of their door latch they also finish assembly modeling, renderings working drawings, or other media for their presentations.

Day 12
Key Question: How do we organize our thoughts in a presentation to the class?

The teacher will discuss how to optimally present their ideas to the class. Students should also be prepared to justify any design enhancements incorporated into the stall door latch design. Students finish the 3D print of their door latch parts. Teams assemble the components that make up their designs.

Students discuss the outline of their presentation. The deliverables could be in the form of a dimensioned working drawing, pictorial representation with balloons, and bill of materials with a 3D printed prototype. Students should also be prepared to justify any design enhancements they incorporated into their door latch. Students discuss the items needed in their presentation to their clients. The team decides on the types of graphics to include. Students should prepare an Engineering Report about the process of designing the kitchen tool. They should be required to write the introduction, provide results including graphics, and a conclusion including an acknowledgement section reporting the sources of information. The rest of the report can be in outline format.

Day 13
Key Question: How do we convey our ideas?

Students present their solutions to the class one at a time. In the end, all students can reflect on their work by giving and receiving feedback on how they could possibly improve their designs.

Vocabulary:

1st class lever
2nd class lever
3rd class lever
Distance
Energy
Force
Fulcrum
Inclined plane
Lever
Mechanical advantage
Mechanisms
Pulley
Screw
Simple machine
Wedge
Wheel and axle
Work

Resources:

CAD Tutorials

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012424/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012420/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012430/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012447/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012454/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012455/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012420/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012460/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012430/index.html

Assembly Tutorials

- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012424/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012454/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012455/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012460/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012451/index.html

Engineering Reference Command for designing Gears, CAMs Pulleys etc.

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1323753:index_xid718565

Solid Edge Robotics and Mechanisms Course

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku

Engineering Reports

- http://web.mit.edu/me-ugoffice/communication/technical-writing.pdf
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/writing_engineering_reports.html
- https://www.youtube.com/playlist?list=PLDAAF7A8FD5CD582C&feature=plcp
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/mechanical_engineering_writing_enhancement_program/report_writing.html
- https://owl.purdue.edu/owl/subject_specific_writing/professional_technical_writing/technical_reports_and_report_abstracts/reports_proposals_and_technical_papers.html

Mechanical Advantage

- http://www.wisegeek.com/what-is-mechanical-advantage.htm
- http://study.com/academy/lesson/mechanical-advantage-definition-formula.html

Project Background

- http://www.allpartitions.com/harmospoplat.html
- https://www.jacknob.com/

Simple Machines Java applet

- http://www.walter-fendt.de/ph14e/
- http://idahoptv.org/sciencetrek/topics/simple_machines/facts.cfm
- https://phet.colorado.edu/en/search?q=simple+machines

Introduction to Mechanisms

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-01-introduction/VJ-5mlGyO?topic=1

CAM and Follower

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=1

Beginning CAM Motion

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=2

Common CAM Types

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=1
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=2
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=3

CAM Physical Motion

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-04-cam-vice-lock-scissors/4JThnbf1d?topic=2

Circular vs. Arc

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-04-cam-vice-lock-scissors/4JThnbf1d?topic=3

Four Bar Mechanisms

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFIzzJ_?topic=0

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=1
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=2
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=3
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=4
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=4

Motion Concepts

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-09-motion-concepts/NytArMfyu?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-09-motion-concepts/NytArMfyu?topic=1

Assembly Example-Rowboat Video Collection

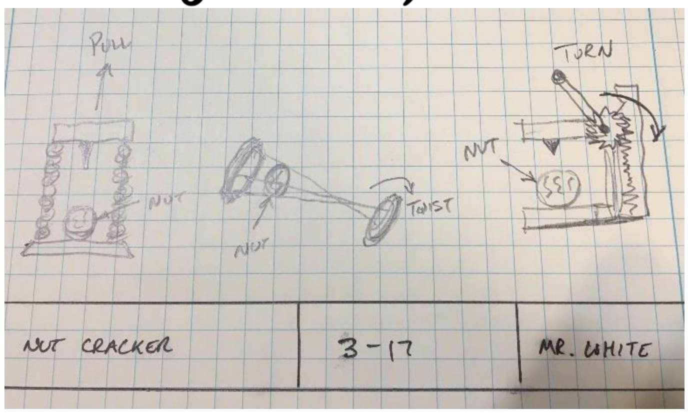
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/rowboat-mechanism-in-solid-edge/EJaWFRQRP

Solid Edge Gear Designer

- https://www.youtube.com/watch?v=_VDfFkPHpxM
- https://www.youtube.com/watch?v=2PR_ByClOM0
- https://www.youtube.com/watch?v=ybLeWmWJTMc
- https://www.youtube.com/watch?v=2AL68JMIkSc
- https://www.youtube.com/watch?v=OrK7c3EGd_0

Videos

- https://www.khanacademy.org/science/physics/work-and-energy/mechanical-advantage/v/introduction-to-mechanical-advantage
- https://www.youtube.com/watch?v=UtfVZtuyuHU
- https://www.youtube.com/watch?v=fvOmaf2GfCY



Project: Nutcracker

Introduction:
Simple machines have been used since ancient times helping humans in numerous ways to make work easier. All simple machines have a mechanical advantage which can be mathematically calculated and used in the design of products. This project is about designing a device to make it simpler to use by employing different types of simple machines and mechanisms.

Purpose of the Project:
The purpose of this project is to introduce students to the six types of simple machines and how they are used on a daily basis. In this activity, the students will research the different types of simple machines and then design a solid model containing several types, also known as a compound machine. Teams will demonstrate their design application of the simple machine(s) in a presentation to the class.

Concepts:
- Utilize mathematical analysis, scientific inquiry, and engineering design to develop solutions to open ended problems.
- Access, generate, process, and transfer information using appropriate technologies.
- Apply the design process in the design of a mechanical system.
- Read and analyze detailed descriptions of machinery and provide a concise summary for documentation purposes.
- Assign mathematical relationships to analyze mechanical advantage.

- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.

Outline:

Documentation

Engineering Notebook-research of 6 simple machines and terms
Documentation object to be designed

Modeling

Creation of 3D model
Assembly of 3D model
Exploded drawing of 3D model
Design renderings and pictorial exploded drawings
Construct 3D prototype of nutcracker (if time allows)

Communication

Presentation of design solutions and calculations

Standards:

Career and Technical Standards

Engineering Design Process

- Create and maintain an Engineering Notebook for daily reflections, research and prototype creation documentation.
- Apply the design and problem solving process as an iterative process incorporating sciences, mathematics and engineering to optimally convert resources to meet a stated objective.
- Communicate solutions utilizing technical writing skills including correct spelling, proper grammar and dependent vocabulary.
- Assume and carry out a role in the smooth running of a team working toward the solution of a problem.
- Assemble a quantitative plan for successful completion of the project.
- Assume responsibility for leadership roles and responsibility for actions, decisions products and policies in the governance of a project.
- Evaluate the need for and costs of resources necessary for the completion of a project.

Sketching

- Create sketches utilizing basic shapes such as lines circles and ellipses.
- Communicate ideas to a group through the use of sketches and other documentation.
- Apply isometric and orthographic sketches to add clarity to design.
- Create necessary sketches to communicate basic ideas during the design process.

3D Solid Modeling/Fabrication and 3-D Printing

- Apply geometric relationships between lines and shapes to create a mathematical database to describe design ideas.

- Create solid models utilizing concepts of Parametric Modeling.
- Analyze models for appropriate engineering design features needed.
- Develop strategies for the creation of solid models for the rapid creation of design solutions.
- Apply the concepts of digital prototyping to accelerate the time frame between ideation and completed project.
- Access, generate, process, and transfer information using appropriate technologies.
- Design and create a model using additive manufacturing technology sometimes called a rapid prototyping system.
- Apply new principles of more rapid and less costly development and deployment of new materials.
- Utilize rapid prototyping/additive manufacturing to create highly complex parts designed in a CAD system.

Renderings/Working Drawings/ Design Presentations

- Create renderings to communicate design ideas and engineering principles to the general public.
- Generate an image from a model utilizing light, texture and shading to create a proposed final appearance of a product.
- Apply rendering techniques to create presentations of design for a non-technical audience.

Assembly Modeling/Documentation/Exploded Assemblies/Bill of Materials

- Conduct model documentation as the process of recording details such as size, material composition, and instructions for assembling, installation and servicing, analysis, development process that describes a model for the purpose of communication of ideas.
- Create a bill of materials to communicate materials and other information about a design.

Reverse Engineering/Engineering Features

- Apply the principles of design for manufacturing enabling the efficient and effective production of products.
- Apply the green principles of design for eventual disassembly and resource recovery.
- Investigate activities that a business conducts with the intention of making a discovery that can either lead to the development of new products or procedures, or to improvement of existing products or procedures and to know the new approaches of rapid development and deployment that saves time and is more efficient.
- Disassemble a product into its parts, utilize precision measurement to create sketches, drawings and models of the product and identify the basic processes, systems, designs, and materials used in the manufacture of the product.

Simple Machines

- Utilize mathematical analysis, scientific inquiry and engineering design to develop solutions to open ended problems.
- Access, generate, process, and transfer information using appropriate technologies
- Apply the design process in the design of a mechanical system.
- Read and analyze detailed descriptions of machinery and provide a concise summary for documentation purposes.
- Assign mathematical relationships to analyze mechanical advantage.
- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.
- Assign mathematical relationships to analyze mechanical advantage.
- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.

College and Career Readiness Math Standards

Modeling with Geometry G-MG

Apply geometric concepts in modeling situations

1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).
2. Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot).
3. Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).

Create equations that describe numbers or relationships CED

A.4. Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.

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Reading Standards for Literacy in History/Social Studies 9-10

Key Ideas and Details

1. Cite specific textual evidence to support analysis of primary and secondary sources, attending to such features as the date and origin of the information.

3. Analyze in detail a series of events described in a text; determine whether earlier events caused later ones or simply preceded them.

Integration of Knowledge and Ideas

7. Integrate quantitative or technical analysis (e.g., charts, research data) with qualitative analysis in print or digital text.

9. Compare and contrast treatments of the same topic in several primary and secondary sources.

Range of Reading and Level of Text Complexity

10. By the end of grade 10, read and comprehend science/technical texts in the grades 9–10 text complexity band independently and proficiently.

Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 9-10

Text Types and Purposes

1. Write arguments focused on *discipline-specific content.*
2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

Production and Distribution of Writing

4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Research to Build and Present Knowledge

7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.

Range of Writing

10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Next Generation Science Standards

The projects engage students in the scientific and engineering practices taken from the National Research Council's Framework for K-12 Science Education, Practices, Crosscutting Concepts, and Core Ideas. This is the document upon which the NGSS are based.

These practices are used for two reasons: 1) they parallel the design process utilized in each project, and 2) they serve as the foundation of the NGSS.

The eight science and engineering practices are:

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data

5. Using mathematics and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Standards for Technological Literacy

Standard 1
Students will develop an understanding of the characteristics and scope of technology.

Standard 2
Students will develop an understanding of the core concepts of technology.

Standard 3
Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Standard 7
Students will develop an understanding of the influence of technology on history.

Standard 8
Students will develop an understanding of the attributes of design.

Standard 9
Students will develop an understanding of engineering design.

Standard 10
Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Standard 11
Students will develop the abilities to apply the design process.

Standard 12
Students will develop the abilities to use and maintain technological products and systems.

Standard 13
Students will develop the abilities to assess the impact of products and systems.

Standard 17
Students will develop an understanding of and be able to select and use information and communication technologies.

Standard 19
Students will develop an understanding of and be able to select and use manufacturing technologies.

Standard 20
Students will develop an understanding of and be able to select and use construction technologies.

Assessment:

Assessment is both formative and summative. It is an integral part of quality instruction. During the course of each project, one of the teacher's main functions is to work with student groups, keeping track of progress and providing formative assessment in the form of feedback and promoting reflection on the part of students. The focus should be on promoting lifetime learning and 21st century skills. The goal of instruction is to promote abilities in research, problem solving, designing, experimenting, testing, collecting and analyzing data.

Rubrics are used in the assessment process to communicate expectations of quality. Rubrics should be shared with students at the beginning of a project to clarify any misconceptions before beginning their work. Students can then build the skills and gather knowledge to solve the problem presented to the expectations of excellence described.

General Rubrics for Literacy tasks:
Argumentative_Pursuasive
Informational_Explanatory

Individual Project Rubric:
Nutcracker Project Rubric

Essential Question:

How can we design a device to easily and mechanically crack or break the outer shell of a tree nut?

Student Scenario:

Certain tree nuts purchased by consumers have a very hard shell. You are part of a home goods store design team charged with making a themed nutcracker that will easily break the hard-outer shell of a nut. It should be any theme of your choice and designed using several simple machines to result in an easy operation. The students will choose a design, calculate its mechanical advantage, and then create it using the software.

The research and learning activities are designed to help students:

- Discover the forces and simple machines
- Use mathematical formulas to aid in the design of a product

- Utilize specific software features to create a solid model of their idea
- Communicate their solution to their peers

Deliverables include:

- Engineering Notebook
- CAD model
- 3D printed model
- Engineering Report that includes 3D images and working and assembly drawings
- Presentation of the development process

Daily Plan:

Day 1
Key Question: What are the expectations of the project?

Introduce students to the project by providing them with the Essential Question and the scenario.

Review and discuss with your students the design process, Engineering Notebook and design documentation requirements. Discuss the problem statement, design brief, testing protocol and management plan. Review the elements of a good engineering report with the students. These were all covered in the first project titled *Introduction to the Engineering Design Process* but should be reinforced on a regular basis. All projects depend on the design process and student activities should relate directly.

Have the students form teams of two. Allow the students five minutes to discuss the problem. Students begin by brainstorming ideas in their Engineering Notebooks. The teacher will provide a list of vocabulary terms that students will need to research on their own. The teams can divide the list of terms among team members and share their definitions. All team members are responsible to know all definitions.

Day 2-4
Key Question: How do we get started in the design process?

The teams will be responsible for researching simple machines and mechanical advantage. Links can be found in the resources section. The client should specify the necessary characteristics of the nutcracker. The teacher will lead a group discussion on the specifications of the nutcracker such as the size and the simple machines it might include. Students should be refining their simple machine sketches in their Engineering Notebooks as well as the mechanical advantage calculations associated with each one. Students begin sketching in their Engineering Notebooks. NOTE: The teacher will decide how the “client” and the client’s needs for the project are to be represented.

The teacher reminds students about the help system to find out how the software accomplishes basic features they might want to incorporate. https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index Students can enter terms to view a tutorial for creating certain features. Students can reference specific terms from the vocabulary list for specific commands to be used in the design of the nutcracker.

The teacher will provide access to the following video tutorials that will provide students with information about the basics of mechanism design. They can also access Siemens Solid Edge Video Resources to allow students to discover further elements to help their designs.

Engineering Reference Command for designing Gears, CAMs Pulleys etc.

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1323753:index_xid718565

Introduction to Mechanisms

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-01-introduction/VJ-5mlGyO?topic=1

CAM and Follower

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=0

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=1

Student teams discuss the specifications of the nutcracker. Students list the criteria and constraints of the problem they are solving. Teams research the existing nutcrackers and discover information about which features are important to customers. The teams will use formulas to calculate mechanical advantage and dictate the shape of the nutcracker. Students should be refining their sketches in the Engineering Notebook.

Remind students to record research notes and sources as well as reflections on the day in the Engineering Notebook.

Day 5-6
Key Question: How do we get started on our individual designs?

Student teams finish creating their isometric sketches and create a design brief to include with their sketch. Then include measurements and mechanical advantage formulas. They then meet with their client who will need to sign off on the design proposal before solid modeling can begin.

Students can reference Basic 3D Commands, Creating Drawing Views and Assembly Modeling and Working with Bodies for specific commands to use in the door latch design. Students can reference web links, videos, and tutorials at any time during the process of the simple machine design.

Day 7-8
Key Question: How can we begin to make our nutcracker design?

Teams discuss their nutcracker and how to achieve the design of the nutcracker given the approved sketch presented. They work together to design the nutcracker and divide the work of creating the 3D solid models of the pieces needed. They utilize the division of work in the creation of their project management plan.

Teams are reminded to continually check their solid models to ensure the sizes are accurate. Student teams also discuss how the various components fit and work together.

Students can review tutorials as necessary. Students record sketches and reflections in the Engineering Notebook. Once the students feel they have a solution that meets the requirements of the nutcracker, consider how varying nut sizes will be handled.

The students should start by modeling the components of the nutcracker design staying within the size parameters specified by the teacher.

Day 9-10
Key Question: How can we put our new designs together?

The teacher will review assembly methods to enable students to virtually create their nutcracker design and assemble the nutcracker in the software. The teacher should review the design process with the class and check with teams to assess their progress with the design process and any known or perceived problems encountered with the nutcracker design. Students should animate the assembly to demonstrate how the nutcracker functions by creating a motor to drive the assembly. Students can revisit the assembly modeling document if needed. See the sections on Gear Relationships, Motors and Animating an Assembly in the Introduction to Assemblies Activity.

Day 11
Key Question: How can we take our designs apart to demonstrate how they function?

Once the assemblies are together, completed and verified, the students can create an exploded drawing of the assembly. The teacher should help the students gather the design into the final stage for the presentation drawings. Students analyze their parts and check animations for collisions.

Students start 3D printing their simple machine designs for the nutcracker as they finish them.

While students are finishing their 3D printing of their nutcracker, they also finish assembly modeling, renderings working drawings or other media for their presentations.

Day 12
Key Question: How do we organize our thoughts in a presentation to the class?

The teacher will discuss with the students how to optimally present their ideas to the class. Students should also be prepared to justify any design enhancements incorporated into the nutcracker design. Students finish the 3D print of their nutcracker parts. Teams assemble the components that make up their designs.

Students discuss the outline of their presentation. The deliverables could be in the form of a dimensioned working drawing, pictorial representation with balloons, and bill of materials with a 3D printed prototype. Students should also be prepared to justify any design enhancements incorporated into their nutcracker. Students discuss the items needed in their presentation. The team decides on the types of graphics to include. Students should prepare an Engineering Report about the process of designing the kitchen tool. They should be required to write the introduction, provide results including graphics, and a conclusion including an acknowledgement sections reporting the source of the information. The rest of the report can be in outline format.

Day 13
Key Question: How do we convey our ideas?

Students can present their solutions to the class one at a time. In the end, all students can reflect on their work by giving and receiving feedback on how they could possibly improve their designs.

Vocabulary:

1st class lever
2nd class lever
3rd class lever
Distance
Energy
Force
Fulcrum
Inclined plane
Lever

Mechanical advantage
Mechanisms
Pulley
Screw
Simple machine
Wedge
Wheel and axle
Work

Resources:

CAD Tutorials

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012424/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012420/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012430/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012447/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012454/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012455/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012420/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012460/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012430/index.html

Assembly Tutorials

- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012424/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012454/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012455/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012460/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012451/index.html

Engineering Reference Command for designing Gears, CAMs Pulleys etc.

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1323753:index_xid718565

Solid Edge Robotics and Mechanisms Course

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku

Engineering Reports

- http://web.mit.edu/me-ugoffice/communication/technical-writing.pdf
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/writing_engineering_reports.html
- https://www.youtube.com/playlist?list=PLDAAF7A8FD5CD582C&feature=plcp
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/mechanical_engineering_writing_enhancement_program/report_writing.html
- https://owl.purdue.edu/owl/subject_specific_writing/professional_technical_writing/technical_reports_and_report_abstracts/reports_proposals_and_technical_papers.html

Mechanical Advantage

- http://www.wisegeek.com/what-is-mechanical-advantage.htm
- http://study.com/academy/lesson/mechanical-advantage-definition-formula.html

Project Background:

- http://www.allpartitions.com/harmospoplat.html
- https://www.jacknob.com/

Simple Machines Java Applet:

- http://www.walter-fendt.de/ph14e/
- http://idahoptv.org/sciencetrek/topics/simple_machines/facts.cfm
- https://phet.colorado.edu/en/search?q=simple+machines

Solid Edge Instructional Videos

Introduction to Mechanisms

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-01-introduction/VJ-5mlGyO?topic=1

CAM and Follower

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=1

Beginning CAM Motion

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=2

Common CAM Types

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=1
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=2
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=3

CAM Physical Motion

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-04-cam-vice-lock-scissors/4JThnbf1d?topic=2

Circular vs. Arc

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-04-cam-vice-lock-scissors/4JThnbf1d?topic=3

Four Bar Mechanisms

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=1
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=2
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=3
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=4
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=4

Motion Concepts

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-09-motion-concepts/NytArMfyu?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-09-motion-concepts/NytArMfyu?topic=1

Assembly Example-Rowboat Video Collection

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/rowboat-mechanism-in-solid-edge/EJaWFRQRP

Assembly Example-Rowboat Video Collection

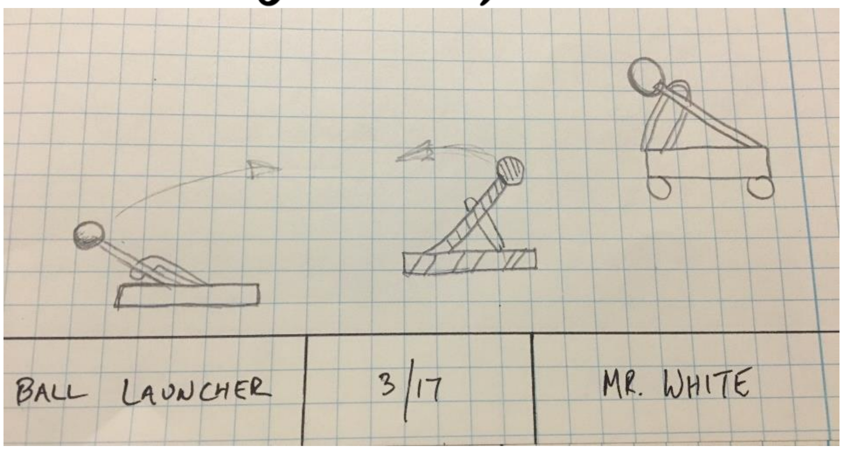
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/rowboat-mechanism-in-solid-edge/EJaWFRQRP

Solid Edge Gear Designer

- https://www.youtube.com/watch?v=_VDfFkPHpxM
- https://www.youtube.com/watch?v=2PR_ByClOM0
- https://www.youtube.com/watch?v=ybLeWmWJTMc
- https://www.youtube.com/watch?v=2AL68JMIkSc
- https://www.youtube.com/watch?v=OrK7c3EGd_0

Videos

- https://www.khanacademy.org/science/physics/work-and-energy/mechanical-advantage/v/introduction-to-mechanical-advantage
- https://www.youtube.com/watch?v=UtfVZtuyuHU
- https://www.youtube.com/watch?v=fvOmaf2GfCY



Project: Ball Launcher

Introduction:
Historically, the **catapult** was invented to be the most powerful mechanism available at the time, to conduct warfare, by throwing projectile objects such as stones, pots of fire, and sharp poles. Projectiles were launched by humans pulling ropes or with a counterweight attached. Today a similar version is still used on ships to deploy planes from short runways and in a wide variety of toys**.**

Purpose of the Project:
The purpose of this project is to introduce students to the mathematics behind the launching, predictable flight behavior, and data acquisition to create a mathematical model that can predict a flight distance and a landing spot of a launched projectile. Students will design and construct a device that will launch a ball accurately to a specific point within a given range. They will learn about forces and motion through designing a ping pong ball launcher. They will test their acquired knowledge by trying to hit a provided target on the first try. Students will design and model necessary parts, assemble them, and present their exploded drawings and Excel data and formula to the class. The catapult components will be 3D printed, assembled, and tested as the final demonstration of the design solution.

Concepts:
- Discover the relationship between launch angle and distance.
- Create renderings to communicate design ideas and engineering principles to an audience.

- Utilize mathematical analysis, scientific inquiry, and engineering design to develop solutions to open ended problems.
- Apply the design process in the design of a mechanical system.
- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.
- Create a bill of materials to communicate materials and other information about a design.

Outline:

Documentation
- Engineering Notebook
- Documentation object to be designed

Modeling
- Creation of 3D model
- Assembly of 3D model
- Design renderings and pictorial exploded drawings
- Construct 3D model of launcher

Communication
- Presentation of design solutions

Standards:

Career and Technical Standards

Engineering Design Process

- Create and maintain an Engineering Notebook for daily reflections, research and prototype creation documentation.
- Apply the design and problem solving process as an iterative process incorporating sciences, mathematics and engineering to optimally convert resources to meet a stated objective.
- Communicate solutions utilizing technical writing skills including correct spelling, proper grammar and dependent vocabulary.
- Assume and carry out a role in the smooth running of a team working toward the solution of a problem.
- Assemble a quantitative plan for successful completion of the project.
- Assume responsibility for leadership roles and responsibility for actions, decisions products and policies in the governance of a project.
- Evaluate the need for and costs of resources necessary for the completion of a project.

Sketching

- Create sketches utilizing basic shapes such as lines circles and ellipses.
- Communicate ideas to a group through the use of sketches and other documentation.
- Apply isometric and orthographic sketches to add clarity to design.
- Create necessary sketches to communicate basic ideas during the design process.

3D Solid Modeling/Fabrication and 3-D Printing

- Apply geometric relationships between lines and shapes to create a mathematical database to describe design ideas.
- Create solid models utilizing concepts of Parametric Modeling.
- Analyze models for appropriate engineering design features needed.
- Develop strategies for the creation of solid models for the rapid creation of design solutions.
- Apply the concepts of digital prototyping to accelerate the time frame between ideation and completed project.
- Access, generate, process, and transfer information using appropriate technologies.
- Design and create a model using additive manufacturing technology sometimes called a rapid prototyping system.
- Apply new principles of more rapid and less costly development and deployment of new materials.
- Utilize rapid prototyping/additive manufacturing to create highly complex parts designed in a CAD system.

Renderings/Working Drawings/ Design Presentations

- Create renderings to communicate design ideas and engineering principles to the general public.
- Generate an image from a model utilizing light, texture and shading to create a proposed final appearance of a product.
- Apply rendering techniques to create presentations of design for a non-technical audience.

Assembly Modeling/Documentation/Exploded Assemblies/Bill of Materials

- Conduct model documentation as the process of recording details such as size, material composition, and instructions for assembling, installation and servicing, analysis, development process that describes a model for the purpose of communication of ideas.
- Create a bill of materials to communicate materials and other information about a design.

Reverse Engineering/Engineering Features

- Apply the principles of design for manufacturing enabling the efficient and effective production of products.
- Apply the green principles of design for eventual disassembly and resource recovery.
- Investigate activities that a business conducts with the intention of making a discovery that can either lead to the development of new products or procedures, or to improvement of existing products or procedures and to know the new approaches of rapid development and deployment that saves time and is more efficient.

- Disassemble a product into its parts, utilize precision measurement to create sketches, drawings and models of the product and identify the basic processes, systems, designs, and materials used in the manufacture of the product.

Simple Machines

- Utilize mathematical analysis, scientific inquiry and engineering design to develop solutions to open ended problems.
- Access, generate, process, and transfer information using appropriate technologies
- Apply the design process in the design of a mechanical system.
- Read and analyze detailed descriptions of machinery and provide a concise summary for documentation purposes.
- Assign mathematical relationships to analyze mechanical advantage.
- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.
- Assign mathematical relationships to analyze mechanical advantage.
- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.

Mechanical systems

- Utilize mathematical analysis, scientific inquiry and engineering design to develop solutions to open ended problems.
- Access, generate, process, and transfer information using appropriate technologies.
- Apply the design process in the design of a mechanical system.
- Read and analyze detailed descriptions of machinery and provide a concise summary for documentation purposes.
- Assign mathematical relationships to schematics to apply forces.
- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.

College and Career Readiness Math Standards

Modeling with Geometry G-MG

Apply geometric concepts in modeling situations

1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).
2. Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot).
3. Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).

Create equations that describe numbers or relationships CED

A.4. Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.

Reading Standards for Literacy in History/Social Studies 9-10

Key Ideas and Details

1. Cite specific textual evidence to support analysis of primary and secondary sources, attending to such features as the date and origin of the information.
3. Analyze in detail a series of events described in a text; determine whether earlier events caused later ones or simply preceded them.

Integration of Knowledge and Ideas

7. Integrate quantitative or technical analysis (e.g., charts, research data) with qualitative analysis in print or digital text.
9. Compare and contrast treatments of the same topic in several primary and secondary sources.

Range of Reading and Level of Text Complexity

10. By the end of grade 10, read and comprehend science/technical texts in the grades 9–10 text complexity band independently and proficiently.

Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 9-10

Text Types and Purposes

1. Write arguments focused on *discipline-specific content.*
2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

Production and Distribution of Writing

4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Research to Build and Present Knowledge

7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.

Range of Writing

10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Next Generation Science Standards
The projects engage students in the scientific and engineering practices taken from the National Research Council's Framework for K-12 Science Education, Practices, Crosscutting Concepts, and Core Ideas. This is the document upon which the NGSS are based.

These practices are used for two reasons: 1) they parallel the design process utilized in each project, and 2) they serve as the foundation of the NGSS.

The eight science and engineering practices are:
1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Standards for Technological Literacy

Standard 1
Students will develop an understanding of the characteristics and scope of technology.

Standard 2
Students will develop an understanding of the core concepts of technology.

Standard 3
Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Standard 7
Students will develop an understanding of the influence of technology on history.

Standard 8
Students will develop an understanding of the attributes of design.

Standard 9
Students will develop an understanding of engineering design.

Standard 10
Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Standard 11
Students will develop the abilities to apply the design process.

Standard 12
Students will develop the abilities to use and maintain technological products and systems.

Standard 13
Students will develop the abilities to assess the impact of products and systems.

Standard 17
Students will develop an understanding of and be able to select and use information and communication technologies.

Standard 19
Students will develop an understanding of and be able to select and use manufacturing technologies.

Standard 20
Students will develop an understanding of and be able to select and use construction technologies.

Assessment:

Assessment is both formative and summative. It is an integral part of quality instruction. During the course of each project, one of the teacher's main functions is to work with student groups, keeping track of progress and providing formative assessment in the form of feedback and promoting reflection on the part of students. The focus should be on promoting lifetime learning and 21st century skills. The goal of instruction is to promote abilities in research, problem solving, designing, experimenting, testing, collecting and analyzing data.

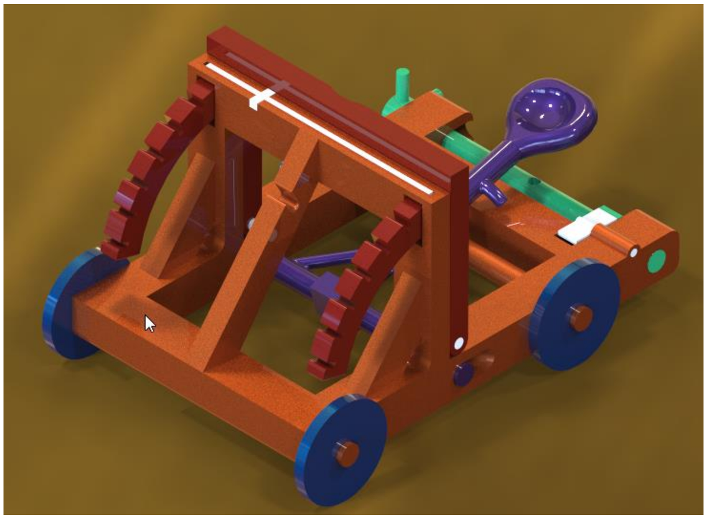
Rubrics are used in the assessment process to communicate expectations of quality. Rubrics should be shared with students at the beginning of a project to clarify any misconceptions before beginning their work. Students can then build the skills and gather knowledge to solve the problem presented to the expectations of excellence described.

General Rubrics for Literacy tasks:
Argumentative_Pursuasive
Informational_Explanatory

Individual Project Rubric:
Ball Launcher Rubric

Essential Question:

How can we design and test a device that will launch an object within a given range to a specified point on the first try?



Student Scenario:

A toy designer has asked your engineering firm to design a ball launching device. This device will be used to launch a ping pong ball into a container. The container will be placed at some point between 10 and 20 feet from the launch point. The design must have methods to adjust the ball launching angle and/or force to acquire predictable and variable ball landings. Performance repeatability is a key criteria.

The research and learning activities are designed to help students:

- Use mathematical formulas to aid in the design and testing of a product
- Utilize specific software features to create a solid model of their idea
- Communicate their solution to their peers

Deliverables include:

- Engineering Notebook
- CAD model
- 3D printed model
- Engineering Report that includes 3D images and working and assembly drawings
- Presentation of the development process along with a demonstration of their device

Daily Plan:

Day 1

Key Question: What are the expectations of the project?

Introduce students to the project by providing them with the Essential Question and the scenario.

Review and discuss with your students the design process, Engineering Notebook and design documentation requirements. Discuss the problem statement, design brief, testing protocol and management plan. Review the elements of a good engineering report with the students. These were all covered in the first project titled *Introduction to the Engineering Design Process* but should be reinforced on a regular basis. All projects depend on the design process and student activities should relate directly.

Have the students form teams of two. Allow the students five minutes to discuss the problem. Students begin by brainstorming ideas in their Engineering Notebooks. The teacher will provide a list of vocabulary terms that students will need to research on their own. The teams can divide the list of terms among team members and share their definitions. All team members are responsible to know all definitions.

Day 2-4
Key Question: How do we get started in the design process?

The teams will be responsible for researching simple machines and mechanical advantage. Links can be found in the Resources area. The client should specify the required characteristics of the catapult. The teacher will lead a group discussion on the specifications of the catapults limiting power provided to rubber bands and what outside parts might be allowed. Student teams should decide on the size and which simple machines the launcher might include. Students should be refining their simple machine sketches in their Engineering Notebooks as well as the mechanical advantage calculations associated with each one. Students begin sketching in their Engineering Notebooks. NOTE: The teacher will decide how the “client” and the client’s needs for the project are to be represented.

The teacher reminds students about the help system to find out how the software accomplishes basic features they might want to incorporate.
https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index
Students can enter terms to view a tutorial for creating certain features. Students can reference specific terms from the vocabulary list for specific commands to be used in the design of the catapult.

Student teams discuss the specifications of the catapult. Students list the criteria and constraints of the problem they are solving. Teams research the existing catapults and discover information about which features are important to controlling power and launch angles. The teams will use formulas to calculate mechanical advantage and dictate the shape of the catapult. Students should be refining their sketches in the Engineering Notebook.

Remind students to record research notes and sources as well as reflections on the day in the Engineering Notebook.

The teacher will provide access to the following video tutorials that will provide students with information about the basics of mechanism design. They can also access Siemens Solid Edge Video Resources to allow students to discover further elements to help their designs.

Engineering Reference Command for designing Gears, CAMs Pulleys etc.

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1323753:index_xid718565

Introduction to Mechanisms

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-01-introduction/VJ-5mlGyO?topic=1

CAM and Follower

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=0

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=1

Day 5
Key Question: How do we get started on our individual designs?

Student teams finish creating their isometric sketches and create a design brief to include with their sketch. Included are the measurements and mechanical advantage formulas. They then meet with the client who will need to sign off on the design proposal before solid modeling can begin.

Students can reference Basic 3D Commands, Creating Drawing Views and Assembly Modeling and Working with Bodies for specific commands to use in the door latch design. Students can reference web links, videos, and tutorials at any time during the process of the simple machine design.

Day 6-8
Key Question: How can we begin to make our launcher?

Teams discuss their launcher and how to achieve the design of the launcher given the approved sketch presented to the client. Students work together to design the catapult and divide the work of creating the 3D solid models of the pieces needed. They utilize the division of work in the creation of their project management plan.

Teams are reminded to continually check their solid models for fit with the other parts being created to ensure the sizes are accurate. Student teams also discuss how the various components fit and work together.

Students can review tutorials as necessary. Students record sketches and reflections in the Engineering Notebook. Once the students feel they have a launcher solution meeting the requirements, they should consider how they will easily let children apply power to launch the ball safely without overpowering the device.

The students should start by modeling the components of the catapult design staying within the size parameters specified by the teacher.

Day 9-10
Key Question: How can we put our new designs together?

The teacher will review assembly methods to enable students to virtually create their launcher design and assemble the catapult in the software. The teacher should review the design process with the class and check with to assess their progress with the design process and any known or perceived problems encountered with the launcher design. Students should animate the assembly to demonstrate how the catapult functions by creating a motor to drive the assembly. Students can revisit the assembly modeling document if needed. See the sections on Gear Relationships, Motors and Animating an Assembly in the Introduction to Assemblies Activity.

Day 11-13
Key Question: How can we take our designs apart to demonstrate how they are made?

Once the assemblies are together, completed, and verified, the students can create an exploded drawings of the assembly. The teacher should help the students gather the design into the final stage for the presentation drawings. Students analyze their parts and check animations for collisions.

Students start 3D printing their parts for the catapult as they finish them.

While students are finishing their 3D printing of their catapult, they also finish assembly modeling, renderings, working drawings, or other media for their presentations.

Students should be 3D printing parts of their catapults for construction as time allows.

Day14-15
Key Question: How do we build and test our designs?

Students should be constructing their designs. Testing and adjusting as they go. Once the catapults are constructed, they investigate launch angle and velocity to chart the trajectory of the ball after launching. Students should gather data about release angle, power, and distance. Students begin creating an Excel file to predict all the factors to ensure hitting the target with their predictions. Students can reference the Charting with Excel to create their Excel chart if necessary.

Day 16-17
Key Question: How do we organize our thoughts in a presentation to the class?

The student teams practice with their launchers to get ready for the demonstration using their Excel spread sheet to predict where the ball will land.

The teacher will discuss with the students how to optimally present their ideas to the class. Students should also be prepared to justify any design enhancements incorporated into the catapult design. Students finish the 3D printing of their catapult parts. Teams assemble the components that make up their designs.

Students discuss the outline of their presentation to their clients. The deliverables could be in the form of a dimensioned working drawing pictorial representation with balloons and bill of materials and/or a 3D printed prototype. They decide on the types of graphics to include. Students should prepare an engineering report about the process of designing the launcher and how the components all fit together. They should be required write the introduction, provide results including graphics, and a conclusion including an acknowledgement section reporting the source of information. Students decide how to divide the work to create a team report. Students should also be prepared to justify any design ideas they used on their catapult.

Day 18
Key Question: How do we convey our ideas?

Students can present their solutions to the class one at a time. As a component of the demonstration of the launcher the students demonstrate the ability of hitting their target. In the end, all students can reflect on their work by giving and receiving feedback on how they could possibly improve their designs

Vocabulary:

Acceleration
Angle
Ballistics
Catapult
Gravity
Initial Velocity
Kinetic Energy

Launch Angle
Laws of motion
Parabolic path
Potential Energy
Range
Repeatability
Trajectory
Trebuchet
Trigger
Vectors

Resources:

CAD Tutorials

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012424/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012420/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012430/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012447/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012454/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012455/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012420/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012460/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012430/index.html

Assembly Tutorials

- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012424/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012454/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012455/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012460/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012451/index.html

Engineering Reference Command for designing Gears, CAMs Pulleys etc.

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1323753:index_xid718565

Solid Edge Robotics and Mechanisms Course

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku

Design Ideas

- http://www.stormthecastle.com/trebuchet/Fast-easy-tennis-ball-trebuchet-part-1.htm
- http://www.wikihow.com/Build-a-Trebuchet

Engineering Reports

- http://web.mit.edu/me-ugoffice/communication/technical-writing.pdf
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/writing_engineering_reports.html
- https://www.youtube.com/playlist?list=PLDAAF7A8FD5CD582C&feature=plcp
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/mechanical_engineering_writing_enhancement_program/report_writing.html
- https://owl.purdue.edu/owl/subject_specific_writing/professional_technical_writing/technical_reports_and_report_abstracts/reports_proposals_and_technical_papers.html

Mechanical Advantage

- http://www.wisegeek.com/what-is-mechanical-advantage.htm
- http://study.com/academy/lesson/mechanical-advantage-definition-formula.html

Projectile Motion

- http://www.physicsclassroom.com/Class/vectors/u3l2a.cfm
- https://phet.colorado.edu/en/simulation/projectile-motion
- https://www.khanacademy.org/science/physics/one-dimensional-motion/old-projectile-motion/v/projectile-motion-part-1
- http://formulas.tutorvista.com/physics/projectile-motion-formula.html

Simple Machines Java Applet

- http://www.walter-fendt.de/ph14e/
- http://idahoptv.org/sciencetrek/topics/simple_machines/facts.cfm
- https://phet.colorado.edu/en/search?q=simple+machines

Solid Edge Instructional Videos

Introduction to Mechanisms

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-01-introduction/VJ-5mlGyO?topic=1

CAM and Follower

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=0

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=1

Beginning CAM Motion

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=2

Common CAM Types

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=1
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=2
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=3

CAM Physical Motion

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-04-cam-vice-lock-scissors/4JThnbf1d?topic=2

Circular vs. Arc

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-04-cam-vice-lock-scissors/4JThnbf1d?topic=3

Four Bar Mechanisms

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=1
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=2

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=3
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=4
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=4

Motion Concepts

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-09-motion-concepts/NytArMfyu?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-09-motion-concepts/NytArMfyu?topic=1

Assembly Example-Rowboat Video Collection

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/rowboat-mechanism-in-solid-edge/EJaWFRQRP

Assembly Example-Rowboat Video Collection

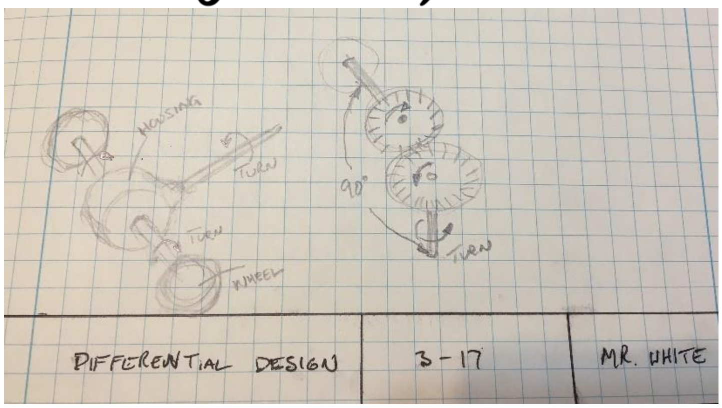
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/rowboat-mechanism-in-solid-edge/EJaWFRQRP

Solid Edge Gear Designer

- https://www.youtube.com/watch?v=_VDfFkPHpxM
- https://www.youtube.com/watch?v=2PR_ByClOM0
- https://www.youtube.com/watch?v=ybLeWmWJTMc
- https://www.youtube.com/watch?v=2AL68JMIkSc
- https://www.youtube.com/watch?v=OrK7c3EGd_0

Videos

- https://www.youtube.com/watch?v=9-Hwxw4fgqk
- https://www.youtube.com/watch?v=egZhg7v4NRs
- https://www.youtube.com/watch?v=N6i-jafgO7Q
- https://www.youtube.com/watch?v=Bdd1Lu5jN08
- https://www.khanacademy.org/science/physics/work-and-energy/mechanical-advantage/v/introduction-to-mechanical-advantage
- https://www.youtube.com/watch?v=UtfVZtuyuHU
- https://www.youtube.com/watch?v=fvOmaf2GfCY



Project: Differential Gear Design

Introduction:

How does a spinning force make its way to spinning wheels? Differentials are mechanical assemblies used for redirecting and multiplying engine power to the wheels of a vehicle. It also allows the vehicle to make turns because the vehicles wheels spin at different speeds in a turn. A differential transmits power to both wheels while they still spin independently from one another.

Purpose of the Project:

The purpose of this project is to introduce design students to an open-ended design that features a moving mechanical system. This project focuses on the solid modeling techniques of assemblies, exploded drawings, and animations. The students will create an animation of a rotating mechanical assembly that will be demonstrated to the class.

Concepts:

- Utilize mathematical analysis, scientific inquiry and engineering design to develop solutions to open ended problems.
- Access, generate process, and transfer information using appropriate technologies.
- Apply the design process in the design of a mechanical system.
- Read and analyze detailed descriptions of machinery and provide a concise summary for documentation purposes.
- Design a system of elements that manages power to accomplish a task that involves defined movement.

Outline:

- Documentation
  - Engineering Notebook
  - Documentation object to be designed
- Modeling
  - Creation of 3D solid models
  - Assembly of modeled parts
  - Exploded drawing of assembly
  - Design renderings and pictorial exploded drawings
  - Construct 3D model of mechanical systems project
- Communication
  - Presentation of design solutions

Standards:

Career and Technical Standards

Engineering Design Process

- Create and maintain an Engineering Notebook for daily reflections, research and prototype creation documentation.
- Apply the design and problem solving process as an iterative process incorporating sciences, mathematics and engineering to optimally convert resources to meet a stated objective.
- Communicate solutions utilizing technical writing skills including correct spelling, proper grammar and dependent vocabulary.
- Assume and carry out a role in the smooth running of a team working toward the solution of a problem.
- Assemble a quantitative plan for successful completion of the project.
- Assume responsibility for leadership roles and responsibility for actions, decisions products and policies in the governance of a project.
- Evaluate the need for and costs of resources necessary for the completion of a project.

Sketching

- Create sketches utilizing basic shapes such as lines circles and ellipses.
- Communicate ideas to a group through the use of sketches and other documentation.
- Apply isometric and orthographic sketches to add clarity to design.
- Create necessary sketches to communicate basic ideas during the design process.

3D Solid Modeling/Fabrication and 3-D Printing

- Apply geometric relationships between lines and shapes to create a mathematical database to describe design ideas.
- Create solid models utilizing concepts of Parametric Modeling.
- Analyze models for appropriate engineering design features needed.

- Develop strategies for the creation of solid models for the rapid creation of design solutions.
- Apply the concepts of digital prototyping to accelerate the time frame between ideation and completed project.
- Access, generate, process, and transfer information using appropriate technologies.
- Design and create a model using additive manufacturing technology sometimes called a rapid prototyping system.
- Apply new principles of more rapid and less costly development and deployment of new materials.
- Utilize rapid prototyping/additive manufacturing to create highly complex parts designed in a CAD system.

Renderings/Working Drawings/ Design Presentations

- Create renderings to communicate design ideas and engineering principles to the general public.
- Generate an image from a model utilizing light, texture and shading to create a proposed final appearance of a product.
- Apply rendering techniques to create presentations of design for a non-technical audience.

Assembly Modeling/Documentation/Exploded Assemblies/Bill of Materials

- Conduct model documentation as the process of recording details such as size, material composition, and instructions for assembling, installation and servicing, analysis, development process that describes a model for the purpose of communication of ideas.
- Create a bill of materials to communicate materials and other information about a design.

Reverse Engineering/Engineering Features

- Apply the principles of design for manufacturing enabling the efficient and effective production of products.
- Apply the green principles of design for eventual disassembly and resource recovery.
- Investigate activities that a business conducts with the intention of making a discovery that can either lead to the development of new products or procedures, or to improvement of existing products or procedures and to know the new approaches of rapid development and deployment that saves time and is more efficient.
- Disassemble a product into its parts, utilize precision measurement to create sketches, drawings and models of the product and identify the basic processes, systems, designs, and materials used in the manufacture of the product.

Simple Machines

- Utilize mathematical analysis, scientific inquiry and engineering design to develop solutions to open ended problems.
- Access, generate, process, and transfer information using appropriate technologies
- Apply the design process in the design of a mechanical system.
- Read and analyze detailed descriptions of machinery and provide a concise summary for documentation purposes.
- Assign mathematical relationships to analyze mechanical advantage.
- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.
- Assign mathematical relationships to analyze mechanical advantage.
- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.

Mechanical systems

- Utilize mathematical analysis, scientific inquiry and engineering design to develop solutions to open ended problems.
- Access, generate, process, and transfer information using appropriate technologies.
- Apply the design process in the design of a mechanical system.
- Read and analyze detailed descriptions of machinery and provide a concise summary for documentation purposes.
- Assign mathematical relationships to schematics to apply forces.
- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.
- Apply the design process in the design of a mechanical system.
- Design a system of elements that manage power to accomplish a task that involves defined movement.
- Read and analyze detailed descriptions of machinery and provide a concise summary for documentation purposes.
- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.

College and Career Readiness Math Standards

Modeling with Geometry G-MG

Apply geometric concepts in modeling situations

1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).
2. Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot).
3. Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).

Create equations that describe numbers or relationships CED

A.4. Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.

Reading Standards for Literacy in History/Social Studies 9-10

Key Ideas and Details

1. Cite specific textual evidence to support analysis of primary and secondary sources, attending to such features as the date and origin of the information.
3. Analyze in detail a series of events described in a text; determine whether earlier events caused later ones or simply preceded them.

Integration of Knowledge and Ideas

7. Integrate quantitative or technical analysis (e.g., charts, research data) with qualitative analysis in print or digital text.
9. Compare and contrast treatments of the same topic in several primary and secondary sources.

Range of Reading and Level of Text Complexity

10. By the end of grade 10, read and comprehend science/technical texts in the grades 9–10 text complexity band independently and proficiently.

Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 9-10

Text Types and Purposes

1. Write arguments focused on *discipline-specific content.*
2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

Production and Distribution of Writing

4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Research to Build and Present Knowledge

7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.

Range of Writing

10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Next Generation Science Standards

The projects engage students in the scientific and engineering practices taken from the National Research Council's Framework for K-12 Science Education, Practices, Crosscutting Concepts, and Core Ideas. This is the document upon which the NGSS are based.

These practices are used for two reasons: 1) they parallel the design process utilized in each project, and 2) they serve as the foundation of the NGSS.

The eight science and engineering practices are:

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Standards for Technological Literacy

Standard 1

Students will develop an understanding of the characteristics and scope of technology.

Standard 2

Students will develop an understanding of the core concepts of technology.

Standard 3

Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Standard 7

Students will develop an understanding of the influence of technology on history.

Standard 8

Students will develop an understanding of the attributes of design.

Standard 9

Students will develop an understanding of engineering design.

Standard 10
Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Standard 11
Students will develop the abilities to apply the design process.

Standard 12
Students will develop the abilities to use and maintain technological products and systems.

Standard 13
Students will develop the abilities to assess the impact of products and systems.

Standard 16
Students will develop an understanding of and be able to select and use energy and power technologies.

Standard 17
Students will develop an understanding of and be able to select and use information and communication technologies.

Standard 19
Students will develop an understanding of and be able to select and use manufacturing technologies.

Standard 20
Students will develop an understanding of and be able to select and use construction technologies.

Assessment:

Assessment is both formative and summative. It is an integral part of quality instruction. During the course of each project, one of the teacher's main functions is to work with student groups, keeping track of progress and providing formative assessment in the form of feedback and promoting reflection on the part of students. The focus should be on promoting lifetime learning and 21st century skills. The goal of instruction is to promote abilities in research, problem solving, designing, experimenting, testing, collecting and analyzing data.

Rubrics are used in the assessment process to communicate expectations of quality. Rubrics should be shared with students at the beginning of a project to clarify any misconceptions before beginning their work. Students can then build the skills and gather knowledge to solve the problem presented to the expectations of excellence described.

General Rubrics for Literacy tasks:
Argumentative_Pursuasive
Informational_Explanatory

Individual Project Rubric:
Differential Gear Design Rubric

Essential Question:

How can we transmit and multiply engine power to the drive wheels and still allow the vehicle to turn?

Student Scenario:

You are an automotive engineer and are part of the team whose job is the design and production of a differential gear set to be used in a wheeled vehicle drivetrain for the surface of Mars. The power will come from an electric motor in the front of the rover. Your team has been asked to design a device that will allow the wheels to both be powered but move independently. You team will need to design a differential that can handle 20 foot pounds of torque produced by the 7.5 HP electric motor.

The research and learning activities are designed to help students:

- Use mathematical formulas to aid in the design and testing of a product
- Utilize specific software features to create a solid model of their idea
- Communicate their solution to their peers

Deliverables include:

- Engineering Notebook
- CAD model
- 3D printed model
- Engineering Report that includes 3D images and working and assembly drawings
- Presentation of the development process along with a demonstration of their device.

Daily Plan:

Day 1

Key Question: What are the expectations of the project?

Introduce students to the project by providing them with the Essential Question and the scenario.

Review and discuss with your students the design process, Engineering Notebook and design documentation requirements. Discuss the problem statement, design brief, testing protocol and management plan. Review the elements of a good engineering report with the students. These were all covered in the first project titled *Introduction to the Engineering Design Process* but should be reinforced on a regular basis. All projects depend on the design process and student activities should relate directly.

Have the students form teams of two. Allow the students five minutes to discuss the problem. Students begin by brainstorming ideas in their Engineering Notebooks. The teacher will provide a list of vocabulary terms that students will need to research on their own. The teams can divide the list of terms among team members and share their definitions. All team members are responsible to know all definitions.

Day 2-4

Key Question: How do we get started in the design process?

The teams will be responsible for researching simple machines and mechanical advantage, gears, and differentials. Links can be found in the Resources section. The client should specify the characteristics required of the differential gear. The teacher will lead a group discussion on the specifications of the differential gear such as the size, gear ratio, and shaft diameters. Students should be refining their gear train sketches in their Engineering Notebooks as well as the mechanical advantage calculations associated with each one. Students begin sketching in their Engineering Notebooks. NOTE: The teacher will decide how the “client” and the client’s needs for the project are to be represented.

The teacher reminds students about the help system to find out how the software accomplishes basic features they might want to incorporate.
https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index

Students can enter terms to view a tutorial for creating certain features. Students can reference specific terms from the vocabulary list for specific commands to be used in the design of the differential gear. The teacher will provide access to the following video tutorials that will provide students with information about the basics of mechanism design. They can also access Siemens Solid Edge Video Resources to allow students to discover further elements to help their designs. Other tutorials in the Resources section are available for use if students struggle.

Engineering Reference Command for designing Gears, CAMs Pulleys etc.

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1323753:index_xid718565

Solid Edge Gear Designer

- https://www.youtube.com/watch?v=_VDfFkPHpxM
- https://www.youtube.com/watch?v=2PR_ByClOM0
- https://www.youtube.com/watch?v=ybLeWmWJTMc
- https://www.youtube.com/watch?v=2AL68JMIkSc
- https://www.youtube.com/watch?v=OrK7c3EGd_0

Student teams construct some basic gear systems identified in the Gears with fischertechniks activity.

Student teams discuss the specifications of the differential gear. Students list the criteria and constraints of the problem they are solving. Teams research the existing gear trains and discover information about standard gear ratios and how to calculate speed vs. torque. The teams will use formulas to calculate mechanical advantage and dictate the gear ratios. Students should be refining their sketches in the Engineering Notebook.

Remind students to record research notes and sources as well as reflections on the day in the Engineering Notebook.

Day 5
Key Question: How do we get started on our individual designs?

Student teams finish creating their isometric sketches and create a design brief to include with their sketch including measurements and gear ratio formulas. They then meet with their client who need to sign off on the design proposal before solid modeling can begin.

Students can reference Basic 3D Commands, Creating Drawing Views and Assembly Modeling and Working with Bodies for specific commands to use in the differential gear design. Students can reference web links, videos, and tutorials at any time during the process of the simple machine design. Students can view videos on using the gear designer in Solid Edge.

Day 6-8

Key Question: How can we begin to make our differential?

Teams discuss their differential gear layout and how to achieve the design of the differential given the approved sketch they presented. They work together to design the differential gear assembly and divide the work of creating the 3D solid models of the pieces needed. They utilize the division of work in the creation of their project management plan.

Teams are reminded to continually check their solid models to ensure the sizes are accurate. Student teams also discuss how the various components fit and work together.

Students can review tutorials as necessary. Students record sketches and reflections in the Engineering Notebook. Once the students feel they have a gear solution that meets the requirements, they should consider how they will support the various sections of the gear train.

The students should start by modeling the components of the differential design staying within the size parameters specified by the teacher.

Day 9-11
Key Question: How can we put our new designs together?

The teacher will review assembly methods to enable students to virtually create their differential design and assemble the gear system in the software. The teacher should review the design process with the class to assess their progress and any known or perceived problems encountered with the differential gear design. Students should animate the assembly to demonstrate how the gears work by creating a motor to drive the assembly. Students can revisit the assembly modeling document if needed. See the sections on Gear Relationships, Motors and Animating an Assembly in the Introduction to Assemblies Activity.

Day 12
Key Question: How can we take our designs apart to demonstrate how they are made?

Once the assemblies are together, completed, and verified, the students can create an exploded drawing of the assembly. The teacher should help the students gather the design into the final stage for the presentation drawings Students analyze their parts and check animations for collisions.

Students start 3D printing their various gears for the differential as soon as possible. Students can utilize plastic shafts or obtain other material to use.

While students are finishing their 3D printing of their differential gears, they can also finish assembly modeling, renderings, working drawings, or other media for their presentations.

Day 13
Key Question: How do we organize our thoughts in a presentation to the class?

The teacher will discuss with the students how to optimally present their ideas to the class. Students should also be prepared to justify any design enhancements incorporated into the rover differential gear design. Students finish the 3D printing of their gear parts. Teams assemble the components that make up their designs.

Students discuss the outline of their presentation. The deliverables could be in the form of a dimensioned working drawing, pictorial representation with balloons, and bill of materials and/or a 3D printed prototype. The team decides on the types of graphics to include. Students should prepare an engineering report about the process of designing the rover's differential gear and how the components all fit together. The students should be required to write the introduction, provide results including graphics, and form a conclusion including an acknowledgement section reporting the source of information. Students decide how to divide the work to create a team report.

Day 14
Key Question: How do we convey our ideas?

Students can present their solutions to the class one at a time. In the end, all students can reflect on their work by giving and receiving feedback on how they could possibly improve their designs

Vocabulary:

Axle
Bearing
Differential
Driven gear
Driving gear
Foot Pound
Gear Ratio
Horse Power
Input Shaft
Newton-meter
Output shaft
Pinion gear
Ring gear
Torque
Worm

Resources:

CAD Tutorials

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012424/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012420/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012430/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012447/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012454/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012455/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012420/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012460/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012430/index.html
- https://docs.plm.automation.siemens.com/tdoc/se/109/se_help#uid:index_xid718565:xid721892
- http://media.plm.automation.siemens.com/goplm/Introduction-Mechanical-Systems.zip

Assembly Tutorials

- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012424/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012454/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012455/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012460/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012451/index.html

Engineering Reference Command for designing Gears, CAMs Pulleys etc.

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1323753:index_xid718565

Solid Edge Robotics and Mechanisms Course

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku

Engineering Reports

- http://web.mit.edu/me-ugoffice/communication/technical-writing.pdf
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/writing_engineering_reports.html
- https://www.youtube.com/playlist?list=PLDAAF7A8FD5CD582C&feature=plcp
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/mechanical_engineering_writing_enhancement_program/report_writing.html
- https://owl.purdue.edu/owl/subject_specific_writing/professional_technical_writing/technical_reports_and_report_abstracts/reports_proposals_and_technical_papers.html

Differentials

- http://auto.howstuffworks.com/differential.htm
- https://www.ringpinion.com/calculators/Calc_GR.aspx
- http://www.learnengineering.org/2014/05/working-of-differential.html
- https://www.youtube.com/watch?v=gIGvhvOhLHU
- https://www.youtube.com/watch?v=SOgoejxzF8c
- https://www.youtube.com/watch?v=WAyD9HIMtcU
- https://www.youtube.com/watch?v=I2jK1a6ZhCo
- http://www.roadandtrack.com/car-culture/car-accessories/videos/a31174/this-electric-go-kart-with-54-ft-lb-of-torque-is-uncontrollably-awesome/

Solid Edge Instructional Videos

Introduction to Mechanisms

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-01-introduction/VJ-5mlGyO?topic=1

CAM and Follower

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=1

Beginning CAM Motion

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=2

Common CAM Types

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-

mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=1

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=2
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=3

CAM Physical Motion

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-04-cam-vice-lock-scissors/4JThnbf1d?topic=2

Circular vs. Arc

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-04-cam-vice-lock-scissors/4JThnbf1d?topic=3

Four Bar Mechanisms

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=1
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=2
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=3
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=4
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=4

Motion Concepts

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-09-motion-concepts/NytArMfyu?topic=0

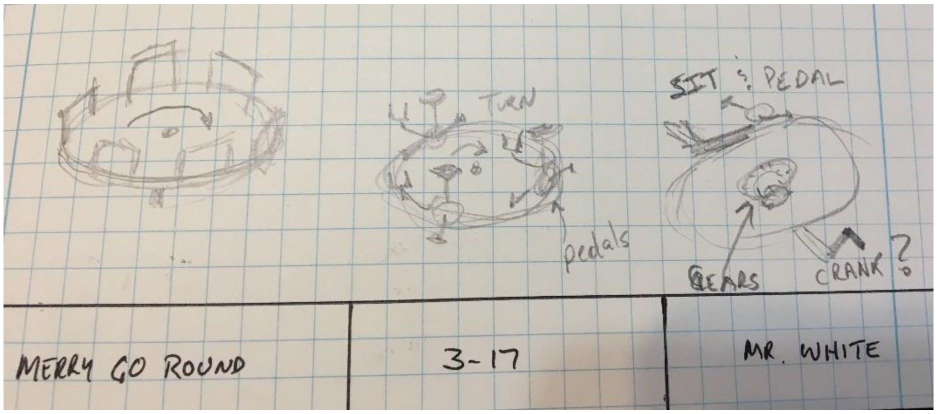
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-09-motion-concepts/NytArMfyu?topic=1

Assembly Example-Rowboat Video Collection

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/rowboat-mechanism-in-solid-edge/EJaWFRQRP

Solid Edge Gear Designer

- https://www.youtube.com/watch?v=_VDfFkPHpxM
- https://www.youtube.com/watch?v=2PR_ByClOM0
- https://www.youtube.com/watch?v=ybLeWmWJTMc
- https://www.youtube.com/watch?v=2AL68JMIkSc
- https://www.youtube.com/watch?v=OrK7c3EGd_0



Project: Merry-Go-Round

Introduction:

Merry-Go-Rounds have been used to entertain people of all ages since the 1700's. The Merry-Go-Round today is mostly found in parks and school yards. They are usually circular in shape, spin freely, and require a person to push it so it rotates. They can have a themed appearance such as animals or vehicles. In some examples, seats are available. Larger Merry-Go-Rounds can be rotated by a motor while smaller versions are powered by humans.

Purpose of the Project:

The purpose of this project is to introduce design students to an open-ended design that features a moving mechanical system. This project focuses on the solid modeling techniques of assemblies, exploded drawings, and animations. The students will create an animation of the rotating mechanical assembly to demonstrate the function of the system to the class.

Concepts:

- Utilize mathematical analysis, scientific inquiry, and engineering design to develop solutions to open ended problems.
- Access, generate, process and transfer information using appropriate technologies.
- Apply the design process in the design of a mechanical system.

- Read and analyze detailed descriptions of machinery and provide a concise summary for documentation purposes.
- Design a system of elements that manages power to accomplish a task that involves defined movement.

Outline:

Documentation
- Engineering Notebook
- Documentation object to be designed

Modeling
- Creation of 3D solid models
- Assembly of modeled parts
- Exploded drawing of assembly
- Design renderings and pictorial exploded drawings
- Construct 3D model of mechanical systems project

Communication
- Presentation of design solutions

Standards:

Career and Technical Standards

Engineering Design Process

- Create and maintain an Engineering Notebook for daily reflections, research and prototype creation documentation.
- Apply the design and problem solving process as an iterative process incorporating sciences, mathematics and engineering to optimally convert resources to meet a stated objective.
- Communicate solutions utilizing technical writing skills including correct spelling, proper grammar and dependent vocabulary.
- Assume and carry out a role in the smooth running of a team working toward the solution of a problem.
- Assemble a quantitative plan for successful completion of the project.
- Assume responsibility for leadership roles and responsibility for actions, decisions products and policies in the governance of a project.
- Evaluate the need for and costs of resources necessary for the completion of a project.

Sketching

- Create sketches utilizing basic shapes such as lines circles and ellipses.
- Communicate ideas to a group through the use of sketches and other documentation.
- Apply isometric and orthographic sketches to add clarity to design.
- Create necessary sketches to communicate basic ideas during the design process.

3D Solid Modeling/Fabrication and 3-D Printing

- Apply geometric relationships between lines and shapes to create a mathematical database to describe design ideas.
- Create solid models utilizing concepts of Parametric Modeling.
- Analyze models for appropriate engineering design features needed.
- Develop strategies for the creation of solid models for the rapid creation of design solutions.
- Apply the concepts of digital prototyping to accelerate the time frame between ideation and completed project.
- Access, generate, process, and transfer information using appropriate technologies.
- Design and create a model using additive manufacturing technology sometimes called a rapid prototyping system.
- Apply new principles of more rapid and less costly development and deployment of new materials.
- Utilize rapid prototyping/additive manufacturing to create highly complex parts designed in a CAD system.

Renderings/Working Drawings/ Design Presentations

- Create renderings to communicate design ideas and engineering principles to the general public.
- Generate an image from a model utilizing light, texture and shading to create a proposed final appearance of a product.
- Apply rendering techniques to create presentations of design for a non-technical audience.

Assembly Modeling/Documentation/Exploded Assemblies/Bill of Materials

- Conduct model documentation as the process of recording details such as size, material composition, and instructions for assembling, installation and servicing, analysis, development process that describes a model for the purpose of communication of ideas.
- Create a bill of materials to communicate materials and other information about a design.

Reverse Engineering/Engineering Features

- Apply the principles of design for manufacturing enabling the efficient and effective production of products.
- Apply the green principles of design for eventual disassembly and resource recovery.
- Investigate activities that a business conducts with the intention of making a discovery that can either lead to the development of new products or procedures, or to improvement of existing products or procedures and to know the new approaches of rapid development and deployment that saves time and is more efficient.

- Disassemble a product into its parts, utilize precision measurement to create sketches, drawings and models of the product and identify the basic processes, systems, designs, and materials used in the manufacture of the product.

Simple Machines

- Utilize mathematical analysis, scientific inquiry and engineering design to develop solutions to open ended problems.
- Access, generate, process, and transfer information using appropriate technologies
- Apply the design process in the design of a mechanical system.
- Read and analyze detailed descriptions of machinery and provide a concise summary for documentation purposes.
- Assign mathematical relationships to analyze mechanical advantage.
- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.
- Assign mathematical relationships to analyze mechanical advantage.
- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.

Mechanical systems

- Utilize mathematical analysis, scientific inquiry and engineering design to develop solutions to open ended problems.
- Access, generate, process, and transfer information using appropriate technologies.
- Apply the design process in the design of a mechanical system.
- Read and analyze detailed descriptions of machinery and provide a concise summary for documentation purposes.
- Assign mathematical relationships to schematics to apply forces.
- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.
- Apply the design process in the design of a mechanical system.
- Design a system of elements that manage power to accomplish a task that involves defined movement.
- Read and analyze detailed descriptions of machinery and provide a concise summary for documentation purposes.
- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.

College and Career Readiness Math Standards

Modeling with Geometry G-MG

Apply geometric concepts in modeling situations

1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).
2. Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot).

3. Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).

Create equations that describe numbers or relationships CED

A.4. Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.

Reading Standards for Literacy in History/Social Studies 9-10

Key Ideas and Details

1. Cite specific textual evidence to support analysis of primary and secondary sources, attending to such features as the date and origin of the information.
3. Analyze in detail a series of events described in a text; determine whether earlier events caused later ones or simply preceded them.

Integration of Knowledge and Ideas

7. Integrate quantitative or technical analysis (e.g., charts, research data) with qualitative analysis in print or digital text.
9. Compare and contrast treatments of the same topic in several primary and secondary sources.

Range of Reading and Level of Text Complexity

10. By the end of grade 10, read and comprehend science/technical texts in the grades 9–10 text complexity band independently and proficiently.

Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 9-10

Text Types and Purposes

1. Write arguments focused on *discipline-specific content.*
2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

Production and Distribution of Writing

4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Research to Build and Present Knowledge

7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into

the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.

Range of Writing

10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Next Generation Science Standards

The projects engage students in the scientific and engineering practices taken from the National Research Council's Framework for K-12 Science Education, Practices, Crosscutting Concepts, and Core Ideas. This is the document upon which the NGSS are based.

These practices are used for two reasons: 1) they parallel the design process utilized in each project, and 2) they serve as the foundation of the NGSS.

The eight science and engineering practices are:

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Standards for Technological Literacy

Standard 1

Students will develop an understanding of the characteristics and scope of technology.

Standard 2

Students will develop an understanding of the core concepts of technology.

Standard 3

Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Standard 5

Students will develop an understanding of the effects of technology on the environment.

Standard 6

Students will develop an understanding of the role of society in the development and use of technology.

Standard 7
Students will develop an understanding of the influence of technology on history.

Standard 8
Students will develop an understanding of the attributes of design.

Standard 9
Students will develop an understanding of engineering design.

Standard 10
Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Standard 11
Students will develop the abilities to apply the design process.

Standard 12
Students will develop the abilities to use and maintain technological products and systems.

Standard 13
Students will develop the abilities to assess the impact of products and systems.

Standard 17
Students will develop an understanding of and be able to select and use information and communication technologies.

Standard 19
Students will develop an understanding of and be able to select and use manufacturing technologies.

Standard 20
Students will develop an understanding of and be able to select and use construction technologies.

Assessment:

Assessment is both formative and summative. It is an integral part of quality instruction. During the course of each project, one of the teacher's main functions is to work with student groups, keeping track of progress and providing formative assessment in the form of feedback and promoting reflection on the part of students. The focus should be on promoting lifetime learning and 21st century skills. The goal of instruction is to promote abilities in research, problem solving, designing, experimenting, testing, collecting and analyzing data.

Rubrics are used in the assessment process to communicate expectations of quality. Rubrics should be shared with students at the beginning of a project to clarify any misconceptions before beginning their work. Students can then build the skills and gather knowledge to solve the problem presented to the expectations of excellence described.

General Rubrics for Literacy tasks:
Argumentative_Pursuasive
Informational_Explanatory

Individual Project Rubric:
Merry-Go-Round Rubric

Essential Question:

How can we create a working Merry-Go-Round with a theme appropriate for young children to use?

Student Scenario:

You are a member of a playground design team. Your team has been asked to design and construct a new themed Merry-Go-Round for your local school. The Merry-Go-Round has to be stable and safe for all ages, and must be able to be rotated or powered by a small child. General safety guidelines for playground equipment must be followed.

The research and learning activities are designed to help students:

- Use mathematical formulas to aid in the design and testing of a product
- Utilize specific software features to create a solid model of their idea
- Communicate their solution to their peers

Deliverables include:

- Engineering Notebook

- CAD model
- Rendering
- Engineering Report that includes 3D images and working and assembly drawings
- Presentation of the development process along with a demonstration of their device

Daily Plan:

Day 1
Key Question: What are the expectations of the project?

Introduce students to the project by providing them with the Essential Question and the scenario.

Review and discuss with your students the design process, Engineering Notebook and design documentation requirements. Discuss the problem statement, design brief, testing protocol and management plan. Review the elements of a good engineering report with the students. These were all covered in the first project titled *Introduction to the Engineering Design Process* but should be reinforced on a regular basis. All projects depend on the design process and student activities should relate directly.

Have the students form teams of two. Allow the students five minutes to discuss the problem. Students begin by brainstorming ideas in their Engineering Notebooks. The teacher will provide a list of vocabulary terms that students will need to research on their own. The teams can divide the list of terms among team members and share their definitions. All team members are responsible to know all definitions.

Day 2-3
Key Question: How do we get started in the design process?

The teams will be responsible for researching simple machines and mechanical advantage, bearings, and types of Merry-Go-Rounds. Links can be found in the Resources section. The client should specify the required characteristics of the Merry-Go-Round. The teacher will lead a group discussion on the specifications of the Merry-G--Round such as the size, gear ratio, and shaft diameters it might include. Students should be refining their Merry-Go-Round sketches in their Engineering Notebooks as well as the mechanical advantage calculations associated with each one. Students begin sketching in their Engineering Notebooks. NOTE: The teacher will decide how the “client” and the client’s needs for the project are to be represented.

The teacher reminds students about the help system to find out how the software accomplishes basic features they might want to incorporate.
https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index

Students can enter terms to view a tutorial for creating certain features. Students can reference specific terms from the vocabulary list for specific commands to be used in the design of the Merry-Go-Round. Other tutorials in the Resources section are available for use if students struggle.

Student teams discuss the specifications of the Merry-Go-Round. Students list the criteria and constraints of the problem they are solving. Teams research the existing Merry-Go-Round and discover information about the types of bearings used, basic diameters, weight restrictions, and how to balance them. The teams will use formulas to calculate mechanical advantage and apply equations for the centrifugal and centripetal forces. Students consider angular momentum for their Merry-Go-Round. Students should be refining their sketches in the Engineering Notebook.

Remind students to record research notes and sources as well as reflections on the day in the Engineering Notebook.

The teacher will provide access to the following video tutorials that will provide students with information about the basics of mechanism design. They can also access Siemens Solid Edge Video Resources to allow students to discover further elements to help their designs.

Engineering Reference Command for designing Gears, CAMs Pulleys etc.

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1323753:index_xid718565

Introduction to Mechanisms

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-01-introduction/VJ-5mlGyO?topic=1

CAM Physical Motion

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-04-cam-vice-lock-scissors/4JThnbf1d?topic=2

Circular vs. Arc

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-04-cam-vice-lock-scissors/4JThnbf1d?topic=3

Day 4
Key Question: How do we get started on our individual designs?

Student teams finish creating their isometric sketches and create a design brief to include with their sketch including measurements and force formulas. They then meet with their client who will need to sign off on the design proposal before solid modeling can begin.

Students can reference Basic 3D Commands, Creating Drawing Views and Assembly Modeling and Working with Bodies for specific commands to use in the Merry-Go-Round design. Students can reference web links, videos, and tutorials at any time during the process of the simple machine design. Students can view videos on angular momentum and centrifugal and centripetal forces. Some examples are found in the Resources.

Students research the types of bearings. They learn the difference between plain bearings and anti-friction bearings. Students also learn the difference between radial bearings and thrust bearings.

Day 5-6
Key Question: How can we begin to make our rotating playground toy?

Teams discuss their Merry-Go-Round layout and how to achieve the design of the Merry-Go-Round given the approved sketch presented. They work together to design the Merry-Go-Round assembly and divide the work of creating the 3D solid models of the pieces needed. They utilize the division of work in the creation of their project management plan.

Teams are reminded to continually check their solid models to ensure the sizes are accurate. Student teams also discuss how the various components fit and work together.

Students can review tutorials as necessary. Students record sketches and reflections in the Engineering Notebook. Once the students feel they have a Merry-Go-Round solution that meets the requirements, ask that they consider how they will support the various sections of the Merry-Go-Round.

Day 7-8
Key Question: How can we put our new designs together?

The teacher will review assembly methods to enable students to virtually create their Merry-Go-Round design and assemble the playground device in the software. The teacher should review the design process with the class and check with teams to assess their progress with the design process and any known or perceived problems encountered with the Merry-Go-Round design. Students should animate the assembly to demonstrate how the Merry-Go-Round will work by creating a motor to drive the assembly. Students can revisit the assembly modeling document if needed. See the sections on Gear Relationships, Motors and Animating an Assembly in the Introduction to Assemblies Activity.

Day 9
Key Question: How can we take our designs apart to demonstrate how they are made?

Once the assemblies are together, completed, and verified, the students can create an exploded drawing of the assembly. The teacher should help the students gather the design into the final stage for the presentation drawings. Students analyze their parts and check animations for collisions.

Students start rendering their Merry-Go-Round. Students might turn on and off sections of the assembly to demonstrate how their bearing system works. Students can utilize plastic shafts or obtain other material as needed. Students can research bearings to make final decisions on the ones to use.

Students finish assembly modeling, renderings, working drawings, or other media for their presentations.

Day 10
Key Question: How do we organize our ideas in a presentation to the class?

The teacher will discuss with the students how to optimally present their ideas to the class. Students should also be prepared to justify any design enhancements they incorporated into the Merry-Go-Round design. Students decide how best to display their work to prospective customers.

The deliverables could be in the form of a dimensioned working drawing, pictorial representation with balloons, and bill of materials and various renderings. The teams decide on the types of graphics to include. Students should prepare an engineering report about the process of designing the Merry-Go-Round and how the components all fit together. The students should be required to write the introduction, provide results including graphics, and form a conclusion including an acknowledgement section reporting the source of information. Students decide how to divide the work to create a team report.

Day 11
Key Question: How do we convey our ideas?

Students can present their solutions to the class one at a time. In the end, all students can reflect on their work by giving and receiving feedback on how they could possibly improve their designs

Vocabulary:

Angular Momentum
Anti-Friction Bearing
Axle

Ball Bearing
Bearing
Bearing Lubrication
Centrifugal force
Centripetal Force
Circumference
Inner Race
Outer Race
Plain Bearing
Radial Bearing
Ratio
Roller Bearing
Shaft
Thrust Bearing
Torque

Resources:

CAD Tutorials

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012424/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012420/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012430/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012447/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012454/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012455/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012420/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012460/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012430/index.html
- http://niveshandnisheeth.blogspot.com/2016/11/content-list-videos-solid-edge-st9.html
- http://media.plm.automation.siemens.com/goplm/Introduction-Mechanical-Systems.zip

Assembly Tutorials

- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012424/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012454/index.html

- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012455/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012460/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012451/index.html

Engineering Reference Command for designing Gears, CAMs Pulleys etc.

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1323753:index_xid718565

Solid Edge Robotics and Mechanisms Course

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku

Solid Edge Structural Analysis

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1325275:index_sesim:xid1602403:activity1a

Engineering Reports

- http://web.mit.edu/me-ugoffice/communication/technical-writing.pdf
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/writing_engineering_reports.html
- https://www.youtube.com/playlist?list=PLDAAF7A8FD5CD582C&feature=plcp
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/mechanical_engineering_writing_enhancement_program/report_writing.html
- https://owl.purdue.edu/owl/subject_specific_writing/professional_technical_writing/technical_reports_and_report_abstracts/reports_proposals_and_technical_papers.html

Merry-go-round

- http://www.madehow.com/Volume-4/Carousel.html
- http://www.archiexpo.com/architecture-design-manufacturer/merry-go-round-313.html
- http://www.bluegrassplaygrounds.com/merry-go-round.html
- http://www.playgroundequipment.com/products/commercial-playgrounds/merry-go-rounds
- http://www.playgroundequipment.com/catalog-online/

Physics

- http://www.livescience.com/52488-centrifugal-centripetal-forces.html
- https://www.youtube.com/watch?v=PwE3eiREYA4
- https://www.youtube.com/watch?v=GoByVGNsX5g
- https://www.youtube.com/watch?v=ayVwMMEg-Ac
- https://www.youtube.com/watch?v=GiMi-QPt1Xk
- https://www.youtube.com/watch?v=mPsLanVS1Q8
- https://www.youtube.com/watch?v=bKu6U3QFsXE

Solid Edge Instructional Videos

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-quick-start/Ey8QWFP7d/chapters/solid-edge-quick-start/Nk1aTuvXd?topic=9

Introduction to Mechanisms

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-01-introduction/VJ-5mlGyO?topic=1

CAM and Follower

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=1

Beginning CAM Motion

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=2

Common CAM Types

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=1
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=2
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=3

CAM Physical Motion

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-04-cam-vice-lock-scissors/4JThnbf1d?topic=2

Circular vs. Arc

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-04-cam-vice-lock-scissors/4JThnbf1d?topic=3

Four Bar Mechanisms

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=1
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=2
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=3
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=4
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=4

Motion Concepts

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-09-motion-concepts/NytArMfyu?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-09-motion-concepts/NytArMfyu?topic=1

Assembly Example-Rowboat Video Collection

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/rowboat-mechanism-in-solid-edge/EJaWFRQRP

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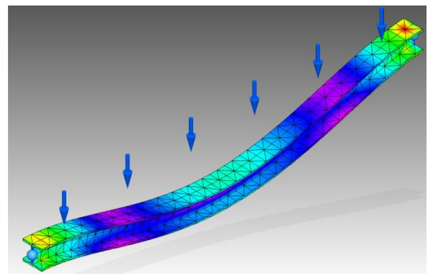
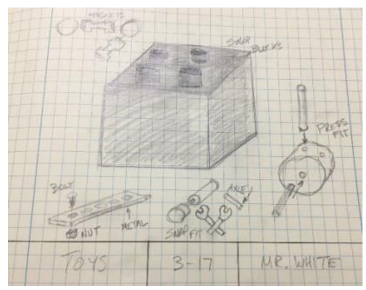
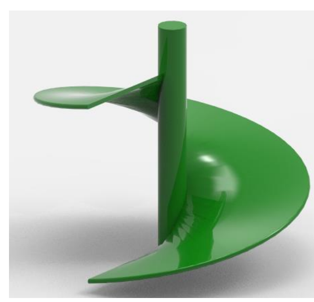
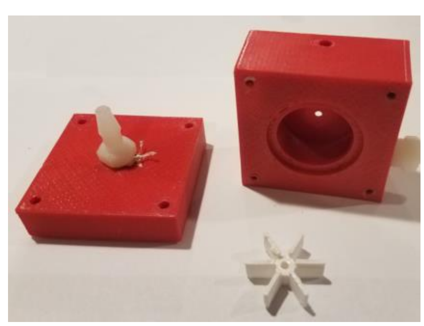
Ingenuity for life

Projects Quarter 4

Structures and Forces • Truss System	
Structures and Forces • Hybrid Toy Connector	
Structures and Forces • Playground Design	
Engineering Systems Select one • Centrifugal Pump • Automatic Training Wheels • Mechanical Bank • Glider • Child's Toy	

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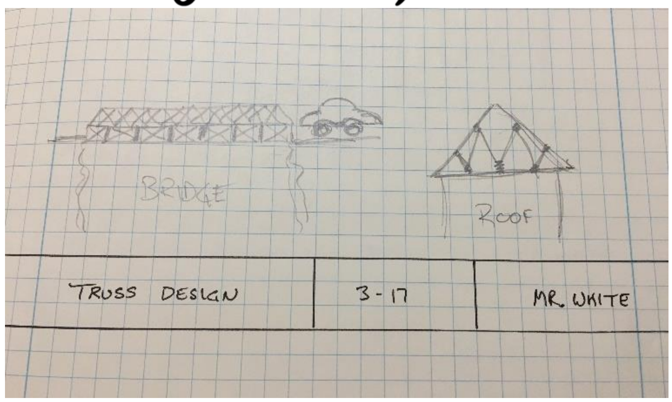
Ingenuity for life



Project: Truss System

Introduction:

How does a truss in a bridge or building help to distribute forces? A truss is an engineered frame connected at joints and supports loads by transferring the forces to the truss end points. The truss members are either in tension or compression, are coplanar, and usually assembled so the members form triangles.
Modern day trusses are important civil engineering structures containing applications of art, architecture, engineering, math, and science.

Purpose of the Project:

The purpose of this project is to test the strength of different geometric shapes as well as the reasons structures can possibly fail. Students will learn methods for strengthening and reinforcing structures. It is an introduction to how civil and structural engineers design trusses and the mathematics that are applied in the tension and compression calculations of truss members.

Concepts:

- Create models that are mathematical or physical systems that are set up to obey certain specified conditions for the purpose of evaluating a design system.
- Conduct model analysis using Finite Element Analysis (FEA) and simulations to produce a detailed examination of the elements, structure, and behavior of a system under certain conditions.
- Assign mathematical relationships to schematics to apply forces.

- Conduct a systematic study of a structure by applying a load to determine the performance of the structure design, the structure members, and the structure materials as determined through the relationship between applied force and the corresponding deflection.
- Apply the knowledge from a stress and strain curve to a design solution.
- Analyze the strength of materials under various types of loading to predict system behavior.
- Calculate the normal loads on a structure when in use including a factor for extreme conditions plus an additional typical added factor for safety.
- Analyze complex structures by breaking them down into components.
- Test scale models to verify the strength predictions made from mathematical models.

Outline:

Documentation
- Engineering Notebook
- Calculations of truss system to be designed

Modeling
- Creation of 3D models
- Assembly of 3D models
- Design renderings and working drawings
- Construct 3D model of truss project

Analysis
- Physical testing of truss system

Communication
- Presentation of design solutions

Standards:

Career and Technical Standards

Engineering Design Process

- Create and maintain an Engineering Notebook for daily reflections, research and prototype creation documentation.
- Apply the design and problem solving process as an iterative process incorporating sciences, mathematics and engineering to optimally convert resources to meet a stated objective.
- Communicate solutions utilizing technical writing skills including correct spelling, proper grammar and dependent vocabulary.
- Assume and carry out a role in the smooth running of a team working toward the solution of a problem.
- Assemble a quantitative plan for successful completion of the project.
- Assume leadership roles and responsibility for decisions making as part of a team.
- Analyze costs of resources necessary for the completion of a project.

Sketching

- Create sketches utilizing basic shapes such as lines circles and ellipses.
- Communicate ideas to a group through the use of sketches and other documentation.
- Apply isometric and orthographic sketches to add clarity to design.
- Create necessary sketches to communicate basic ideas during the design process.

3D Solid Modeling/Fabrication and 3-D Printing

- Apply geometric relationships between lines and shapes to create a mathematical database to describe design ideas.
- Create solid models utilizing concepts of Parametric Modeling.
- Analyze models for appropriate engineering design features needed.
- Develop strategies for the creation of solid models for the rapid creation of design solutions.
- Apply the concepts of digital prototyping to accelerate the time frame between ideation and completed project.
- Access, generate, and transfer information using appropriate technologies.
- Design and create a model using additive manufacturing technology sometimes called a rapid prototyping system.
- Apply new principles of more rapid and less costly development and deployment of new materials.
- Utilize rapid prototyping/additive manufacturing to create highly complex parts designed in a CAD system.

Renderings/Working Drawings/ Design Presentations

- Create renderings to communicate design ideas and engineering principles to the customer.
- Produce a final pictorial rendering of a design concept utilizing light, texture and shading.
- Apply rendering techniques to create final design presentations for the customer.

Assembly Modeling/Documentation/Exploded Assemblies/Bill of Materials

- Conduct model documentation as the process of recording details such as size, material composition, and instructions for assembling, installation and servicing, analysis, development process that describes a model for the purpose of communication of ideas.
- Create a bill of materials to communicate materials and other information about a design.

Reverse Engineering/Engineering Features

- Apply the principles of design for manufacturing enabling the efficient and effective production of products.
- Apply the green principles of design for eventual disassembly and resource recovery.

- Investigate activities that a business conducts with the intention of making a discovery that can either lead to the development of new products or procedures, or to improvement of existing products or procedures and to know the new approaches of rapid development and deployment that saves time and is more efficient.
- Disassemble a product into its parts, utilize precision measurement to create sketches, drawings and models of the product and identify the basic processes, systems, designs, and materials used in the manufacture of the product.
-

Simple Machines

- Utilize mathematical analysis, scientific inquiry and engineering design to develop solutions to open ended problems.
- Access, generate, process, and transfer information using appropriate technologies
- Apply the engineering design process in the design of a mechanical system.
- Read and analyze detailed descriptions of machinery and provide a concise summary for documentation purposes.
- Assign mathematical relationships to analyze mechanical advantage.
- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.
- Assign mathematical relationships to analyze mechanical advantage.
- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.

Mechanical systems

- Utilize mathematical analysis, scientific inquiry and engineering design to develop solutions to open ended problems.
- Access, generate, process, and transfer information using appropriate technologies.
- Apply the engineering design process in the design of a mechanical system.
- Read and analyze detailed descriptions of machinery and provide a concise summary for documentation purposes.
- Assign mathematical relationships to schematics to apply forces.
- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.
- Design a system of elements that manage power to accomplish a task that involves defined movement.

Structures/Forces

- Create models that are mathematical or physical systems that are set up to obey certain specified conditions having behavior intended to understand or evaluate a design system.
- Conduct model analysis using Finite Element Analysis (FEA) and simulations to produce a detailed examination of the elements, structure and behavior of a system under certain conditions.

- Assign mathematical relationships to schematics to apply forces.
- Conduct a systematic study of a structure by applying a load to determine the performance of the structure design, the structure members, and the structure materials as determined through the relationship between applied force and the corresponding deflection.
- Apply the knowledge from a stress and strain curve to a design solution.
- Analyze the strength of materials under various types of loading to predict system behavior.
- Calculate the normal loads on a structure when in use including a factor for extreme conditions plus an additional typical added factor for safety.
- Analyze complex structures by breaking them down into components.
- Test scale models to verify the strength predictions made from mathematical models.

Engineering Systems

- Utilize mathematical analysis, scientific inquiry and engineering design to develop solutions to open ended problems.
- Defend a selected material for use in a product, explaining material properties and characterization, based upon manufacturing processes, chemical composition, internal defects, temperature, previous loading, dimensions and other factors.

College and Career Readiness Math Standards

Number and Quantity

1. Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
2. Define appropriate quantities for the purpose of descriptive modeling.
1. Recognize vector quantities as having both magnitude and direction. Represent vector quantities by directed line segments, and use appropriate symbols for vectors and their magnitudes
4. Given two vectors in magnitude and direction form, determine the magnitude and direction of their sum.

Modeling with Geometry G-MG

Apply geometric concepts in modeling situations

1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).
2. Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot).
3. Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).

Create equations that describe numbers or relationships CED

A.4. Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.

Reading Standards for Literacy in History/Social Studies 9-10

Key Ideas and Details

1. Cite specific textual evidence to support analysis of primary and secondary sources, attending to such features as the date and origin of the information.
3. Analyze in detail a series of events described in a text; determine whether earlier events caused later ones or simply preceded them.

Integration of Knowledge and Ideas

7. Integrate quantitative or technical analysis (e.g., charts, research data) with qualitative analysis in print or digital text.
9. Compare and contrast treatments of the same topic in several primary and secondary sources.

Range of Reading and Level of Text Complexity

10. By the end of grade 10, read and comprehend science/technical texts in the grades 9–10 text complexity band independently and proficiently.

Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 9-10

Text Types and Purposes

1. Write arguments focused on *discipline-specific content.*
2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

Production and Distribution of Writing

4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Research to Build and Present Knowledge

7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.

Range of Writing

10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Next Generation Science Standards

The projects engage students in the scientific and engineering practices taken from the National Research Council's Framework for K-12 Science Education, Practices, Crosscutting Concepts, and Core Ideas. This is the document upon which the NGSS are based.

These practices are used for two reasons: 1) they parallel the design process utilized in each project, and 2) they serve as the foundation of the NGSS.

The eight science and engineering practices are:

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Standards for Technological Literacy

Standard 1

Students will develop an understanding of the characteristics and scope of technology.

Standard 2

Students will develop an understanding of the core concepts of technology.

Standard 3

Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Standard 5

Students will develop an understanding of the effects of technology on the environment.

Standard 7

Students will develop an understanding of the influence of technology on history.

Standard 8

Students will develop an understanding of the attributes of design.

Standard 9
Students will develop an understanding of engineering design.

Standard 10
Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Standard 11
Students will develop the abilities to apply the design process.

Standard 12
Students will develop the abilities to use and maintain technological products and systems.

Standard 13
Students will develop the abilities to assess the impact of products and systems.

Standard 14
Students will develop an understanding of and be able to select and use medical technologies.

Standard 17
Students will develop an understanding of and be able to select and use information and communication technologies.

Standard 19
Students will develop an understanding of and be able to select and use manufacturing technologies.

Standard 20
Students will develop an understanding of and be able to select and use construction technologies.

Assessment:

Assessment is both formative and summative. It is an integral part of quality instruction. During the course of each project, one of the teacher's main functions is to work with student groups, keeping track of progress and providing formative assessment in the form of feedback and promoting reflection on the part of students. The focus should be on promoting lifetime learning and 21st century skills. The goal of instruction is to promote abilities in research, problem solving, designing, experimenting, testing, collecting and analyzing data.

Rubrics are used in the assessment process to communicate expectations of quality. Rubrics should be shared with students at the beginning of a project to clarify any misconceptions before beginning their work. Students can then build the skills and gather knowledge to solve the problem presented to the expectations of excellence described.

General Rubrics for Literacy tasks:
Argumentative_Pursuasive
Informational_Explanatory

Individual Project Rubric:
Truss System Rubric

Essential Question:
How can we calculate, design, build, and test a truss bridge system that will hold a specific amount of weight?

Student Scenario:
A civil engineering firm has contracted with you and your team to design, build, and test a new pedestrian bridge over a street with heavy traffic. The bridge must support the weight of 100 people in addition to the weight of the bridge including snow, ice, and wind loading.

Deliverables:
- Engineering Notebook with reflections, research notes, bibliography and other processes used in the design.
- Sketches and working drawings for the pedestrian bridge
- Analysis of the bridge truss design
- 3D model of the pedestrian bridge
- Engineering report of the design process
- Presentation for the authentic audience

Daily Plan:
Day 1
Key Question: What are the expectations of the project?

Introduce students to the project by providing them with the Essential Question and the scenario.

Review and discuss with your students the design process, Engineering Notebook and design documentation requirements. Discuss the problem statement, design brief, testing protocol and management plan. Review the elements of a good engineering report with the students. These were all covered in the first project titled *Introduction to the Engineering Design Process* but should be reinforced on a regular basis. All projects depend on the design process and student activities should relate directly.

Have the students form teams of two. Allow the students five minutes to discuss the problem. Students begin by brainstorming ideas in their Engineering Notebooks. The teacher will provide a list of vocabulary terms that students will need to research on their own. The teams can divide the list of terms among team members and share their definitions. All team members are responsible to know all definitions.

Day 2-4
Key Question: How do we get started in the design process?

The teams will be responsible for researching beams, forces, trusses, structures, strength of materials, and analysis. Links can be found in the Resources section. The teacher will lead a group discussion on the specifications of the truss design such as the size and amount of weight it should hold. Students begin sketching and adding force calculations associated with each type of structure. Students add items from their reading to their Engineering Notebooks.

The teacher reminds students about the help system to find out how the software accomplishes basic features they might want to incorporate.
https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index
Students can enter terms and view a tutorial for creating certain features. Students can reference specific terms from the vocabulary list for specific commands to be used in the design of the bridge.

Other tutorials in the Resources section are available for use if students struggle.

The teacher will provide access to the following video tutorials that will provide students with information about the basics of structural design. They can also access Siemens Solid Edge Video Resources to allow students to discover further elements to help their designs.

Solid Edge Structural Analysis

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1325275:index_sesim:xid1602403:activity1a

Solid Edge Analysis Videos

- https://www.youtube.com/watch?v=515un5vL-2Y
- https://www.youtube.com/watch?v=AzHT9DC0xaA
- https://www.youtube.com/watch?v=EwubY6Dx964
- https://www.youtube.com/watch?v=z57kz8m3gQo
- https://www.youtube.com/watch?v=I3Q0cQHIxyI

Engineering Reference Command for designing Gears, CAMs Pulleys etc.

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1323753:index_xid718565

The teams should decide on the design constraints which could include:

- How long and wide is the span we are supporting?
- What are the maximum and minimum sizes for the truss?
- Should the truss contain a certain number of members?
- What materials should the truss be made?
- How should the truss be assembled?
- How many trusses would be needed for the design?
- How much weight should each truss optimally support?
- How can we predict the amount of weight the structure will hold?
- How can we create a scale model of the bridge.

Student teams discuss the specifications of the structure they will create. Students list the criteria and constraints of the problem they are solving. Teams research the existing structures and discover information about forces and reactance causes of failure in structures. Teams will define the total weight the structure must hold including snow, ice, and wind force. Students will plan for a structure that will hold the established weight with a minimum of material.

Remind students to record research notes and sources as well as reflections on the day in the Engineering Notebook.

Day 5
Key Question: How do we get started on our individual designs?

Student teams finish creating their isometric sketches and create a design brief to include with their sketch. They include measurements with their free body diagrams and include formulas used to evaluate their designs. They then meet with their clients who will need to sign off on the design proposal before solid modeling can begin. NOTE: The teacher will decide how the “client” and the client’s needs for the project are to be represented.

Students can reference Basic 3D Commands, Creating Drawing Views and Assembly Modeling and Working with Bodies for specific commands to use in the bridge design. Students can reference web links, videos and tutorials at any time during the process of the bridge design.

Teams discuss how their bridges should be tested. The groups decide what components they will test and how they will know when their design achieves the test requirements.

Day 6
Key Question: How can we begin to plan our bridge?

Students record sketches and reflections in the Engineering Notebook. Once the students feel they have a bridge solution that meets the requirements, consider how the design will be tested before building.

Teams discuss their bridges and how to achieve the design given the approved sketch. Students work together to brainstorm ideas and begin to narrow their vision of the solution. Divide the work of creating the 3D solid model of the pieces needed and the plan to assemble. Utilize the division of work in the creation of the project management plan.

Teams are reminded to continually check their beginning bridge designs with the team to ensure the accurate sizes. Teams discuss how the various designs work and that the designs created will meet the budget requirements. Student teams also discuss how the designs are built and how the forces are counteracted.

Day 7-8
Key Question: How can we put our new designs together?

The teacher will review testing methods in the software enabling the virtual creation of their bridge design and assembly it within Solid Edge. The teacher reviews the design process with the class and checks with teams to assess progress as well as any known or perceived problems with their bridge designs.

Students are introduced to the activity Designing and Analyzing Beams. Students should create the animate testing of their bridge to demonstrate how their bridge will react and make predictions on when it might fail.

Day 9-10
Key Question: How can we check our designs?

Students conduct meetings to review all designs created so far. Students review the criteria and testing protocols. They discuss which design they wish to use as the team final design. It could be a single design or contain elements of several designs. Once the decision is made, the students create a plan for creating the team prototype. They need to create a design that incorporates their ideas. Once the final plan is created they will create individual parts in Solid Edge and assemble them into assemblies. The teams discuss the final testing of their prototypes and how their design will incorporate the necessary structure for the testing. The teacher will introduce the testing equipment to teams along with the attachment points needed.

Students create the final plans and begin 3D printing the necessary components and assemble their scale model of the bridge from the printed parts. Students record any changes in their designs and enter reflections in their Engineering Notebooks.

Day 11-12
Key Question: How do we build our designs?

Students assemble their bridges from the materials following the plans. When students encounter problems assembling their designs they must discuss how they will resolve the issue and change the design.

Students record any changes in their designs and enter reflections in their Engineering Notebooks.

Day13-14
Key Question: How can we test our designs to see if the desired weight can be sustained?

Students conduct preliminary tests to see if their bridge meets the established requirements. Students also analyze the structure for any changes their design will need before final testing. Students record any changes in their designs and enter reflections in their Engineering Notebooks.

Day 15-16
Key Question: How do we organize our thoughts for a presentation to the class?

The student teams discuss and finish any changes that are needed.
The teacher will discuss with the teams how to optimally present their ideas.

Students discuss the outline of the presentation to their client. The deliverables could be in the form of a dimensioned working drawing pictorial representation with balloons and bill of materials and/or a 3D printed prototype as well as the final testing data and demonstrations. Students should prepare an engineering report about the process of designing their bridge and how the components all fit together. The students should be required to write the introduction, provide results including graphics, and form a conclusion including an acknowledgement section reporting the source of information. Students decide how to divide the work to create a team report.

Day 17
Key Question: How do we convey our ideas?

Students can present their solutions to the class one at a time. Students perform a final test of their bridge for the group as a component of the presentation. Students discuss changes they would consider if they had time to create another iteration of their design.

In the end, all students can reflect on their work by giving and receiving feedback on how they could possibly improve their designs

Vocabulary:

Beam
Bearing
Bottom chord
Cantilever
Clear span
Column
Compression

Dead load
Deflection
Diagonal bracing
Finite Element Analysis (FEA)
Fixed support
Foot pounds
Force
Force diagram
Girders
Gusset plate
I beam
Impact load
Joists
Kips
Live load
Newtons
Overhang
Pin connection
Pinned connection
Pitch (slope)
Point load
Reactance
Roller
Sheer
Strain
Stress
Tension
Top chord
Web joist
Webs

Resources:

Bridge Basics

- http://pghbridges.com/basics.htm
- http://partners-ink.net/pghbridges//basics.htm
- http://science.howstuffworks.com/engineering/civil/bridge4.htm
- https://www.ncdot.gov/projects/ncbridges/historic/types/?p=17
- http://engineeringfeed.com/roof-truss-elements-understand

Truss Basics

- http://www.steelconstruction.info/Trusses
- https://www.khanacademy.org/partner-content/49ers-steam/ka-videos-topic/ka-videos-tutorial/v/truss-basics
- https://www.youtube.com/watch?v=1OIJQyZ3YIw
- https://www.youtube.com/watch?v=2uSQPm3_4mY

Design Factors

- http://www.learnengineering.org/2013/08/truss-analysis-method-of-joints.html
- http://www.conteches.com/knowledge-center/pdh-article-series/design-considerations-for-pedestrian-truss-bridge.aspx
- http://www.permatrak.com/news-events/bid/93919/Pedestrian-Bridge-Design-7-Considerations-for-Architects-Engineers
- https://www.ipfw.edu/dotAsset/239460.pdf
- http://3Dprint.com/31075/tethers-unlimited-trusselator/
- http://www.pbs.org/wgbh/buildingbig/bridge/

Engineering Reports

- http://web.mit.edu/me-ugoffice/communication/technical-writing.pdf
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/writing_engineering_reports.html
- https://www.youtube.com/playlist?list=PLDAAF7A8FD5CD582C&feature=plcp
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/mechanical_engineering_writing_enhancement_program/report_writing.html
- https://owl.purdue.edu/owl/subject_specific_writing/professional_technical_writing/technical_reports_and_report_abstracts/reports_proposals_and_technical_papers.html

CAD Tutorials

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012424/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012420/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012430/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012447/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012454/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012455/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012420/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012460/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012430/index.html
- http://niveshandnisheeth.blogspot.com/2016/11/content-list-videos-solid-edge-st9.html
- http://media.plm.automation.siemens.com/goplm/Introduction-FEA.zip
- http://media.plm.automation.siemens.com/goplm/Introduction-Mechanical-Systems.zip

Assembly Tutorials

- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012424/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012454/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012455/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012460/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012451/index.html

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- https://www.youtube.com/watch?v=515un5vL-2Y
- https://www.youtube.com/watch?v=AzHT9DC0xaA
- https://www.youtube.com/watch?v=EwubY6Dx964
- https://www.youtube.com/watch?v=z57kz8m3gQo
- https://www.youtube.com/watch?v=I3Q0cQHIxyI

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- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1323753:index_xid718565

Solid Edge Robotics and Mechanisms Course

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku

Solid Edge Structural Analysis

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1325275:index_sesim:xid1602403:activity1a

Material Properties:

- http://www.matweb.com
- http://www.engineeringtoolbox.com/material-properties-t_24.html
- http://www.technologystudent.com/joints/matprop1.htm
- http://www.makeitfrom.com/
- http://web.mit.edu/course/3/3.225/book.pdf

Solid Edge Instructional Videos

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-quick-start/Ey8QWFP7d/chapters/solid-edge-quick-start/Nk1aTuvXd?topic=9

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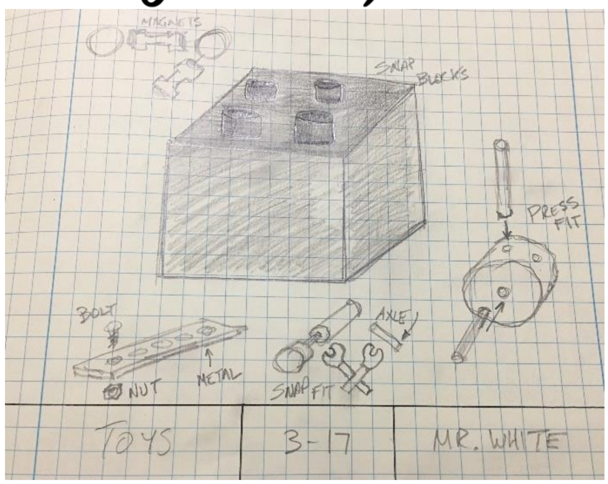

Project: Hybrid Toy Connector

Introduction:

What job could be more fun than designing toys all day long? Toys are designed for any and all ages in varying colors, shapes, and themes and as a toy designer; your imagination can run wild.

Some toys come with many parts to assemble creating an object such as a bridge, house, or robot. These types of toys are referred to as builders' sets. There are many toy sets available to purchase for all age levels of builders. Each different set has its own unique way of attaching components to form creative assemblies. Every manufacturer has their own design of how their components fasten together. These companies patent the connecting system to protect their product and business interest. As of today, there are no tangible parts to connect these sets together so that children can create even more endless possibilities between two or more sets.

Purpose of the Project:

The purpose of this project is to utilize prior knowledge of reverse engineering to create a set of parts that will connect dissimilar existing toy sets. Students will obtain multiple tangible toy products, disassemble as necessary, measure, record findings, and then design a new product with their own ideas incorporated. In the end, the students must demonstrate that their new toys work with the existing sets. They must design a connector that does not violate existing patents but still works with the sets.

Concepts:

- Utilize mathematical analysis, scientific inquiry, and engineering design to develop solutions to open ended problems.
- Select and defend a material for use in a product, explaining material properties and characterization based upon manufacturing processes, chemical composition, internal defects, temperature, loading, physical dimensions, and other factors.
- Design and create a model using additive manufacturing technology also referred to rapid prototyping.
- Disassemble a product into its parts, utilize precision measurement to create sketches, drawings, and models of the product while being able to identify the basic processes, systems, designs, and materials used to manufacture the product.
- Develop strategies for the creation of solid models for the rapid creation of design solutions.
- Conduct model documentation as the process of recording details such as size, material composition and instructions for assembling, installation and servicing analysis.

Outline:

Documentation
- Engineering Notebook
- Documentation of hybrid toy to be designed

Modeling
- Creation of 3D models
- Assembly of 3D models
- Design renderings and pictorials of exploded drawings
- Construct 3D prototype of hybrid toy project

Communication
- Presentation of hybrid toy design solutions

Standards:

Career and Technical Standards

Engineering Design Process

- Create and maintain an Engineering Notebook for daily reflections, research and prototype creation documentation.
- Apply the design and problem solving process as an iterative process incorporating sciences, mathematics and engineering to optimally convert resources to meet a stated objective.
- Communicate solutions utilizing technical writing skills including correct spelling, proper grammar and dependent vocabulary.
- Assume and carry out a role in the smooth running of a team working toward the solution of a problem.
- Assemble a quantitative plan for successful completion of the project.
- Assume leadership roles and responsibility for decisions making as part of a team.

- Analyze costs of resources necessary for product production.

Sketching

- Create sketches utilizing basic shapes such as lines circles and ellipses.
- Apply isometric and orthographic sketches to add clarity to design.
- Create necessary sketches to communicate basic ideas during the design process.

3D Solid Modeling/Fabrication and 3-D Printing

- Apply geometric relationships between lines and shapes to create a mathematical database to describe design ideas.
- Create solid models utilizing concepts of Parametric Modeling.
- Analyze models for appropriate engineering design features needed.
- Develop strategies for the creation of solid models for the rapid creation of design solutions.
- Apply the concepts of digital prototyping to accelerate the time frame between ideation and completed project.
- Access, generate, and transfer information using appropriate technologies.
- Design and create a model using additive manufacturing technology sometimes called a rapid prototyping system.
- Apply principles of rapid and less costly product development including the application of new materials.
- Utilize rapid prototyping/additive manufacturing to create highly complex parts designed with a CAD system.

Renderings/Working Drawings/ Design Presentations

- Create renderings to communicate design ideas and engineering principles to the customer.
- Produce a final pictorial rendering of a design concept utilizing light, texture and shading.
- Apply rendering techniques to create final design presentations for the customer.

Assembly Modeling/Documentation/Exploded Assemblies/Bill of Materials

- Conduct model documentation as the process of recording details such as size, material composition, and instructions for assembling, installation and servicing, analysis, development process that describes a model for the purpose of communication of ideas.
- Create a bill of materials to communicate materials and other information about a design.

Reverse Engineering/Engineering Features

- Apply the principles of design for manufacturing enabling the efficient and effective production of products.
- Apply the green principles of design for eventual disassembly and resource recovery.

- Investigate activities that a business conducts with the intention of making a discovery that can either lead to the development of new products or procedures, or to improvement of existing products or procedures and to know the new approaches of rapid development and deployment that saves time and is more efficient.
- Disassemble a product into its parts, utilize precision measurement to create sketches, drawings and models of the product and identify the basic processes, systems, designs, and materials used in the manufacture of the product.

Simple Machines

- Utilize mathematical analysis, scientific inquiry and engineering design to develop solutions to open ended problems.
- Access, generate, process, and transfer information using appropriate technologies
- Apply the engineering design process in the creation of a mechanical system.
- Read and analyze detailed descriptions of machinery and provide a concise summary for documentation purposes.
- Assign mathematical relationships to analyze mechanical advantage.
- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.

Mechanical Systems

- Utilize mathematical analysis, scientific inquiry and engineering design to develop solutions to open ended problems.
- Access, generate, process, and transfer information using appropriate technologies.
- Apply the engineering design process in the creation of a mechanical system.
- Read and analyze detailed descriptions of machinery and provide a concise summary for documentation purposes.
- Assign mathematical relationships to schematics to apply forces.
- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.
- Design a system of elements that manage power to accomplish a task that involves defined movement.

Structures/Forces

- Create models that are mathematical or physical systems that are set up to obey certain specified conditions having behavior intended to understand or evaluate a design system.
- Conduct model analysis using Finite Element Analysis (FEA) and simulations to produce a detailed examination of the elements, structure and behavior of a system under certain conditions.
- Assign mathematical relationships to schematics to apply forces.
- Conduct a systematic study of a structure by applying a load to determine the performance of the structure design, the structure members, and the structure

materials as determined through the relationship between applied force and the corresponding deflection.

- Apply the knowledge from a stress and strain curve to a design solution.
- Analyze the strength of materials under various types of loading to predict system behavior.
- Calculate the normal loads on a structure when in use including a factor for extreme conditions plus an additional typical added factor for safety.
- Analyze complex structures by breaking them down into components.
- Test scale models to verify the strength predictions made from mathematical models.

Engineering Systems

- Utilize mathematical analysis, scientific inquiry and engineering design to develop solutions to open ended problems.
- Defend a selected material for use in a product, explaining material properties and characterization, based upon manufacturing processes, chemical composition, internal defects, temperature, previous loading, dimensions and other factors.

College and Career Readiness Math Standards

Number and Quantity

3. Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
4. Define appropriate quantities for the purpose of descriptive modeling.
2. Recognize vector quantities as having both magnitude and direction. Represent vector quantities by directed line segments, and use appropriate symbols for vectors and their magnitudes
5. Given two vectors in magnitude and direction form, determine the magnitude and direction of their sum.

Modeling with Geometry G-MG

Apply geometric concepts in modeling situations

1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).
2. Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot).
3. Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).

Create equations that describe numbers or relationships CED

A.4. Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.

Reading Standards for Literacy in History/Social Studies 9-10

Key Ideas and Details

1. Cite specific textual evidence to support analysis of primary and secondary sources, attending to such features as the date and origin of the information.
3. Analyze in detail a series of events described in a text; determine whether earlier events caused later ones or simply preceded them.

Integration of Knowledge and Ideas

7. Integrate quantitative or technical analysis (e.g., charts, research data) with qualitative analysis in print or digital text.
9. Compare and contrast treatments of the same topic in several primary and secondary sources.

Range of Reading and Level of Text Complexity

10. By the end of grade 10, read and comprehend science/technical texts in the grades 9–10 text complexity band independently and proficiently.

Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 9-10

Text Types and Purposes

1. Write arguments focused on *discipline-specific content.*
2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

Production and Distribution of Writing

4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Research to Build and Present Knowledge

7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.

Range of Writing

10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Next Generation Science Standards

The projects engage students in the scientific and engineering practices taken from the National Research Council's Framework for K-12 Science Education, Practices, Crosscutting Concepts, and Core Ideas. This is the document upon which the NGSS are based.

These practices are used for two reasons: 1) they parallel the design process utilized in each project, and 2) they serve as the foundation of the NGSS.

The eight science and engineering practices are:

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Standards for Technological Literacy

Standard 1

Students will develop an understanding of the characteristics and scope of technology.

Standard 2

Students will develop an understanding of the core concepts of technology.

Standard 3

Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Standard 7

Students will develop an understanding of the influence of technology on history.

Standard 8

Students will develop an understanding of the attributes of design.

Standard 9

Students will develop an understanding of engineering design.

Standard 10

Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Standard 11
Students will develop the abilities to apply the design process.

Standard 12
Students will develop the abilities to use and maintain technological products and systems.

Standard 13
Students will develop the abilities to assess the impact of products and systems.

Standard 14
Students will develop an understanding of and be able to select and use medical technologies.

Standard 17
Students will develop an understanding of and be able to select and use information and communication technologies.

Standard 19
Students will develop an understanding of and be able to select and use manufacturing technologies.

Standard 20
Students will develop an understanding of and be able to select and use construction technologies.

Assessment:

Assessment is both formative and summative. It is an integral part of quality instruction. During the course of each project, one of the teacher's main functions is to work with student groups, keeping track of progress and providing formative assessment in the form of feedback and promoting reflection on the part of students. The focus should be on promoting lifetime learning and 21st century skills. The goal of instruction is to promote abilities in research, problem solving, designing, experimenting, testing, collecting and analyzing data.

Rubrics are used in the assessment process to communicate expectations of quality. Rubrics should be shared with students at the beginning of a project to clarify any misconceptions before beginning their work. Students can then build the skills and gather knowledge to solve the problem presented to the expectations of excellence described.

General Rubrics for Literacy tasks:
Argumentative_Pursuasive
Informational_Explanatory

Individual Project Rubric:
Hybrid Toy Connector Rubric

Essential Question:
How can two or more toy sets, each having unique connecting geometry, be used together to assemble a structure?

Student Scenario:
Children often have multiple play sets that have similar characteristics but have different connecting systems that do not fit together. You are given the job as a design engineer at a large toy company to design and build a connecting component that will permit the assembly of components from two or more unique toy sets.

Deliverables:

- Engineering Notebook
- CAD model
- 3D printed model
- Engineering Report that includes 3D images and working and assembly drawings
- Presentation of the development process

The teacher and class should decide on design constraints to include:

- How many different toy sets will be used?
- What material will the new parts will be made from?
- How will the new parts be marketed?
- How many new parts are needed per set?

Daily Plan:
Day 1
Key Question: What are the expectations of the project?

Introduce students to the project by providing them with the Essential Question and the scenario.

Review and discuss with your students the design process, Engineering Notebook and design documentation requirements. Discuss the problem statement, design brief, testing protocol and management plan. Review the elements of a good engineering report with the students. These were all covered in the first project titled *Introduction to the Engineering Design Process* but should be reinforced on a regular basis. All projects depend on the design process and student activities should relate directly.

Have the students form teams of two. Allow the students five minutes to discuss the problem. Students begin by brainstorming ideas in their Engineering Notebooks. The teacher will provide a list of vocabulary terms that students will need to research on their own. The teams can divide the list of terms among team members and share their definitions. All team members are responsible to know all definitions.

Day 2
Key Question: How do we get started in the design process?

The teams will be responsible for researching classes of fit, tolerance, strength of materials, material properties, and analysis. Links can be found in the Resources section. Students begin sketching and adding necessary tolerances associated with each type of connector. Students add items from their reading to their Engineering Notebooks.

The teacher reminds students about the help system to find out how the software accomplishes basic features they might want to incorporate.
https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index
Students can enter terms and view a tutorial for creating certain features. Students can reference specific terms from the vocabulary list for specific commands to be used in the design of the hybrid toy connector.
The teacher will also show students the Siemens Solid Edge Video Resources to allow students to discover further elements to help their designs. Other tutorials in the Resources section are available for use if students struggle.

Solid Edge Structural Analysis

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1325275:index_sesim:xid1602403:activity1a

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- https://www.youtube.com/watch?v=z57kz8m3gQo
- https://www.youtube.com/watch?v=I3Q0cQHIxyI

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The teams discuss different types of toy sets. The teams should decide on design constraints which might include:

- How many different toy sets will be used?
- What material will the new parts will be made from?
- How will the new parts be marketed?
- How many new parts are needed per set?

Student teams discuss the specifications of the playset connector they will create. Each team will create a different type of connector. Students list the criteria and constraints of the equipment they will be designing. Teams research the existing playset equipment and discover information about connectors and the forces they must withstand over repeated use. Teams must select the material for the connector in addition to how the components might be mass produced. Teams create a 3D model of the connector actual size to check for fit between the playsets and a mold to create their connector.

Remind students to record research notes and sources as well as reflections on the day in the Engineering Notebook.

Day 3
Key Question: How do we get started on our individual designs?

Student teams finish creating their isometric sketches and create a design brief to include with their sketch. They then meet with their clients who will need to sign off on the design proposal before solid modeling can begin. Once the design has been verified and permission given, solid modeling can begin on the software.

Students can reference Basic 3D Commands, Creating Drawing Views and Assembly Modeling, Designing and Analyzing Beams and Working with Bodies for specific commands to use in the playset connector design. Students can reference web links, videos, and tutorials at any time during the process of the connector design.

Teams discuss how their connector should be tested. The groups decide what components they will test and how they will know when their design achieves the test requirements.

Day 4
Key Question: How can we begin to make our toys?

Teams discuss their proposed connector and how to achieve the design given the approved sketch they presented. They work together to brainstorm ideas and begin to narrow their vision of their solution. Next the team divides the work of creating the 3D solid model of the pieces needed and a plan to assemble the connector with the different playsets. They utilize the division of work in the creation of the project management plan.

Students record sketches and reflections in the Engineering Notebook during the brainstorming sessions. Once the students feel they have a connector solution that meets the requirements, consider how the design will be tested before building.

Teams are reminded to continually check their 3D components of the designs to ensure accurate sizes. Teams discuss how the various designs work and that the playset requirements are met. Student teams also discuss how the designs will be built and how the connectors will be stable.

Day 5-7
Key Question: How can we put our new designs together?

Students conduct meetings to review all designs created so far. Students need to look at the criteria and testing protocols. They discuss which design they wish to use as the team final design. It could be a single design or contain elements of several designs. Once the decision is made the students create a plan for creating the team prototype. They need to create a design that incorporates their ideas. Once the final plan is created they will create individual parts in Solid Edge and assemble them into assemblies. The teams discuss the final testing of their prototypes and how that will be achieved.

Students create the final plans and begin 3D printing the necessary components and assemble the toy sets. Students record any changes in their designs and enter reflections in their Engineering Notebooks.

Day 8-9
Key Question: How can we check our designs?

Students do a trial assembly of the toy sets and the connector. Students review the fit and finish of the printed component and evaluate the necessity of changes to the parts so they function better. Teams discuss how their connector might be manufactured and begin the process of designing the type of molds it would take to create.

Day 10-11
Key Question: How do we organize our thoughts for a presentation to the class?

The teacher will discuss with the students how to optimally present their ideas to the class. Students should also be prepared to justify any design enhancements incorporated into the new toy connector. Students will continue to model using the software. Students finish the 3D print samples of the toy connector. Teams finalize their designs.

Students discuss the outline of the presentation to their clients. The deliverables could be in the form of a dimensioned working drawing pictorial representation with balloons and bill of materials and/or a 3D printed prototype as well as the final testing data and demonstrations. Students should prepare an engineering report about the process of designing their connector and how the components all fit together. The students should be required to write the introduction, provide results including graphics, and form a conclusion including an acknowledgement section reporting the source of information. Students decide how to divide the work to create a team report.

Day 12
Key Question: How do we convey our ideas?

Students can present their solutions to the class one at a time. Students discuss changes they would consider if they had time to create another iteration of their design.

In the end, all students can reflect on their work by giving and receiving feedback on how they could possibly improve their designs

Vocabulary:

Age group
Articulation
Ball joint
Bricks
Classes of fits
Detachable
Deflection
Finite Element Analysis (FEA)
Notches
Panels
Pressure fit
Sleeves
Space frames
Splines
Stress/Strain
Struts
Studs
Tolerance

Resources:

CAD Tutorials
CAD Tutorials

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012424/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012420/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012430/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012447/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012454/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012455/index.html

- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012420/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012460/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012430/index.html
- http://niveshandnisheeth.blogspot.com/2016/11/content-list-videos-solid-edge-st9.html
- https://docs.plm.automation.siemens.com/tdoc/se/109/se_help#uid:index_xid718565:xid721892

Assembly Tutorials
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012424/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012454/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012455/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012460/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012451/index.html

Solid Edge Analysis Videos
- https://www.youtube.com/watch?v=515un5vL-2Y
- https://www.youtube.com/watch?v=AzHT9DC0xaA
- https://www.youtube.com/watch?v=EwubY6Dx964
- https://www.youtube.com/watch?v=z57kz8m3gQo
- https://www.youtube.com/watch?v=I3Q0cQHIxyI

Engineering Reference Command for designing Gears, CAMs Pulleys etc.
- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1323753:index_xid718565

Solid Edge Robotics and Mechanisms Course
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku

Solid Edge Structural Analysis
- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1325275:index_sesim:xid1602403:activity1a

Engineering Reports
- http://web.mit.edu/me-ugoffice/communication/technical-writing.pdf
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/writing_engineering_reports.html
- https://www.youtube.com/playlist?list=PLDAAF7A8FD5CD582C&feature=plcp

- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/mechanical_engineering_writing_enhancement_program/report_writing.html
- https://owl.purdue.edu/owl/subject_specific_writing/professional_technical_writing/technical_reports_and_report_abstracts/reports_proposals_and_technical_papers.html

Material Properties

- http://www.matweb.com
- http://www.engineeringtoolbox.com/material-properties-t_24.html
- http://www.technologystudent.com/joints/matprop1.htm
- http://www.makeitfrom.com/
- http://web.mit.edu/course/3/3.225/book.pdf

Tolerance and Classes of Fits

- http://mmto.org/~dclark/Reports/Encoder%20Upgrade/fittolerences%20%5BRead-Only%5D.pdf
- http://www.mitcalc.com/doc/tolerances/help/en/tolerancestxt.htm
- https://engineering.pages.tcnj.edu/files/2012/02/dimensioning_and_tolerancing.pdf
- https://www.nmri.go.jp/eng/khirata/metalwork/basic/accuracy/index_e.html
- http://www.cobanengineering.com/Tolerances/TolerancesDefinitions.asp
- http://www.machinedesign.com/datasheet/working-dimensional-tolerances-pdf-download

Toy Sets

- http://www.roominatetoy.com/
- http://childhood101.com/2015/01/building-constructing-toy-sets-for-kids/
- https://www.wedgits.com/
- http://www.greentoys.com/green-toys-block-set
- https://www.magformers.com/
- https://brackitz.com/
- https://www.pinblock.com/

Solid Edge Instructional Videos
Introduction to Mechanisms

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-01-introduction/VJ-5mlGyO?topic=1

CAM and Follower

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=0

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=1

Beginning CAM Motion

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=2

Common CAM Types

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=1
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=2
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=3

CAM Physical Motion

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-04-cam-vice-lock-scissors/4JThnbf1d?topic=2

Circular vs. Arc

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-04-cam-vice-lock-scissors/4JThnbf1d?topic=3

Four Bar Mechanisms

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=1
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=2
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=3

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=4
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=4

Motion Concepts

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-09-motion-concepts/NytArMfyu?topic=0

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-09-motion-concepts/NytArMfyu?topic=1

Assembly Example-Rowboat Video Collection

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/rowboat-mechanism-in-solid-edge/EJaWFRQRP

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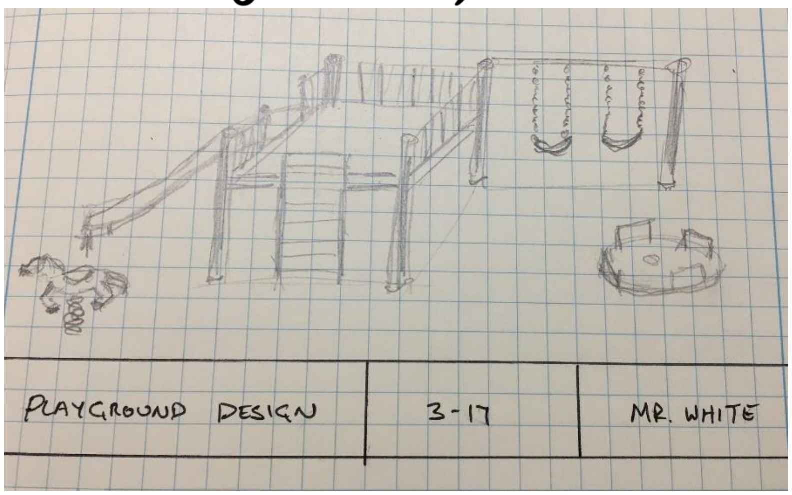
Ingenuity for life



Project: Playground Design

Introduction:

A playground is a designated place specifically designed for children to play either indoors or outdoors. Very often they are found at schools or public parks and they usually contain climbing structures, swings, seesaws, and play houses. Playgrounds must be safe, easily accessible, sort activities by age, and have easy sight lines with minimum hiding spaces. There is a great deal of thought and planning when creating a modern playground.

Purpose of the Project:

The purpose of this project is to utilize many of the features previously learned in Solid Edge and combine them into a large open ended playground design project. Students will research the various aspects of playground design and develop an appropriate solution. Many pieces of the playground design will require moving parts. The students create prototypes of parts of their designs to share with the class.

Concepts:

- Utilize mathematical analysis, scientific inquiry, and engineering design to develop solutions to open ended problems.
- Select and defend a material for use in a product, explaining material properties and characterization based upon manufacturing processes, chemical

composition, internal defects, temperature, loading, physical dimensions and other factors.
- Design and create a model using additive manufacturing technology also referred to rapid prototyping.
- Disassemble a product into its parts, utilize precision measurement to create sketches, drawings and models of the product while being able to identify the basic processes, systems, designs, and materials used to manufacture the product.
- Develop strategies for the creation of solid models for the rapid creation of design solutions.
- Conduct model documentation as the process of recording details such as size, material composition, and instructions for assembling, installation, and servicing analysis.
- Analyze strength of materials to predict behavior of solid bodies subjected to various types of loading to determine the stresses, strains, and displacements caused by the loading.
- Predict loads exerted on a product, machine, or structure during any foreseeable use to determine safety.
- Analyze complex structures by breaking them down into components.
- Test scale models to verify the strength predictions made from mathematical models.

Outline:

Documentation
- Engineering Notebook
- Documentation playground to be designed

Modeling
- Creation of 3D models
- Assembly of 3D models
- Design renderings and pictorial exploded drawings
- Construct 3D prototype of playground project

Communication
- Presentation of design solutions

Standards:

Career and Technical Standards

Engineering Design Process

- Create and maintain an Engineering Notebook for daily reflections, research and prototype creation documentation.
- Apply the design and problem solving process as an iterative process incorporating sciences, mathematics and engineering to optimally convert resources to meet a stated objective.
- Communicate solutions utilizing technical writing skills including correct spelling, proper grammar and dependent vocabulary.

- Assume and carry out a role in the smooth running of a team working toward the solution of a problem.
- Assemble a quantitative plan for successful completion of the project.
- Assume leadership roles and responsibility for decisions making as part of a team.
- Analyze costs of resources necessary for product production.

Sketching

- Create sketches utilizing basic shapes such as lines circles and ellipses.
- Apply isometric and orthographic sketches to add clarity to design.
- Create necessary sketches to communicate basic ideas during the design process.

3D Solid Modeling/Fabrication and 3-D Printing

- Apply geometric relationships between lines and shapes to create a mathematical database to describe design ideas.
- Create solid models utilizing concepts of Parametric Modeling.
- Analyze models for appropriate engineering design features needed.
- Develop strategies for the creation of solid models for the rapid creation of design solutions.
- Apply the concepts of digital prototyping to accelerate the time frame between ideation and completed project.
- Access, generate, and transfer information using appropriate technologies.
- Design and create a model using additive manufacturing technology sometimes called a rapid prototyping system.
- Apply principles of rapid and less costly product development including the application of new materials.
- Utilize rapid prototyping/additive manufacturing to create highly complex parts designed with a CAD system.

Renderings/Working Drawings/ Design Presentations

- Create renderings to communicate design ideas and engineering principles to the customer.
- Produce a final pictorial rendering of a design concept utilizing light, texture and shading.
- Apply rendering techniques to create final design presentations for the customer.

Assembly Modeling/Documentation/Exploded Assemblies/Bill of Materials

- Conduct model documentation as the process of recording details such as size, material composition, and instructions for assembling, installation and servicing, analysis, development process that describes a model for the purpose of communication of ideas.
- Create a bill of materials to communicate materials and other information about a design.

Reverse Engineering/Engineering Features

- Apply the principles of design for manufacturing enabling the efficient and effective production of products.
- Apply the green principles of design for eventual disassembly and resource recovery.
- Investigate activities that a business conducts with the intention of making a discovery that can either lead to the development of new products or procedures, or to improvement of existing products or procedures and to know the new approaches of rapid development and deployment that saves time and is more efficient.
- Disassemble a product into its parts, utilize precision measurement to create sketches, drawings and models of the product and identify the basic processes, systems, designs, and materials used in the manufacture of the product.
  -

Simple Machines

- Utilize mathematical analysis, scientific inquiry and engineering design to develop solutions to open ended problems.
- Access, generate, process, and transfer information using appropriate technologies
- Apply the engineering design process in the creation of a mechanical system.
- Read and analyze detailed descriptions of machinery and provide a concise summary for documentation purposes.
- Assign mathematical relationships to analyze mechanical advantage.
- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.

Mechanical Systems

- Utilize mathematical analysis, scientific inquiry and engineering design to develop solutions to open ended problems.
- Access, generate, process, and transfer information using appropriate technologies.
- Apply the engineering design process in the creation of a mechanical system.
- Read and analyze detailed descriptions of machinery and provide a concise summary for documentation purposes.
- Assign mathematical relationships to schematics to apply forces.
- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.
- Design a system of elements that manage power to accomplish a task that involves defined movement.

Structures/Forces

- Create models that are mathematical or physical systems that are set up to obey certain specified conditions having behavior intended to understand or evaluate a design system.

- Conduct model analysis using Finite Element Analysis (FEA) and simulations to produce a detailed examination of the elements, structure and behavior of a system under certain conditions.
- Assign mathematical relationships to schematics to apply forces.
- Conduct a systematic study of a structure by applying a load to determine the performance of the structure design, the structure members, and the structure materials as determined through the relationship between applied force and the corresponding deflection.
- Apply the knowledge from a stress and strain curve to a design solution.
- Analyze the strength of materials under various types of loading to predict system behavior.
- Calculate the normal loads on a structure when in use including a factor for extreme conditions plus an additional typical added factor for safety.
- Analyze complex structures by breaking them down into components.
- Test scale models to verify the strength predictions made from mathematical models.

Engineering Systems

- Utilize mathematical analysis, scientific inquiry and engineering design to develop solutions to open ended problems.
- Defend a selected material for use in a product, explaining material properties and characterization, based upon manufacturing processes, chemical composition, internal defects, temperature, previous loading, dimensions and other factors.

College and Career Readiness Math Standards

Number and Quantity

5. Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
6. Define appropriate quantities for the purpose of descriptive modeling.
3. Recognize vector quantities as having both magnitude and direction. Represent vector quantities by directed line segments, and use appropriate symbols for vectors and their magnitudes
6. Given two vectors in magnitude and direction form, determine the magnitude and direction of their sum.

Modeling with Geometry G-MG

Apply geometric concepts in modeling situations

1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).
2. Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot).
3. Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).

Create equations that describe numbers or relationships CED

A.4. Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.

Reading Standards for Literacy in History/Social Studies 9-10

Key Ideas and Details

1. Cite specific textual evidence to support analysis of primary and secondary sources, attending to such features as the date and origin of the information.
3. Analyze in detail a series of events described in a text; determine whether earlier events caused later ones or simply preceded them.

Integration of Knowledge and Ideas

7. Integrate quantitative or technical analysis (e.g., charts, research data) with qualitative analysis in print or digital text.
9. Compare and contrast treatments of the same topic in several primary and secondary sources.

Range of Reading and Level of Text Complexity

10. By the end of grade 10, read and comprehend science/technical texts in the grades 9–10 text complexity band independently and proficiently.

Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 9-10

Text Types and Purposes

1. Write arguments focused on *discipline-specific content.*
2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

Production and Distribution of Writing

4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Research to Build and Present Knowledge

7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.

Range of Writing

10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Next Generation Science Standards

The projects engage students in the scientific and engineering practices taken from the National Research Council's Framework for K-12 Science Education, Practices, Crosscutting Concepts, and Core Ideas. This is the document upon which the NGSS are based.

These practices are used for two reasons: 1) they parallel the design process utilized in each project, and 2) they serve as the foundation of the NGSS.

The eight science and engineering practices are:

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Standards for Technological Literacy

Standard 2

Students will develop an understanding of the core concepts of technology.

Standard 3

Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Standard 4

Students will develop an understanding of the cultural, social, economic, and political effects of technology.

Standard 5

Students will develop an understanding of the effects of technology on the environment.

Standard 6

Students will develop an understanding of the role of society in the development and use of technology.

Standard 7

Students will develop an understanding of the influence of technology on history.

Standard 8
Students will develop an understanding of the attributes of design.

Standard 9
Students will develop an understanding of engineering design.

Standard 10
Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Standard 11
Students will develop the abilities to apply the design process.

Standard 12
Students will develop the abilities to use and maintain technological products and systems.

Standard 13
Students will develop the abilities to assess the impact of products and systems.

Standard 17
Students will develop an understanding of and be able to select and use information and communication technologies.

Standard 19
Students will develop an understanding of and be able to select and use manufacturing technologies.

Standard 20
Students will develop an understanding of and be able to select and use construction technologies.

Assessment:

Assessment is both formative and summative. It is an integral part of quality instruction. During the course of each project, one of the teacher's main functions is to work with student groups, keeping track of progress and providing formative assessment in the form of feedback and promoting reflection on the part of students. The focus should be on promoting lifetime learning and 21st century skills. The goal of instruction is to promote abilities in research, problem solving, designing, experimenting, testing, collecting and analyzing data.

Rubrics are used in the assessment process to communicate expectations of quality. Rubrics should be shared with students at the beginning of a project to clarify any misconceptions before beginning their work. Students can then build the skills and gather knowledge to solve the problem presented to the expectations of excellence described.

General Rubrics for Literacy tasks:
Argumentative_Pursuasive
Informational_Explanatory

Individual Project Rubric:
Playground Design Project Rubric

Essential Question:

How can we design and construct an age appropriate playground for young children to play safely?

Student Scenario:

A new elementary school is under construction in your school district. The school's Parent Teachers Association (PTA) has received a grant to develop the playground. Your team is given the job to design and build a model of the new outdoor playground to be constructed near the building.

The research and learning activities are designed to help students:

- Create sketches to communicate to a group
- Use mathematical formulas to aid in the design of a product
- Utilize specific software features to create a solid model of their idea
- Communicate their solution to their peers

Deliverables:

- Engineering Notebook with reflections, research notes, bibliography, and other processes used in the design.
- Sketches and working drawings for the elements of the playground
- Analysis of the structural elements of the playground design
- 3D model of the playground elements
- Engineering report of the design process
- Presentation for the authentic audience

Daily Plan:

Day 1
Key Question: What are the expectations of the project?

Introduce students to the project by providing them with the Essential Question and the scenario.

Review and discuss with your students the design process, Engineering Notebook and design documentation requirements. Discuss the problem statement, design brief, testing protocol and management plan. Review the elements of a good engineering report with the students. These were all covered in the first project titled *Introduction to the Engineering Design Process* but should be reinforced on a regular basis. All projects depend on the design process and student activities should relate directly.

Have the students form teams of two. Allow the students five minutes to discuss the problem. Students begin by brainstorming ideas in their Engineering Notebooks. The teacher will provide a list of vocabulary terms that students will need to research on their own. The teams can divide the list of terms among team members and share their definitions. All team members are responsible to know all definitions.

Day 2-3
Key Question: How do we get started in the design process?

The teams will be responsible for researching beams, forces, trusses, structures, strength of materials, and analysis. Links can be found in the Resources section. The teacher will lead a group discussion on the specifications of the playground equipment design such as the size and amount of weight it should hold. Students begin sketching and adding force calculations associated with each type of structure. Students add items from their reading to their Engineering Notebooks.

The teacher reminds students about the help system to find out how the software accomplishes basic features they might want to incorporate. https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index Students can enter terms to view a tutorial for creating certain features. Students can reference specific terms from the vocabulary list for specific commands to be used in the design of the playground equipment.

The teacher will also show students the Siemens Solid Edge Video Resources to allow students to discover further elements to help their designs. Other tutorials in the Resources section are available for use if students struggle.

Solid Edge Structural Analysis

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1325275:index_sesim:xid1602403:activity1a

Solid Edge Analysis Videos

- https://www.youtube.com/watch?v=515un5vL-2Y
- https://www.youtube.com/watch?v=AzHT9DC0xaA
- https://www.youtube.com/watch?v=EwubY6Dx964
- https://www.youtube.com/watch?v=z57kz8m3gQo
- https://www.youtube.com/watch?v=I3Q0cQHIxyI

Engineering Reference Command for designing Gears, CAMs Pulleys etc.

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1323753:index_xid718565

NOTE: The teacher will decide how the "client" and the client's needs for the project are to be represented.

Student teams discuss the specifications of the playground and the equipment/apparatus to be included. Each team will select a different equipment/apparatus for their design. Students list the criteria and constraints of the apparatus they will be designing. Teams research the existing playground equipment/ apparatus and discover information about forces and reactance causes of failure in playground equipment. Teams will define the total weight the structures must hold and plan equipment that will hold the established weight with minimal material.

The student teams discuss possible playground features. The teams should decide on design constraints which might include:

- Footprint of playground (size in square feet)
- How many playground activities could be included?
- Height of the playground.
- Assembly methods of the playground apparatus.
- Materials for the playground apparatus.
- What are the ages of the playground users?
- Can the activities be easily moved or changed in the future?
- Can parts of it be ADA compliant?

Remind students to record research notes and sources as well as reflections on the day in the Engineering Notebook.

Day 4
Key Question: How do we get started on our individual designs?

Student teams brainstorm needed components of their design and then create their isometric sketches to add to their design brief to include with their sketches. They include measurements with their free body diagrams and include formulas used to evaluate their designs. They then meet with the PTA clients who will need to sign off on the design proposal before they begin solid modeling.

Students can reference Basic 3D Commands, Creating Drawing Views and Assembly Modeling, Designing and Analyzing Beams and Working with Bodies for specific commands to use in the playground equipment design. Students can reference web links, videos, and tutorials at any time during the process of the design.

Teams discuss how their playground equipment should be tested. The groups decide which components will be tested and how they will know when their design achieves the test requirements.

Day 5-6
Key Question: How can we begin to make our playground equipment?

Students record sketches and reflections in the Engineering Notebook. Once the students have a playground solution meeting requirements, the team should consider how they will test the design before building.

Teams discuss their proposed equipment and how to achieve the design given the approved sketch. Students work together to brainstorm ideas and begin to narrow their vision of what they want to do. The work to create the 3D solid models is divided among team members. A plan to assemble the playground equipment is considered. Teams utilize the division of work in the creation of their project management plan.

Teams are reminded to continually check their 3D components of the designs to ensure sizes are accurate. Teams discuss how the various designs work and that the designs created meet the playground requirements. Student teams also discuss how the designs will be built and how the forces are counteracted.

Day 7-10
Key Question: How can we put our new designs together?

Student teams conduct meetings to review all designs created so far. They look at the criteria and testing protocols created. They discuss which design they wish to use as the team final design. It could be a single design or contain elements of several designs. Once the decision is made, the students develop a plan for creating the team prototype. They need to create a design that incorporates their ideas. Once the plan is finalized they will create individual parts in Solid Edge and assemble them. The teams discuss the final testing of their prototypes and how that will be achieved.

Students create the final plans and begin 3D printing the necessary components and assemble their scale model of the playground equipment from the printed parts. Students record any changes in their designs and enter reflections in their Engineering Notebooks.

Day 11-13
Key Question: How can we check our designs?

Students assemble their 3D playground equipment from the materials following their plans. When students encounter problems assembling their designs they must discuss how they will solve the problem and change the design.

Students record any changes in their design plan and enter reflections in their Engineering Notebooks. Students exchange assembly files so each can create a presentation file for their component of the playground with the other equipment in the background.

Day 14-15
Key Question: How do we organize our results in a presentation to the class?

The student teams discuss and finish any changes they need to make.
The teacher will discuss with the teams how to optimally present their ideas.

Students discuss the outline of their presentation to the PTA clients. The deliverables could be in the form of a dimensioned working drawing pictorial representation with balloons and bill of materials and/or a 3D printed prototype as well as the final testing data and demonstrations. Students should prepare an engineering report about the process of designing the playground and how the components all fit together. The students should be required to write the introduction, provide results including graphics, and form a conclusion including an acknowledgement section reporting the source of information. Students decide how to divide the work to create a team report.

Day 16
Key Question: How do we convey our ideas?

Students can present their solutions to the class one at a time. Students display the completed playground and discuss how their section of the playground allows for parental observation, child safety, and interaction with the other equipment. Students discuss changes they would consider if they had time to create another iteration of their design.

In the end, all students can reflect on their work by giving and receiving feedback on how they could possibly improve their designs

Vocabulary:

Americans with Disabilities Act (ADA)
ADA accessible
Barrier
Entanglement
Ergonomics
Fall height
Finite Element Analysis (FEA)
Footprint
Guardrail
Inclusive playground
Pinch point
Play surface
Preschool age
School age
Toddler

Resources:

CAD Tutorials

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012424/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012420/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012430/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012447/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012454/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012455/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012420/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012460/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012430/index.html
- http://niveshandnisheeth.blogspot.com/2016/11/content-list-videos-solid-edge-st9.html
- http://media.plm.automation.siemens.com/goplm/Introduction-FEA.zip
- http://media.plm.automation.siemens.com/goplm/Introduction-Mechanical-Systems.zip

Assembly Tutorials

- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012424/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012454/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012455/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012460/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012451/index.html

Solid Edge Structural Analysis

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1325275:index_sesim:xid1602403:activity1a

Solid Edge Analysis Videos

- https://www.youtube.com/watch?v=515un5vL-2Y
- https://www.youtube.com/watch?v=AzHT9DC0xaA
- https://www.youtube.com/watch?v=EwubY6Dx964
- https://www.youtube.com/watch?v=z57kz8m3gQo

- https://www.youtube.com/watch?v=I3Q0cQHIxyI

Solid Edge Robotics and Mechanisms Course

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku

Engineering Reference Command for designing Gears, CAMs Pulleys etc.

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1323753:index_xid718565

Engineering Reports

- http://web.mit.edu/me-ugoffice/communication/technical-writing.pdf
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/writing_engineering_reports.html
- https://www.youtube.com/playlist?list=PLDAAF7A8FD5CD582C&feature=plcp
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/mechanical_engineering_writing_enhancement_program/report_writing.html
- https://owl.purdue.edu/owl/subject_specific_writing/professional_technical_writing/technical_reports_and_report_abstracts/reports_proposals_and_technical_papers.html

Material Properties

- http://www.matweb.com
- http://www.engineeringtoolbox.com/material-properties-t_24.html
- http://www.technologystudent.com/joints/matprop1.htm
- http://www.makeitfrom.com/
- http://web.mit.edu/course/3/3.225/book.pdf

Playground Safety:

- https://www.cpsc.gov/s3fs-public/325.pdf

Handicapped Playground:

- https://www.youtube.com/watch?v=LGRFhvsvF6Y

Playground Design

- http://www.playgroundequipment.com/catalog-online/
- https://www.playlsi.com/en/playground-design-ideas
- https://www.playlsi.com/
- http://www.pwap.com/planner/
- https://www.ptotoday.com/pto-today-articles/article/278-6-keys-for-playground-design
- https://playgroundideas.org/
- https://www.youtube.com/watch?v=qgKdS9JLVl4
- https://www.youtube.com/watch?v=ZUw8CH6Mxj0
- https://www.youtube.com/watch?v=suJr1eMV7AU
- https://www.youtube.com/watch?v=RC037ZwoJ8o

Solid Edge Instructional Videos

Introduction to Mechanisms

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-01-introduction/VJ-5mlGyO?topic=1

CAM and Follower

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=1

Beginning CAM Motion

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=2

Common CAM Types

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=1
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=2
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=3

CAM Physical Motion

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-04-cam-vice-lock-scissors/4JThnbf1d?topic=2

Circular vs. Arc

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-04-cam-vice-lock-scissors/4JThnbf1d?topic=3

Four Bar Mechanisms

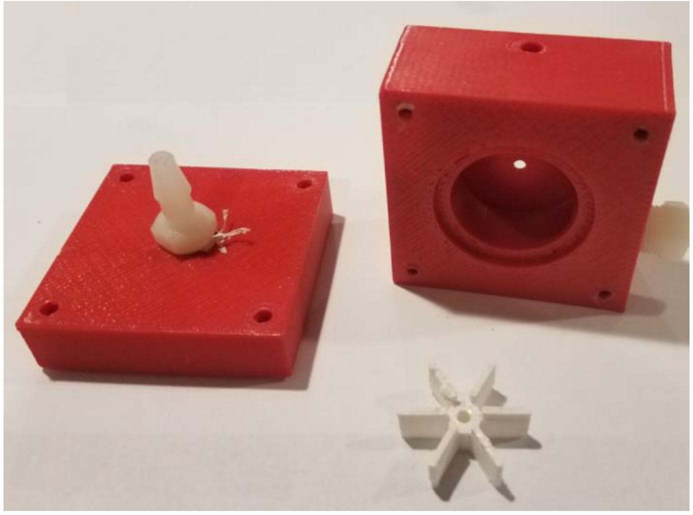
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=1
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=2
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=3
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=4
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=4

Motion Concepts

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-09-motion-concepts/NytArMfyu?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-09-motion-concepts/NytArMfyu?topic=1

Assembly Example-Rowboat Video Collection

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/rowboat-mechanism-in-solid-edge/EJaWFRQRP



Project: Centrifugal Pump

Introduction:

The first water pump, created about 2000 BC, has been evolving ever since. Water pumps fill such a valuable function in society that some of the greatest thinkers of all time have contributed to the improvement of these devices for moving water. Archimedes, Ctesibius, James Watt and even Daniel Bernoulli have written, designed, and built pumps. Today pumps bring water into our houses, irrigate farms, circulate water in a pool, and are an essential part of firefighting. One style, a centrifugal pump, moves fluid by using centrifugal force to generate fluid flow. They are best at moving a high volume of low viscosity fluids at very fast speeds. In this project students are going to design a custom pump that will move water from one point to another.

Purpose of the Project:

The purpose of the pump project is to utilize the design process as well as mathematical formulas to create a working pump prototype. It is an open-ended design utilizing many concepts learned from previous units. Students will research centrifugal pumps and design, 3D print, and construct a small centrifugal pump having a housing and impeller. Students will communicate the pump performance using a pump curve diagram produced by multiple experiments conducted on the pump design.

Concepts:

- Utilize mathematical analysis, scientific inquiry, and engineering design to develop solutions to open ended problems.
- Select and defend a material for use in a product, explaining material properties and characterization, based upon manufacturing processes, chemical composition, internal defects, temperature, previous loading, dimensions, and other factors.
- Apply the design process in the design of a mechanical system.
- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.
- Design a system of elements that manage power to accomplish a task that involves defined movement.
- Access, generate, process, and transfer information using appropriate technologies.

Outline:

- Documentation
  - Engineering Notebook
  - Documentation object to be designed
- Modeling
  - Creation of 3D model
  - Assembly of 3D model
  - Exploded drawing of 3D model
  - Design renderings and pictorial exploded drawings
  - Construct 3D model of centrifugal pump project
- Evaluation
  - Testing of centrifugal pumps
- Communication
  - Presentation of design solutions

Standards:

Career and Technical Standards

Engineering Design Process

- Create and maintain an Engineering Notebook for daily reflections, research and prototype creation documentation.
- Apply the design and problem solving process as an iterative process incorporating sciences, mathematics and engineering to optimally convert resources to meet a stated objective.
- Communicate solutions utilizing technical writing skills including correct spelling, proper grammar and dependent vocabulary.
- Assume and carry out a role in the smooth running of a team working toward the solution of a problem.

- Assemble a quantitative plan for successful completion of the project.
- Assume leadership roles and responsibility for decisions making as part of a team.
- Analyze costs of resources necessary for product production.

Sketching

- Create sketches utilizing basic shapes such as lines circles and ellipses.
- Apply isometric and orthographic sketches to add clarity to design.
- Create necessary sketches to communicate basic ideas during the design process.

3D Solid Modeling/Fabrication and 3-D Printing

- Apply geometric relationships between lines and shapes to create a mathematical database to describe design ideas.
- Create solid models utilizing concepts of Parametric Modeling.
- Analyze models for appropriate engineering design features needed.
- Develop strategies for the creation of solid models for the rapid creation of design solutions.
- Apply the concepts of digital prototyping to accelerate the time frame between ideation and completed project.
- Access, generate, and transfer information using appropriate technologies.
- Design and create a model using additive manufacturing technology sometimes called a rapid prototyping system.
- Apply principles of rapid and less costly product development including the application of new materials.
- Utilize rapid prototyping/additive manufacturing to create highly complex parts designed with a CAD system.

Renderings/Working Drawings/ Design Presentations

- Create renderings to communicate design ideas and engineering principles to the customer.
- Produce a final pictorial rendering of a design concept utilizing light, texture and shading.
- Apply rendering techniques to create final design presentations for the customer.

Assembly Modeling/Documentation/Exploded Assemblies/Bill of Materials

- Conduct model documentation as the process of recording details such as size, material composition, and instructions for assembling, installation and servicing, analysis, development process that describes a model for the purpose of communication of ideas.
- Create a bill of materials to communicate materials and other information about a design.

Reverse Engineering/Engineering Features

- Apply the principles of design for manufacturing enabling the efficient and effective production of products.
- Apply the green principles of design for eventual disassembly and resource recovery.
- Investigate activities that a business conducts with the intention of making a discovery that can either lead to the development of new products or procedures, or to improvement of existing products or procedures and to know the new approaches of rapid development and deployment that saves time and is more efficient.
- Disassemble a product into its parts, utilize precision measurement to create sketches, drawings and models of the product and identify the basic processes, systems, designs, and materials used in the manufacture of the product.

Simple Machines

- Utilize mathematical analysis, scientific inquiry and engineering design to develop solutions to open ended problems.
- Access, generate, process, and transfer information using appropriate technologies
- Apply the engineering design process in the creation of a mechanical system.
- Read and analyze detailed descriptions of machinery and provide a concise summary for documentation purposes.
- Assign mathematical relationships to analyze mechanical advantage.
- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.

Mechanical Systems

- Utilize mathematical analysis, scientific inquiry and engineering design to develop solutions to open ended problems.
- Access, generate, process, and transfer information using appropriate technologies.
- Apply the engineering design process in the creation of a mechanical system.
- Read and analyze detailed descriptions of machinery and provide a concise summary for documentation purposes.
- Assign mathematical relationships to schematics to apply forces.
- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.
- Design a system of elements that manage power to accomplish a task that involves defined movement.

Structures/Forces

- Create models that are mathematical or physical systems that are set up to obey certain specified conditions having behavior intended to understand or evaluate a design system.

- Conduct model analysis using Finite Element Analysis (FEA) and simulations to produce a detailed examination of the elements, structure and behavior of a system under certain conditions.
- Assign mathematical relationships to schematics to apply forces.
- Conduct a systematic study of a structure by applying a load to determine the performance of the structure design, the structure members, and the structure materials as determined through the relationship between applied force and the corresponding deflection.
- Apply the knowledge from a stress and strain curve to a design solution.
- Analyze the strength of materials under various types of loading to predict system behavior.
- Calculate the normal loads on a structure when in use including a factor for extreme conditions plus an additional typical added factor for safety.
- Analyze complex structures by breaking them down into components.
- Test scale models to verify the strength predictions made from mathematical models.

Engineering Systems

- Utilize mathematical analysis, scientific inquiry and engineering design to develop solutions to open ended problems.
- Defend a selected material for use in a product, explaining material properties and characterization, based upon manufacturing processes, chemical composition, internal defects, temperature, previous loading, dimensions and other factors.

College and Career Readiness Math Standards

Number and Quantity

7. Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
8. Define appropriate quantities for the purpose of descriptive modeling.
4. Recognize vector quantities as having both magnitude and direction. Represent vector quantities by directed line segments, and use appropriate symbols for vectors and their magnitudes
7. Given two vectors in magnitude and direction form, determine the magnitude and direction of their sum.

Modeling with Geometry G-MG

Apply geometric concepts in modeling situations

1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).
2. Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot).
3. Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).

Create equations that describe numbers or relationships CED

A.4. Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.

Reading Standards for Literacy in History/Social Studies 9-10

Key Ideas and Details

1. Cite specific textual evidence to support analysis of primary and secondary sources, attending to such features as the date and origin of the information.
3. Analyze in detail a series of events described in a text; determine whether earlier events caused later ones or simply preceded them.

Integration of Knowledge and Ideas

7. Integrate quantitative or technical analysis (e.g., charts, research data) with qualitative analysis in print or digital text.
9. Compare and contrast treatments of the same topic in several primary and secondary sources.

Range of Reading and Level of Text Complexity

10. By the end of grade 10, read and comprehend science/technical texts in the grades 9–10 text complexity band independently and proficiently.

Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 9-10

Text Types and Purposes

1. Write arguments focused on *discipline-specific content.*
2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

Production and Distribution of Writing

4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Research to Build and Present Knowledge

7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.

Range of Writing

10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Next Generation Science Standards

The projects engage students in the scientific and engineering practices taken from the National Research Council's Framework for K-12 Science Education, Practices, Crosscutting Concepts, and Core Ideas. This is the document upon which the NGSS are based.

These practices are used for two reasons: 1) they parallel the design process utilized in each project, and 2) they serve as the foundation of the NGSS.

The eight science and engineering practices are:

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Standards for Technological Literacy

STL Standard 8:

Standard 1

Students will develop an understanding of the characteristics and scope of technology.

Standard 2

Students will develop an understanding of the core concepts of technology.

Standard 3

Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Standard 5

Students will develop an understanding of the effects of technology on the environment.

Standard 7

Students will develop an understanding of the influence of technology on history.

Standard 8

Students will develop an understanding of the attributes of design.

Standard 9
Students will develop an understanding of engineering design.

Standard 10
Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Standard 11
Students will develop the abilities to apply the design process.

Standard 12
Students will develop the abilities to use and maintain technological products and systems.

Standard 13
Students will develop the abilities to assess the impact of products and systems.

Standard 14
Students will develop an understanding of and be able to select and use medical technologies.

Standard 16
Students will develop an understanding of and be able to select and use energy and power technologies.

Standard 17
Students will develop an understanding of and be able to select and use information and communication technologies.

Standard 19
Students will develop an understanding of and be able to select and use manufacturing technologies.

Standard 20
Students will develop an understanding of and be able to select and use construction technologies.

Assessment:

Assessment is both formative and summative. It is an integral part of quality instruction. During the course of each project, one of the teacher's main functions is to work with student groups, keeping track of progress and providing formative assessment in the form of feedback and promoting reflection on the part of students. The focus should be on promoting lifetime learning and 21st century skills. The goal of instruction is to

promote abilities in research, problem solving, designing, experimenting, testing, collecting and analyzing data.

Rubrics are used in the assessment process to communicate expectations of quality. Rubrics should be shared with students at the beginning of a project to clarify any misconceptions before beginning their work. Students can then build the skills and gather knowledge to solve the problem presented to the expectations of excellence described.

General Rubrics for Literacy tasks:
Argumentative_Pursuasive
Informational_Explanatory

Individual Project Rubric:
Centrifugal Pump Rubric

Essential Question:

How can we design a device to use centrifugal force to move water from one location to another?

Student Scenario:

A major civil engineering firm has contacted your team about designing a new efficient pump for storm water drains in large cities. These drains can get overwhelmed with water at times from either heavy rains or an obstruction which could lead to clogging. Your centrifugal pump will be designed to move water from one area to another in a specified amount of time.

The research and learning activities are designed to help students:

- Create sketches to communicate to a group
- Use mathematical formulas to aid in the design of a product
- Utilize specific software features to create a solid model of their idea
- Communicate their solution to their peers

Deliverables:

- Engineering Notebook with reflections, research notes, bibliography, and other processes used in the design.
- Sketches and working drawings for the elements of the pump
- Analysis of the structural elements of the pump design
- 3D printed model of the assembled pump
- Engineering report of the design process
- Presentation for the authentic audience

Daily Plan:

Day 1

Key Question: What are the expectations of the project?

Introduce students to the project by providing them with the Essential Question and the scenario.

Review and discuss with your students the design process, Engineering Notebook and design documentation requirements. Discuss the problem statement, design brief, testing protocol and management plan. Review the elements of a good engineering report with the students. These were all covered in the first project titled *Introduction to the Engineering Design Process* but should be reinforced on a regular basis. All projects depend on the design process and student activities should relate directly.

Have the students form teams of two. Allow the students five minutes to discuss the problem. Students begin by brainstorming ideas in their Engineering Notebooks. The teacher will provide a list of vocabulary terms that students will need to research on their own. The teams can divide the list of terms among team members and share their definitions. All team members are responsible to know all definitions.

Day 2-3

Key Question: How do we get started in the design process?

The teams will be responsible for researching pumps, pump types, head, pumping power, pressure, friction, flow efficiency, structures, strength of materials, and analysis. Additionally, students should learn what a pump curve is and what it is designed to communicate. Links can be found in the Resources section. Teams hold a group discussion on the specifications of the pump design. Students begin sketching and adding power calculations associated with each type of pump. Students add items from their reading to their Engineering Notebooks.

The student teams discuss possible centrifugal pump features. The teams should decide on design constraints which might include:

- What material will the pump be made from?
- What is the physical size of the pump?
- How will the pump be powered?
- How much water will be moved with the pump?
- Can the pump be made to reverse?
- What is the total head of the pump?

The teacher reminds students about the help system to find out how the software accomplishes basic features they might want to incorporate.
https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index

Students can enter terms and view a tutorial for creating certain features. Students can reference specific terms from the vocabulary list for specific commands to be used in the design of the pump.

The teacher will also show students the Siemens Solid Edge Video Resources to allow students to discover further elements to help their designs. Other tutorials in the Resources section are available for use if students struggle.

Solid Edge Structural Analysis

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1325275:index_sesim:xid1602403:activity1a

Solid Edge Analysis Videos

- https://www.youtube.com/watch?v=515un5vL-2Y
- https://www.youtube.com/watch?v=AzHT9DC0xaA
- https://www.youtube.com/watch?v=EwubY6Dx964
- https://www.youtube.com/watch?v=z57kz8m3gQo
- https://www.youtube.com/watch?v=I3Q0cQHIxyI

Engineering Reference Command for designing Gears, CAMs Pulleys etc.

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1323753:index_xid718565

Remind students to record research notes and sources as well as reflections on the day in the Engineering Notebook.

Day 4
Key Question: How do we get started on our individual designs?

Student teams brainstorm needed components of their design and then create their isometric sketches to add to their design brief to include with their sketches. They include preliminary sizes and power requirements including formulas used to evaluate their designs. They then meet with their clients who will need to sign off on the design proposal before solid modeling can begin.

Students can reference Basic 3D Commands, Creating Drawing Views and Assembly Modeling, Designing and Analyzing Beams and Working with Bodies for specific commands to use in the pump design. Students can reference web links, videos, and tutorials at any time during the process of the design.

Day 5-7
Key Question: How can we begin to make our pump idea?

Students record sketches and reflections in the Engineering Notebook. Once the students have a solution to the pump design meeting requirements, consider how the design will be tested before building.

Teams discuss their proposed pump and how to achieve the design given the approved sketch they presented. They work together to brainstorm ideas and begin to narrow their vision of the solution. Divide the work of creating the 3D solid model of the pieces needed and a plan to assemble the pump. Utilize the division of work in the project management plan.

Teams are reminded to continually check their 3D components of the designs with their team to ensure the accurate sizes. Teams discuss how the various designs work and that the designs created will meet the pump requirements. Student teams also discuss how the designs will be assembled and how the seals will work.

Day 8-9
Key Question: How can we put our new designs together?

Student teams conduct meetings to review all designs created so far. They look at the criteria and testing protocols created. They discuss which design they wish to use as the team final design. It could be a single design or contain elements of several designs. Once the decision is made the students create a plan for creating the team prototype. They need to create a design that incorporates their ideas. Once the final plan is created they will create individual parts in Solid Edge and assemble them into assemblies. The teams discuss the final testing of their prototypes and how that will be achieved.

Students create the final plans and begin 3D printing the necessary components and assemble their scale model of the pump from the printed parts. Students record any changes in their designs and enter reflections in their Engineering Notebooks.

Day 11-12
Key Question: How do we build and test our designs?

Students assemble their pump from the materials following their plans. When students encounter problems assembling their designs they must discuss how they will resolve the issue and change the design.

Students record any changes in their designs and enter reflections in their Engineering Notebooks.

As students finish assembling their pumps, testing can begin to see if it pumps water. Teams identify sources of problems and redesign parts as needed.

Day 13-14
Key Question: How do we organize our thoughts in a presentation to the class?

The student teams discuss and finish any changes that are needed.
The teacher will discuss with the teams how to optimally present their ideas.

Students discuss the outline of the presentation to their clients. The deliverables could be in the form of a dimensioned working drawing pictorial representation with balloons and bill of materials and/or a 3D printed prototype as well as the final testing data and demonstrations. Students should prepare an engineering report about the process of designing their pump and how the components all fit together. The students should be required to write the introduction, provide results including graphics, and form a conclusion including an acknowledgement section reporting the source of information. Students decide how to divide the work to create a team report.

Day 15
Key Question: How do we convey our ideas?

Students can present their solutions to the class one at a time. Students display the completed pump and demonstrate how it functions. Students discuss changes they would consider if they had time to create another iteration of their design.

In the end, all students can reflect on their work by giving and receiving feedback on how they could possibly improve their designs

Vocabulary:

Casing
Centrifugal Force
Diffuser
Displacement
Friction
Head Pressure
Horsepower
Pump Housing
Pump and Motor Coupling
Impeller
Performance Curve
Pressure
Pump Curve
Rate of Flow (Capacity)
Seals
Shaft
Suction
Total Head

Viscosity
Volute
Work

Resources:

CAD Tutorials

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012424/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012420/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012430/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012447/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012454/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012455/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012420/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012460/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012430/index.html
- http://niveshandnisheeth.blogspot.com/2016/11/content-list-videos-solid-edge-st9.html
- http://media.plm.automation.siemens.com/goplm/Introduction-FEA.zip
- http://media.plm.automation.siemens.com/goplm/Introduction-Mechanical-Systems.zip

Assembly Tutorials

- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012424/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012454/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012455/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012460/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012451/index.html

Engineering Reference Command for designing Gears, CAMs Pulleys etc.

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1323753:index_xid718565

Solid Edge Robotics and Mechanisms Course

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku

Solid Edge Structural Analysis

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1325275:index_sesim:xid1602403:activity1a

Solid Edge Analysis Videos

- https://www.youtube.com/watch?v=515un5vL-2Y
- https://www.youtube.com/watch?v=AzHT9DC0xaA
- https://www.youtube.com/watch?v=EwubY6Dx964
- https://www.youtube.com/watch?v=z57kz8m3gQo
- https://www.youtube.com/watch?v=I3Q0cQHIxyI

Engineering Reports

- http://web.mit.edu/me-ugoffice/communication/technical-writing.pdf
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/writing_engineering_reports.html
- https://www.youtube.com/playlist?list=PLDAAF7A8FD5CD582C&feature=plcp
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/mechanical_engineering_writing_enhancement_program/report_writing.html
- https://owl.purdue.edu/owl/subject_specific_writing/professional_technical_writing/technical_reports_and_report_abstracts/reports_proposals_and_technical_papers.html
-

Material Properties

- http://www.matweb.com
- http://www.engineeringtoolbox.com/material-properties-t_24.html
- http://www.technologystudent.com/joints/matprop1.htm
- http://www.makeitfrom.com/
- http://web.mit.edu/course/3/3.225/book.pdf

Pumps

- http://www.learnengineering.org/2013/03/centrifugal-pumps-design-aspects.html
- http://www.engineeringtoolbox.com/centrifugal-pumps-d_54.html
- http://www.pumpfundamentals.com/tutorial1.htm
- http://www.pumpfundamentals.com/tutorial2.htm
- http://www.pumpfundamentals.com/tutorial3.htm
- https://www.introtopumps.com/pump-fundamentals/pumps-101/
- http://www.pumpsandsystems.com/tags/history-pumps
- https://www.engineeringforchange.org/five-water-pumps-design-ideas-and-how-tos/
- http://net.grundfos.com/doc/webnet/mining/_downloads/pump-handbook.pdf
- https://www.youtube.com/watch?v=dyMEB-4tmv8
- https://www.youtube.com/watch?v=BaEHVpKc-1Q
- https://www.youtube.com/watch?v=0ycvbFxB87s
- https://www.youtube.com/watch?v=_BAnnTLpros

Solid Edge Instructional Videos

Introduction to Mechanisms

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-01-introduction/VJ-5mlGyO?topic=1

CAM and Follower

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=1

Beginning CAM Motion

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=2

Common CAM Types

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=1
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=2
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=3

CAM Physical Motion

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-04-cam-vice-lock-scissors/4JThnbf1d?topic=2

Circular vs. Arc

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-04-cam-vice-lock-scissors/4JThnbf1d?topic=3

Four Bar Mechanisms

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=1
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=2
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=3
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=4
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=4

Motion Concepts

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-09-motion-concepts/NytArMfyu?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-09-motion-concepts/NytArMfyu?topic=1

Assembly Example-Rowboat Video Collection

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/rowboat-mechanism-in-solid-edge/EJaWFRQRP

SIEMENS
Ingenuity for life

Project: Automatic Training Wheels

Introduction:
When young children are learning to ride a bicycle, they often need training wheels mounted to the rear of the bicycle to help them balance. The training wheels have to be a certain size to fit the bike and are usually difficult to remove and not adjustable. How convenient would it be to have a pair of training wheels that would easily adjust as the rider requires them to?

Purpose of the Project:
The purpose of this project is to have the students utilize many previously learned concepts in the course to solve an open-ended design problem. They will research current training wheel designs, brainstorm, design, and model their mechanically based ideas in the software. Their concepts will be translated to 3D solid models and prototypes can be created and demonstrated.

Concepts:

- Utilize mathematical analysis, scientific inquiry and engineering design to develop solutions to open ended problems.
- Select and defend a material for use in a product, explaining material properties and characterization, based upon manufacturing processes, chemical composition, internal defects, temperature, previous loading, dimensions and other factors.
- Apply the design process in the design of a mechanical system.
- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.
- Design a system of elements that manage power to accomplish a task that involves defined movement.
- Access, generate, process, and transfer information using appropriate technologies.

Outline:

- Documentation
  - Engineering Notebook
  - Documentation object to be designed
- Modeling
  - Creation of 3D model
  - Assembly of 3D model
  - Exploded drawing of 3D model
  - Design renderings and pictorial exploded drawings
  - Construct 3D model of automatic training wheel project
- Communication
  - Presentation of design solutions

Standards:

Career and Technical Standards

Engineering Design Process

- Create and maintain an Engineering Notebook for daily reflections, research and prototype creation documentation.
- Apply the design and problem solving process as an iterative process incorporating sciences, mathematics and engineering to optimally convert resources to meet a stated objective.
- Communicate solutions utilizing technical writing skills including correct spelling, proper grammar and dependent vocabulary.
- Assume and carry out a role in the smooth running of a team working toward the solution of a problem.
- Assemble a quantitative plan for successful completion of the project.
- Assume leadership roles and responsibility for decisions making as part of a team.
- Analyze costs of resources necessary for product production.

Sketching

- Create sketches utilizing basic shapes such as lines circles and ellipses.
- Apply isometric and orthographic sketches to add clarity to design.
- Create necessary sketches to communicate basic ideas during the design process.

3D Solid Modeling/Fabrication and 3-D Printing

- Apply geometric relationships between lines and shapes to create a mathematical database to describe design ideas.
- Create solid models utilizing concepts of Parametric Modeling.
- Analyze models for appropriate engineering design features needed.
- Develop strategies for the creation of solid models for the rapid creation of design solutions.
- Apply the concepts of digital prototyping to accelerate the time frame between ideation and completed project.
- Access, generate, and transfer information using appropriate technologies.
- Design and create a model using additive manufacturing technology sometimes called a rapid prototyping system.
- Apply principles of rapid and less costly product development including the application of new materials.
- Utilize rapid prototyping/additive manufacturing to create highly complex parts designed with a CAD system.

Renderings/Working Drawings/ Design Presentations

- Create renderings to communicate design ideas and engineering principles to the customer.
- Produce a final pictorial rendering of a design concept utilizing light, texture and shading.
- Apply rendering techniques to create final design presentations for the customer.

Assembly Modeling/Documentation/Exploded Assemblies/Bill of Materials

- Conduct model documentation as the process of recording details such as size, material composition, and instructions for assembling, installation and servicing, analysis, development process that describes a model for the purpose of communication of ideas.
- Create a bill of materials to communicate materials and other information about a design.

Reverse Engineering/Engineering Features

- Apply the principles of design for manufacturing enabling the efficient and effective production of products.
- Apply the green principles of design for eventual disassembly and resource recovery.
- Investigate activities that a business conducts with the intention of making a discovery that can either lead to the development of new products or procedures,

or to improvement of existing products or procedures and to know the new approaches of rapid development and deployment that saves time and is more efficient.

- Disassemble a product into its parts, utilize precision measurement to create sketches, drawings and models of the product and identify the basic processes, systems, designs, and materials used in the manufacture of the product.
-

Simple Machines

- Utilize mathematical analysis, scientific inquiry and engineering design to develop solutions to open ended problems.
- Access, generate, process, and transfer information using appropriate technologies
- Apply the engineering design process in the creation of a mechanical system.
- Read and analyze detailed descriptions of machinery and provide a concise summary for documentation purposes.
- Assign mathematical relationships to analyze mechanical advantage.
- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.

Mechanical Systems

- Utilize mathematical analysis, scientific inquiry and engineering design to develop solutions to open ended problems.
- Access, generate, process, and transfer information using appropriate technologies.
- Apply the engineering design process in the creation of a mechanical system.
- Read and analyze detailed descriptions of machinery and provide a concise summary for documentation purposes.
- Assign mathematical relationships to schematics to apply forces.
- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.
- Design a system of elements that manage power to accomplish a task that involves defined movement.

Structures/Forces

- Create models that are mathematical or physical systems that are set up to obey certain specified conditions having behavior intended to understand or evaluate a design system.
- Conduct model analysis using Finite Element Analysis (FEA) and simulations to produce a detailed examination of the elements, structure and behavior of a system under certain conditions.
- Assign mathematical relationships to schematics to apply forces.
- Conduct a systematic study of a structure by applying a load to determine the performance of the structure design, the structure members, and the structure materials as determined through the relationship between applied force and the corresponding deflection.

- Apply the knowledge from a stress and strain curve to a design solution.
- Analyze the strength of materials under various types of loading to predict system behavior.
- Calculate the normal loads on a structure when in use including a factor for extreme conditions plus an additional typical added factor for safety.
- Analyze complex structures by breaking them down into components.
- Test scale models to verify the strength predictions made from mathematical models.
    -

Engineering Systems

- Utilize mathematical analysis, scientific inquiry and engineering design to develop solutions to open ended problems.
- Defend a selected material for use in a product, explaining material properties and characterization, based upon manufacturing processes, chemical composition, internal defects, temperature, previous loading, dimensions and other factors.

College and Career Readiness Math Standards

Number and Quantity

9. Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
10. Define appropriate quantities for the purpose of descriptive modeling.
5. Recognize vector quantities as having both magnitude and direction. Represent vector quantities by directed line segments, and use appropriate symbols for vectors and their magnitudes
8. Given two vectors in magnitude and direction form, determine the magnitude and direction of their sum.

Modeling with Geometry G-MG

Apply geometric concepts in modeling situations

1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).
2. Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot).
3. Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).

Create equations that describe numbers or relationships CED

A.4. Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.

Reading Standards for Literacy in History/Social Studies 9-10

Key Ideas and Details

1. Cite specific textual evidence to support analysis of primary and secondary sources, attending to such features as the date and origin of the information.
3. Analyze in detail a series of events described in a text; determine whether earlier events caused later ones or simply preceded them.

Integration of Knowledge and Ideas

7. Integrate quantitative or technical analysis (e.g., charts, research data) with qualitative analysis in print or digital text.
9. Compare and contrast treatments of the same topic in several primary and secondary sources.

Range of Reading and Level of Text Complexity

10. By the end of grade 10, read and comprehend science/technical texts in the grades 9–10 text complexity band independently and proficiently.

Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 9-10

Text Types and Purposes

1. Write arguments focused on *discipline-specific content.*
2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

Production and Distribution of Writing

4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Research to Build and Present Knowledge

7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.

Range of Writing

10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Next Generation Science Standards
The projects engage students in the scientific and engineering practices taken from the National Research Council's Framework for K-12 Science Education, Practices, Crosscutting Concepts, and Core Ideas. This is the document upon which the NGSS are based.

These practices are used for two reasons: 1) they parallel the design process utilized in each project, and 2) they serve as the foundation of the NGSS.

The eight science and engineering practices are:
1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Standards for Technological Literacy

Standard 1
Students will develop an understanding of the characteristics and scope of technology.

Standard 2
Students will develop an understanding of the core concepts of technology.

Standard 3
Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Standard 4
Students will develop an understanding of the cultural, social, economic, and political effects of technology.

Standard 5
Students will develop an understanding of the effects of technology on the environment.

Standard 6
Students will develop an understanding of the role of society in the development and use of technology.

Standard 7
Students will develop an understanding of the influence of technology on history.

Standard 8
Students will develop an understanding of the attributes of design.

Standard 9
Students will develop an understanding of engineering design.

Standard 10
Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Standard 11
Students will develop the abilities to apply the design process.

Standard 12
Students will develop the abilities to use and maintain technological products and systems.

Standard 13
Students will develop the abilities to assess the impact of products and systems.
Standard 14
Students will develop an understanding of and be able to select and use medical technologies.

Standard 16
Students will develop an understanding of and be able to select and use energy and power technologies.

Standard 17
Students will develop an understanding of and be able to select and use information and communication technologies.

Standard 19
Students will develop an understanding of and be able to select and use manufacturing technologies.

Standard 20
Students will develop an understanding of and be able to select and use construction technologies.

Assessment:

Assessment is both formative and summative. It is an integral part of quality instruction. During the course of each project, one of the teacher's main functions is to work with student groups, keeping track of progress and providing formative assessment in the form of feedback and promoting reflection on the part of students. The focus should be on promoting lifetime learning and 21st century skills. The goal of instruction is to

promote abilities in research, problem solving, designing, experimenting, testing, collecting and analyzing data.

Rubrics are used in the assessment process to communicate expectations of quality. Rubrics should be shared with students at the beginning of a project to clarify any misconceptions before beginning their work. Students can then build the skills and gather knowledge to solve the problem presented to the expectations of excellence described.

General Rubrics for Literacy tasks:
Argumentative_Pursuasive
Informational_Explanatory

Individual Project Rubric:
Automatic Training Wheels Rubric

Essential Question:

How can we design a pair of bicycle training wheels that will easily adjust to different bikes and riding abilities?

Student Scenario:

You have been hired by a chain of bicycle stores to design a set of adjustable training wheels for a beginner cyclist. Students will research beginner bicycles, attachment possibilities, and mechanisms in the design of training wheels for a person learning to balance a bicycle. The design must be easily installed and removed as well as adjustable in height allowing the rider to gradually adjust to riding without the training wheels.

The research and learning activities are designed to help students:

- Create sketches to communicate to a group
- Use mathematical formulas to aid in the design of a product
- Utilize specific software features to create a solid model of their idea
- Communicate their solution to their peers

Deliverables

- Engineering Notebook with reflections, research notes, bibliography and other processes used in the design
- Sketches and working drawings for the elements of the auto training wheels
- Linkage diagram
- Analysis of the structural elements of the wheels
- 3D model of the bank elements
- Engineering report of the design process
- Presentation for the authentic audience

Daily Plan:

Day 1

Key Question: What are the expectations of the project?

Introduce students to the project by providing them with the Essential Question and the scenario.

Review and discuss with your students the design process, Engineering Notebook and design documentation requirements. Discuss the problem statement, design brief, testing protocol and management plan. Review the elements of a good engineering report with the students. These were all covered in the first project titled *Introduction to the Engineering Design Process* but should be reinforced on a regular basis. All projects depend on the design process and student activities should relate directly.

Have the students form teams of two. Allow the students five minutes to discuss the problem. Students begin by brainstorming ideas in their Engineering Notebooks. The teacher will provide a list of vocabulary terms that students will need to research on their own. The teams can divide the list of terms among team members and share their definitions. All team members are responsible to know all definitions.

Day 2-4

Key Question: How do we get started in the design process?

The teams will be responsible for researching mechanisms, existing training wheels, bicycle attachment points, strength of materials and analysis. Links can be found in the Resources section. Students begin sketching ideas for their toy design. Students add items from their reading to their Engineering Notebooks.

The teacher reminds students about the help system to find out how the software accomplishes basic features they might want to incorporate.
https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index
Students can enter terms and view a tutorial for creating certain features. Students can reference specific terms from the vocabulary list for specific commands to be used in the design of training wheels.

The student teams discuss possible training wheel features. The teams should decide on design constraints which might include:

- What material will the training wheels be made from?
- What size bicycles will they fit?
- How will they adjust automatically?
- Will there be any tools needed to operate or install them?
- Can they be removed or installed easily?
- How much weight do they have to hold?

Student teams discuss the specifications of the training wheels and the mechanisms to be included. Students list the criteria and constraints necessary for the training wheels to be designed. Teams research the existing training wheels and discover information about work and types of mechanisms and transfer of power. Teams will define mechanisms and how they will fit onto a bicycle and how those mechanisms create motion.

The teacher will also show students the Siemens Solid Edge Video Resources to allow students to discover further elements to help their designs. Other tutorials in the Resources section are available for use if students struggle.

Solid Edge Robotics and Mechanisms Course

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku

Engineering Reference Command for designing Gears, CAMs Pulleys etc.

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1323753:index_xid718565

Solid Edge Structural Analysis

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1325275:index_sesim:xid1602403:activity1a

Solid Edge Analysis Videos

- https://www.youtube.com/watch?v=515un5vL-2Y
- https://www.youtube.com/watch?v=AzHT9DC0xaA
- https://www.youtube.com/watch?v=EwubY6Dx964
- https://www.youtube.com/watch?v=z57kz8m3gQo
- https://www.youtube.com/watch?v=I3Q0cQHIxyI

Engineering Reference Command for designing Gears, CAMs Pulleys etc.

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1323753:index_xid718565

Remind students to record research notes and sources as well as reflections on the day in the Engineering Notebook.

Day 5-6
Key Question: How do we get started on our individual designs?

Students are provided the activity Linkage Diagrams. Student teams learn to create linkage diagrams to represent the mechanisms they want to create. Student teams brainstorm needed components of their design and then create their isometric sketches and linkage diagrams to add to their design brief. They include measurements with their linkage diagrams and include formulas used to evaluate their designs. They then meet with their clients who will need to sign off on the design proposal before solid modeling can begin. NOTE: The teacher will decide how the “client” and the client’s needs for the project are to be represented.

Students can reference Linkage Diagrams, Basic 3D Commands, Creating Drawing Views and Assembly Modeling , Designing and Analyzing Beams and Working with Bodies for specific commands to use in the training wheels design. Students can reference web links, videos, and tutorials at any time during the process of the design.

Teams discuss how their training wheels should be tested. The students decide which components need to be tested and how they will know when their design achieves the test requirements.

Day 7-8
Key Question: How can we begin to make our training wheels?

Students record sketches and reflections in the Engineering Notebook. Once the students feel they have a training wheel design that meets the requirements, consider how the design will be tested before beginning to build.

Teams discuss their proposed training wheels and how to achieve the design given the approved sketch. Students work together to brainstorm ideas and begin to narrow their vision of the solution. Divide the work of creating the 3D solid model of the pieces needed and a plan to assemble the training wheels. Utilize the division of work in the creation of the project management plan.

Teams are reminded to continually check the 3D components of the designs with the team to ensure accurate sizes. Teams discuss how the various designs work and that the designs created will meet the requirements of their training wheels. Student teams also discuss how the designs will be assembled and how the mechanism will operate.

Day 9-10
Key Question: How can we put our new designs together?

Student teams conduct meetings to review all designs created. Students review the criteria and testing protocols. They discuss which design they wish to use as the team final design. It could be a single design or contain elements of several designs. Once the decision is made the students create a plan for creating the team prototype. They need to create a design that incorporates their ideas. Once the final plan is created they will create individual parts in Solid Edge and assemble them into assemblies. The teams discuss the final testing of their prototypes and how that will be achieved.

Students create the final plans and begin 3D printing the necessary components and assemble their scale model of the training wheels from the printed parts. Students record any changes in their designs and enter reflections in their Engineering Notebooks.

Day 11-13
Key Question: How can we take our designs apart to demonstrate how they are made?

Students assemble their training wheels from the materials following their plans. When students encounter problems assembling their designs they must discuss how they will resolve the issue and change the design.

Students record any changes in their designs and enter reflections in their Engineering Notebooks.

Day 14-15
Key Question: How do we organize our results in a presentation to the class?

The student teams discuss and finish any changes they need to make.
The teacher will discuss with the teams how to optimally present their ideas.

Students discuss the outline of their presentation to the client. The deliverables could be in the form of a dimensioned working drawing pictorial representation with balloons and bill of materials and/or a 3D printed prototype as well as the final testing data and demonstrations. Students should prepare an engineering report about the process of designing their training wheels and how the components all fit together. The students should be required to write the introduction, provide results including graphics, and form a conclusion including an acknowledgement section reporting the source of information. Students decide how to divide the work to create a team report.

Day 16
Key Question: How do we convey our ideas?

Students can present their solutions to the class one at a time. Students display the completed training wheels and demonstrate how it functions. Students discuss changes they would consider if they had time to create another iteration of their design.

In the end, all students can reflect on their work by giving and receiving feedback on how they could possibly improve their designs

Vocabulary:

Articulation
Ball joint
Bell Crank

Cam
Compression
Crank
Crank and slider
Eccentric
Efficiency
Flywheel
Follower
Force
Gear
Joint
Lever
Linear motion
Linkage
Linkage diagram
Links
Oscillating motion
Pulley
Reciprocating motion
Rotary motion
Spring
Tension
Torque
Universal joint
Work

Resources:

CAD Tutorials

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012424/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012420/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012430/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012447/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012454/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012455/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012420/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012460/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012430/index.html

Assembly Tutorials

- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012424/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012454/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012455/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012460/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012451/index.html

Solid Edge Structural Analysis

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1325275:index_sesim:xid1602403:activity1a

Solid Edge Analysis Videos

- https://www.youtube.com/watch?v=515un5vL-2Y
- https://www.youtube.com/watch?v=AzHT9DC0xaA
- https://www.youtube.com/watch?v=EwubY6Dx964
- https://www.youtube.com/watch?v=z57kz8m3gQo
- https://www.youtube.com/watch?v=I3Q0cQHIxyI

Material Properties

- http://www.matweb.com
- http://www.engineeringtoolbox.com/material-properties-t_24.html
- http://www.technologystudent.com/joints/matprop1.htm
- http://www.makeitfrom.com/
- http://web.mit.edu/course/3/3.225/book.pdf

Mechanisms:

- http://www.technologystudent.com/cams/camdex.htm
- http://www.technologystudent.com/cams/link1.htm
- http://www.technologystudent.com/gears1/geardex1.htm
- http://www.technologystudent.com/cams/crkslid1.htm
- http://www.brockeng.com/mechanism/index.htm
- http://www.physicsgames.net/game/Mechanism.html

Animated Mechanisms:

- http://www.mekanizmalar.com/

Gear Ratio:

- https://www.youtube.com/watch?v=D_i3PJIYtuY

Engineering Reference Command for designing Gears, CAMs Pulleys etc.

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1323753:index_xid718565

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- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku

Engineering Reports

- http://web.mit.edu/me-ugoffice/communication/technical-writing.pdf
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/writing_engineering_reports.html
- https://www.youtube.com/playlist?list=PLDAAF7A8FD5CD582C&feature=plcp
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/mechanical_engineering_writing_enhancement_program/report_writing.html
- https://owl.purdue.edu/owl/subject_specific_writing/professional_technical_writing/technical_reports_and_report_abstracts/reports_proposals_and_technical_papers.html

Existing Training Wheel Designs

- http://www.thingiverse.com/thing:835845
- https://www.shutterstock.com/search/bicycle+training+wheels
- http://wheelworld.com/product/giant-training-wheels-206890-1.htm
- http://www.stabilizerwheels.com/
- https://www.newegg.com/Product/Product.aspx?Item=9SIA05Y26W2910
- https://www.youtube.com/watch?v=goYISu7HO6Y
- https://www.youtube.com/watch?v=WmAV6g4lEMM

Solid Edge Instructional Videos

Introduction to Mechanisms

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-01-introduction/VJ-5mlGyO?topic=1

CAM and Follower

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=1

Beginning CAM Motion

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=2

Common CAM Types

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=1
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=2
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=3

CAM Physical Motion

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-04-cam-vice-lock-scissors/4JThnbf1d?topic=2

Circular vs. Arc

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-04-cam-vice-lock-scissors/4JThnbf1d?topic=3

Four Bar Mechanisms

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=1
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=2
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=3
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=4
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=4

Motion Concepts

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-09-motion-concepts/NytArMfyu?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-09-motion-concepts/NytArMfyu?topic=1

Assembly Example-Rowboat Video Collection

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/rowboat-mechanism-in-solid-edge/EJaWFRQRP

SIEMENS

Ingenuity for life

Project: Mechanical Bank

Introduction:

A mechanical bank is a toy bank where a coin is deposited by some process- often mechanical. The coin is placed somewhere on the bank, an action takes place, and the coin then travels into a safe place. This function encourages children to begin to save money while having some fun at the same time.

Purpose of the Project:

The purpose of this project is to design an open-ended project with one or more mechanical actions. The mechanical bank brings together many features in the software, assemblies, exploded drawings, and mechanical motions. The students can choose a theme and various forms of mechanical movements that would transport their loose change.

Concepts:

- Utilize mathematical analysis, scientific inquiry, and engineering design to develop solutions to open ended problems.
- Select and defend a material for use in a product, explaining material properties and characterization, based upon manufacturing processes, chemical composition, internal defects, temperature, previous loading, dimensions, and other factors.
- Apply the design process in the design of a mechanical system.
- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.
- Design a system of elements that manage power to accomplish a task that involves defined movement.
- Access, generate, process, and transfer information using appropriate technologies.

Outline:

- Documentation
    - Engineering Notebook
    - Documentation of bank to be designed
- Modeling
    - Creation of 3D model
    - Assembly of 3D model
    - Explosion of 3D model
    - Design renderings and pictorial exploded drawings
    - Construct 3D model of mechanical bank project
- Communication
    - Presentation of design solutions

Standards:

Career and Technical Standards

Engineering Design Process

- Create and maintain an Engineering Notebook for daily reflections, research and prototype creation documentation.
- Apply the design and problem solving process as an iterative process incorporating sciences, mathematics and engineering to optimally convert resources to meet a stated objective.
- Communicate solutions utilizing technical writing skills including correct spelling, proper grammar and dependent vocabulary.
- Assume and carry out a role in the smooth running of a team working toward the solution of a problem.
- Assemble a quantitative plan for successful completion of the project.
- Assume leadership roles and responsibility for decisions making as part of a team.
- Analyze costs of resources necessary for product production.

Sketching

- Create sketches utilizing basic shapes such as lines circles and ellipses.
- Apply isometric and orthographic sketches to add clarity to design.
- Create necessary sketches to communicate basic ideas during the design process.

3D Solid Modeling/Fabrication and 3-D Printing

- Apply geometric relationships between lines and shapes to create a mathematical database to describe design ideas.
- Create solid models utilizing concepts of Parametric Modeling.
- Analyze models for appropriate engineering design features needed.
- Develop strategies for the creation of solid models for the rapid creation of design solutions.
- Apply the concepts of digital prototyping to accelerate the time frame between ideation and completed project.
- Access, generate, and transfer information using appropriate technologies.
- Design and create a model using additive manufacturing technology sometimes called a rapid prototyping system.
- Apply principles of rapid and less costly product development including the application of new materials.
- Utilize rapid prototyping/additive manufacturing to create highly complex parts designed with a CAD system.

Renderings/Working Drawings/ Design Presentations

- Create renderings to communicate design ideas and engineering principles to the customer.
- Produce a final pictorial rendering of a design concept utilizing light, texture and shading.
- Apply rendering techniques to create final design presentations for the customer.

Assembly Modeling/Documentation/Exploded Assemblies/Bill of Materials

- Conduct model documentation as the process of recording details such as size, material composition, and instructions for assembling, installation and servicing, analysis, development process that describes a model for the purpose of communication of ideas.
- Create a bill of materials to communicate materials and other information about a design.

Reverse Engineering/Engineering Features

- Apply the principles of design for manufacturing enabling the efficient and effective production of products.
- Apply the green principles of design for eventual disassembly and resource recovery.
- Investigate activities that a business conducts with the intention of making a discovery that can either lead to the development of new products or procedures,

or to improvement of existing products or procedures and to know the new approaches of rapid development and deployment that saves time and is more efficient.

- Disassemble a product into its parts, utilize precision measurement to create sketches, drawings and models of the product and identify the basic processes, systems, designs, and materials used in the manufacture of the product.
-

Simple Machines

- Utilize mathematical analysis, scientific inquiry and engineering design to develop solutions to open ended problems.
- Access, generate, process, and transfer information using appropriate technologies
- Apply the engineering design process in the creation of a mechanical system.
- Read and analyze detailed descriptions of machinery and provide a concise summary for documentation purposes.
- Assign mathematical relationships to analyze mechanical advantage.
- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.

Mechanical Systems

- Utilize mathematical analysis, scientific inquiry and engineering design to develop solutions to open ended problems.
- Access, generate, process, and transfer information using appropriate technologies.
- Apply the engineering design process in the creation of a mechanical system.
- Read and analyze detailed descriptions of machinery and provide a concise summary for documentation purposes.
- Assign mathematical relationships to schematics to apply forces.
- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.
- Design a system of elements that manage power to accomplish a task that involves defined movement.

Structures/Forces

- Create models that are mathematical or physical systems that are set up to obey certain specified conditions having behavior intended to understand or evaluate a design system.
- Conduct model analysis using Finite Element Analysis (FEA) and simulations to produce a detailed examination of the elements, structure and behavior of a system under certain conditions.
- Assign mathematical relationships to schematics to apply forces.
- Conduct a systematic study of a structure by applying a load to determine the performance of the structure design, the structure members, and the structure materials as determined through the relationship between applied force and the corresponding deflection.

- Apply the knowledge from a stress and strain curve to a design solution.
- Analyze the strength of materials under various types of loading to predict system behavior.
- Calculate the normal loads on a structure when in use including a factor for extreme conditions plus an additional typical added factor for safety.
- Analyze complex structures by breaking them down into components.
- Test scale models to verify the strength predictions made from mathematical models.
  -

Engineering Systems

- Utilize mathematical analysis, scientific inquiry and engineering design to develop solutions to open ended problems.
- Defend a selected material for use in a product, explaining material properties and characterization, based upon manufacturing processes, chemical composition, internal defects, temperature, previous loading, dimensions and other factors.

College and Career Readiness Math Standards

Number and Quantity

11. Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
12. Define appropriate quantities for the purpose of descriptive modeling.
6. Recognize vector quantities as having both magnitude and direction. Represent vector quantities by directed line segments, and use appropriate symbols for vectors and their magnitudes
9. Given two vectors in magnitude and direction form, determine the magnitude and direction of their sum.

Modeling with Geometry G-MG

Apply geometric concepts in modeling situations

1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).
2. Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot).
3. Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).

Create equations that describe numbers or relationships CED

A.4. Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.

Reading Standards for Literacy in History/Social Studies 9-10

Key Ideas and Details

1. Cite specific textual evidence to support analysis of primary and secondary sources, attending to such features as the date and origin of the information.
3. Analyze in detail a series of events described in a text; determine whether earlier events caused later ones or simply preceded them.

Integration of Knowledge and Ideas

7. Integrate quantitative or technical analysis (e.g., charts, research data) with qualitative analysis in print or digital text.
9. Compare and contrast treatments of the same topic in several primary and secondary sources.

Range of Reading and Level of Text Complexity

10. By the end of grade 10, read and comprehend science/technical texts in the grades 9–10 text complexity band independently and proficiently.

Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 9-10

Text Types and Purposes

1. Write arguments focused on *discipline-specific content.*
2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

Production and Distribution of Writing

4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Research to Build and Present Knowledge

7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.

Range of Writing

10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Next Generation Science Standards
The projects engage students in the scientific and engineering practices taken from the National Research Council's Framework for K-12 Science Education, Practices, Crosscutting Concepts, and Core Ideas. This is the document upon which the NGSS are based.

These practices are used for two reasons: 1) they parallel the design process utilized in each project, and 2) they serve as the foundation of the NGSS.

The eight science and engineering practices are:
1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Standards for Technological Literacy

Standard 2
Students will develop an understanding of the core concepts of technology.

Standard 3
Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Standard 7
Students will develop an understanding of the influence of technology on history.

Standard 8
Students will develop an understanding of the attributes of design.

Standard 9
Students will develop an understanding of engineering design.

Standard 10
Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Standard 11
Students will develop the abilities to apply the design process.

Standard 12
Students will develop the abilities to use and maintain technological products and systems.

Standard 13
Students will develop the abilities to assess the impact of products and systems.

Standard 14
Students will develop an understanding of and be able to select and use medical technologies.

Standard 17
Students will develop an understanding of and be able to select and use information and communication technologies.

Standard 19
Students will develop an understanding of and be able to select and use manufacturing technologies.

Standard 20
Students will develop an understanding of and be able to select and use construction technologies.

Assessment:

Assessment is both formative and summative. It is an integral part of quality instruction. During the course of each project, one of the teacher's main functions is to work with student groups, keeping track of progress and providing formative assessment in the form of feedback and promoting reflection on the part of students. The focus should be on promoting lifetime learning and 21st century skills. The goal of instruction is to promote abilities in research, problem solving, designing, experimenting, testing, collecting and analyzing data.

Rubrics are used in the assessment process to communicate expectations of quality. Rubrics should be shared with students at the beginning of a project to clarify any misconceptions before beginning their work. Students can then build the skills and gather knowledge to solve the problem presented to the expectations of excellence described.

General Rubrics for Literacy tasks:
Argumentative_Pursuasive
Informational_Explanatory

Individual Project Rubric:
Mechanical Bank Rubric

Essential Question:
How can we use a mechanical device to transport various coins into a storage container?

Student Scenario:
A large national bank chain has asked your design team to develop a new way to encourage children to save their coins. Students will design their own personal mechanical bank to be branded by the bank as a promotion in their bank branches. Students will research different mechanisms and design a themed mechanical bank. The bank will accept a coin and then move it to a different location for storage. Students will produce a rendering of their final mechanical bank design and present it to the teacher and the class.

The research and learning activities are designed to help students:
- Create sketches to communicate to a group
- Use mathematical formulas to aid in the design of a product
- Utilize specific software features to create a solid model of their idea
- Communicate their solution to their peers

Deliverables
- Engineering Notebook with reflections, research notes, bibliography, and other processes used in the design.
- Sketches and working drawings for the elements of the mechanical bank
- Linkage diagram
- Analysis of the structural elements of the bank
- 3D model of the bank elements
- Engineering report of the design process
- Presentation for the authentic audience

Daily Plan:
Day 1
Key Question: What are the expectations of the project?

Introduce students to the project by providing them with the Essential Question and the scenario.

Review and discuss with your students the design process, Engineering Notebook and design documentation requirements. Discuss the problem statement, design brief, testing protocol and management plan. Review the elements of a good engineering report with the students. These were all covered in the first project titled *Introduction to the Engineering Design Process* but should be reinforced on a regular basis. All projects depend on the design process and student activities should relate directly.

Have the students form teams of two. Allow the students five minutes to discuss the problem. Students begin by brainstorming ideas in their Engineering Notebooks. The teacher will provide a list of vocabulary terms that students will need to research on their own. The teams can divide the list of terms among team members and share their definitions. All team members are responsible to know all definitions.

Day 2-4
Key Question: How do we get started in the design process?

The teams will be responsible for researching mechanisms, existing styles, strength of materials and analysis. Links can be found in the Resources section. Students begin sketching ideas for their bank design. Students add items from their reading to their Engineering Notebooks.

The teacher reminds students about the help system to find out how the software accomplishes basic features they might want to incorporate.
https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index
Students can enter terms and view a tutorial for creating certain features. Students can reference specific terms from the vocabulary list for specific commands to be used in the design of bank mechanism.

The student teams discuss possible bank features. The teams should decide on design constraints which might include:

- What material will the bank be made from?
- How big will the bank be?
- How far will the coins travel?
- How many coins should it hold?
- How can the action be reset once the coin has been transported?
- How are the coins stored?
- Can it work with different sized coins?

Student teams discuss the specifications of the bank and the mechanisms to be included. Students list the criteria and constraints of the bank. Teams research the existing mechanical banks and discover information about types of mechanisms and transfer of power. Teams will define mechanisms and how they will fit into the bank to create motion.

The teacher will also show students the Siemens Solid Edge Video Resources to allow students to discover further elements to help their designs. Other tutorials in the Resources section are available for use if students struggle.

Solid Edge Robotics and Mechanisms Course

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku

Engineering Reference Command for designing Gears, CAMs Pulleys etc.

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1323753:index_xid718565

Solid Edge Structural Analysis

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1325275:index_sesim:xid1602403:activity1a

Solid Edge Analysis Videos

- https://www.youtube.com/watch?v=515un5vL-2Y
- https://www.youtube.com/watch?v=AzHT9DC0xaA
- https://www.youtube.com/watch?v=EwubY6Dx964
- https://www.youtube.com/watch?v=z57kz8m3gQo
- https://www.youtube.com/watch?v=I3Q0cQHIxyI

Remind students to record research notes and sources as well as reflections on the day in the Engineering Notebook.

Day 5-6
Key Question: How do we get started on our individual designs?

Students are provided the activity Linkage Diagrams. Student teams learn to create linkage diagrams to represent the mechanisms they want to create. Student teams brainstorm needed components of their design and then create their isometric sketches and linkage diagrams to add to their design brief. They include measurements with their linkage diagrams and include formulas used to evaluate their designs. They then meet with their clients who will need to sign off on the design proposal before solid modeling can begin.

Students can reference Linkage Diagrams, Basic 3D Commands, Creating Drawing Views and Assembly Modeling , Designing and Analyzing Beams and Working with Bodies for specific commands to use in the mechanical bank design. Students can reference web links, videos, and tutorials at any time during the process of the design.

Teams discuss how their mechanical bank should be tested. The teams decide which components will be tested and how to assess when their design achieves the test requirements.

Day 7-8
Key Question: How can we begin to make our bank?

Students record sketches and reflections in the Engineering Notebook. Once the students feel they have a mechanical bank design meeting the requirements, consider how the design will be tested before beginning to design and build.

Teams discuss their proposed bank and how to achieve the design given the approved sketch they presented. They work together to brainstorm ideas and begin to narrow their vision of the solution. Divide the work of creating the 3D solid model of the pieces needed and the plan to assemble the mechanical bank. Utilize the division of work in the creation of the project management plan.

Teams are reminded to continually check their 3D components of the designs to ensure accurate sizes. Teams discuss how the various designs work and that the designs created will meet the requirements of the bank. Student teams also discuss how the designs will be assembled and how the mechanism will operate.

Day 9-10
Key Question: How can we put our new designs together?

Student teams conduct meetings to review all designs created. Students review the criteria and testing protocols created. They discuss which design they wish to use as the team final design. It could be a single design or contain elements of several designs. Once the decision is made the students create a plan for creating the team prototype. They need to create a design that incorporates their ideas. Once the final plan is created they will create individual parts in Solid Edge and assemble them into assemblies. The teams discuss the final testing of their prototypes and how that will be achieved.

Students create the final plans and begin 3D printing the necessary components and assemble their scale model of the mechanical bank mechanism from the printed parts. Students record any changes in their designs and enter reflections in their Engineering Notebooks.

Day 11-13
Key Question: How can we take our designs apart to demonstrate how they are made?

Students assemble their 3D mechanical bank from the materials following their plans. When students encounter problems assembling their designs they must discuss how they will resolve the issue and change the design.

Students record any changes in their designs and enter reflections in their Engineering Notebooks.

Day 14-15
Key Question: How do we organize our results in a presentation to the class?

The student teams discuss and finish any changes they need to make.
The teacher will discuss with the teams how to optimally present their ideas.

Students discuss the outline of the presentation to the client. The deliverables could be in the form of a dimensioned working drawing pictorial representation with balloons and bill of materials and/or a 3D printed prototype as well as the final testing data and demonstrations. Students should prepare an engineering report about the process of designing the mechanical bank and how the components all fit together. The students should be required to write the introduction, provide results including graphics, and form a conclusion including an acknowledgement section reporting the source of information. Students decide how to divide the work to create a team report.

Day 16
Key Question: How do we convey our ideas?

Students can present their solutions to the class one at a time. Students display the completed mechanical bank and demonstrate how it functions. Students discuss changes they would consider if they had time to create another iteration of their design.

In the end, all students can reflect on their work by giving and receiving feedback on how they could possibly improve their designs

Vocabulary:

Articulation
Ball joint
Bell Crank
Cam
Compression
Crank
Crank and slider
Eccentric
Efficiency
Flywheel
Follower
Force
Gear
Joint
Lever
Linear motion
Linkage
Linkage diagram
Links
Oscillating motion
Pulley
Reciprocating motion
Rotary motion
Spring
Tension
Torque

Universal joint
Work

Resources:

CAD Tutorials

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012424/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012420/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012430/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012447/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012454/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012455/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012420/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012460/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012430/index.html
- http://niveshandnisheeth.blogspot.com/2016/11/content-list-videos-solid-edge-st9.html
- http://media.plm.automation.siemens.com/goplm/Introduction-FEA.zip
- http://media.plm.automation.siemens.com/goplm/Introduction-Mechanical-Systems.zip

Assembly Tutorials

- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012424/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012454/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012455/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012460/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012451/index.html

Solid Edge Structural Analysis

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1325275:index_sesim:xid1602403:activity1a

Solid Edge Analysis Videos

- https://www.youtube.com/watch?v=515un5vL-2Y
- https://www.youtube.com/watch?v=AzHT9DC0xaA
- https://www.youtube.com/watch?v=EwubY6Dx964
- https://www.youtube.com/watch?v=z57kz8m3gQo
- https://www.youtube.com/watch?v=I3Q0cQHIxyI

Solid Edge Robotics and Mechanisms Course

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku

Engineering Reference Command for designing Gears, CAMs Pulleys etc.

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1323753:index_xid718565

Engineering Reports

- http://web.mit.edu/me-ugoffice/communication/technical-writing.pdf
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/writing_engineering_reports.html
- https://www.youtube.com/playlist?list=PLDAAF7A8FD5CD582C&feature=plcp
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/mechanical_engineering_writing_enhancement_program/report_writing.html
- https://owl.purdue.edu/owl/subject_specific_writing/professional_technical_writing/technical_reports_and_report_abstracts/reports_proposals_and_technical_papers.html

Material Properties

- http://www.matweb.com
- http://www.engineeringtoolbox.com/material-properties-t_24.html
- http://www.technologystudent.com/joints/matprop1.htm
- http://www.makeitfrom.com/
- http://web.mit.edu/course/3/3.225/book.pdf

Mechanisms

- http://www.technologystudent.com/cams/camdex.htm
- http://www.technologystudent.com/cams/link1.htm
- http://www.technologystudent.com/gears1/geardex1.htm
- http://www.technologystudent.com/cams/crkslid1.htm
- http://www.brockeng.com/mechanism/index.htm
- http://www.physicsgames.net/game/Mechanism.html

Animated Mechanisms

- http://www.mekanizmalar.com/

Gear Ratio

- https://www.youtube.com/watch?v=D_i3PJIYtuY

Mechanical Banks

- http://www.mechanicalbanks.org/
- http://www.collectorsweekly.com/coin-operated/mechanical-banks
- http://www.zandkantiques.com/Mechanical_Banks.html
- http://blog.dugnorth.com/2013/03/hand-cranked-mechanical-bank-featuring.html
- https://www.youtube.com/watch?v=HU8UceasV3c
- https://www.youtube.com/watch?v=9roW-agHxSs
- https://www.youtube.com/watch?v=wTo4vQ9ZZs8

Solid Edge Instructional Videos
Introduction to Mechanisms

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-01-introduction/VJ-5mlGyO?topic=1

CAM and Follower

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=1

Beginning CAM Motion

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=2

Common CAM Types

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=1
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=2
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=3

CAM Physical Motion

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-04-cam-vice-lock-scissors/4JThnbf1d?topic=2

Circular vs. Arc

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-04-cam-vice-lock-scissors/4JThnbf1d?topic=3

Four Bar Mechanisms

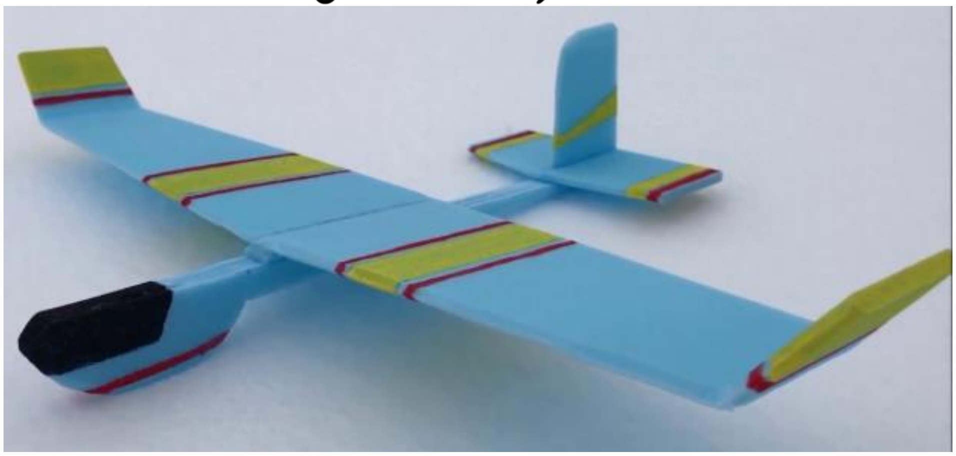
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=1
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=2
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=3
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=4
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=4

Motion Concepts

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-09-motion-concepts/NytArMfyu?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-09-motion-concepts/NytArMfyu?topic=1

Assembly Example-Rowboat Video Collection

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/rowboat-mechanism-in-solid-edge/EJaWFRQRP



Project: Glider

Introduction:
A glider is a light engineless aircraft that flies. Gliders are powered by gravity and air currents. They are very efficient at slow descents but can actually gain altitude by updrafts or thermals of air. An aircraft tows a full sized glider aloft or it can be launched from mountain sides. The Wright brothers originally started out using gliders and then later attached an engine to it. Today we see gliders used mostly for sport.

Purpose of the Project:
The purpose of this project is to introduce the students to the concept of flight and use prior design knowledge to solve an open-ended problem. The design process is iterative and the students see quickly that certain designs need to be slightly modified and retested to achieve the desired result.

Concepts:
- Utilize mathematical analysis, scientific inquiry, and engineering design to develop solutions to open ended problems.
- Select and defend a material for use in a product, explaining material properties and characterization, based upon manufacturing processes, chemical composition, internal defects, temperature, previous loading, dimensions, and other factors.
- Apply the design process in the design of a mechanical system.

- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.
- Design a system of elements that manage power to accomplish a task that involves defined movement.
- Access, generate, process, and transfer information using appropriate technologies.

Outline:

- Documentation
  - Engineering Notebook
  - Documentation of glider to be designed
- Modeling
  - Creation of 3D model
  - Assembly of 3D model
  - Design renderings and pictorial exploded drawings
  - Construct 3D model of glider project
- Evaluation
  - Test flights of gliders
- Communication
  - Presentation of design solutions

Standards:

Career and Technical Standards

Engineering Design Process

- Create and maintain an Engineering Notebook for daily reflections, research and prototype creation documentation.
- Apply the design and problem solving process as an iterative process incorporating sciences, mathematics and engineering to optimally convert resources to meet a stated objective.
- Communicate solutions utilizing technical writing skills including correct spelling, proper grammar and dependent vocabulary.
- Assume and carry out a role in the smooth running of a team working toward the solution of a problem.
- Assemble a quantitative plan for successful completion of the project.
- Assume leadership roles and responsibility for decisions making as part of a team.
- Analyze costs of resources necessary for product production.

Sketching

- Create sketches utilizing basic shapes such as lines circles and ellipses.
- Apply isometric and orthographic sketches to add clarity to design.
- Create necessary sketches to communicate basic ideas during the design process.

3D Solid Modeling/Fabrication and 3-D Printing

- Apply geometric relationships between lines and shapes to create a mathematical database to describe design ideas.
- Create solid models utilizing concepts of Parametric Modeling.
- Analyze models for appropriate engineering design features needed.
- Develop strategies for the creation of solid models for the rapid creation of design solutions.
- Apply the concepts of digital prototyping to accelerate the time frame between ideation and completed project.
- Access, generate, and transfer information using appropriate technologies.
- Design and create a model using additive manufacturing technology sometimes called a rapid prototyping system.
- Apply principles of rapid and less costly product development including the application of new materials.
- Utilize rapid prototyping/additive manufacturing to create highly complex parts designed with a CAD system.

Renderings/Working Drawings/ Design Presentations

- Create renderings to communicate design ideas and engineering principles to the customer.
- Produce a final pictorial rendering of a design concept utilizing light, texture and shading.
- Apply rendering techniques to create final design presentations for the customer.

Assembly Modeling/Documentation/Exploded Assemblies/Bill of Materials

- Conduct model documentation as the process of recording details such as size, material composition, and instructions for assembling, installation and servicing, analysis, development process that describes a model for the purpose of communication of ideas.
- Create a bill of materials to communicate materials and other information about a design.

Reverse Engineering/Engineering Features

- Apply the principles of design for manufacturing enabling the efficient and effective production of products.
- Apply the green principles of design for eventual disassembly and resource recovery.
- Investigate activities that a business conducts with the intention of making a discovery that can either lead to the development of new products or procedures, or to improvement of existing products or procedures and to know the new approaches of rapid development and deployment that saves time and is more efficient.
- Disassemble a product into its parts, utilize precision measurement to create sketches, drawings and models of the product and identify the basic processes, systems, designs, and materials used in the manufacture of the product.

Simple Machines

- Utilize mathematical analysis, scientific inquiry and engineering design to develop solutions to open ended problems.
- Access, generate, process, and transfer information using appropriate technologies
- Apply the engineering design process in the creation of a mechanical system.
- Read and analyze detailed descriptions of machinery and provide a concise summary for documentation purposes.
- Assign mathematical relationships to analyze mechanical advantage.
- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.

Mechanical Systems

- Utilize mathematical analysis, scientific inquiry and engineering design to develop solutions to open ended problems.
- Access, generate, process, and transfer information using appropriate technologies.
- Apply the engineering design process in the creation of a mechanical system.
- Read and analyze detailed descriptions of machinery and provide a concise summary for documentation purposes.
- Assign mathematical relationships to schematics to apply forces.
- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.
- Design a system of elements that manage power to accomplish a task that involves defined movement.

Structures/Forces

- Create models that are mathematical or physical systems that are set up to obey certain specified conditions having behavior intended to understand or evaluate a design system.
- Conduct model analysis using Finite Element Analysis (FEA) and simulations to produce a detailed examination of the elements, structure and behavior of a system under certain conditions.
- Assign mathematical relationships to schematics to apply forces.
- Conduct a systematic study of a structure by applying a load to determine the performance of the structure design, the structure members, and the structure materials as determined through the relationship between applied force and the corresponding deflection.
- Apply the knowledge from a stress and strain curve to a design solution.
- Analyze the strength of materials under various types of loading to predict system behavior.
- Calculate the normal loads on a structure when in use including a factor for extreme conditions plus an additional typical added factor for safety.
- Analyze complex structures by breaking them down into components.

- Test scale models to verify the strength predictions made from mathematical models.

Engineering Systems

- Utilize mathematical analysis, scientific inquiry and engineering design to develop solutions to open ended problems.
- Defend a selected material for use in a product, explaining material properties and characterization, based upon manufacturing processes, chemical composition, internal defects, temperature, previous loading, dimensions and other factors.

College and Career Readiness Math Standards

Number and Quantity

13. Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
14. Define appropriate quantities for the purpose of descriptive modeling.
7. Recognize vector quantities as having both magnitude and direction. Represent vector quantities by directed line segments, and use appropriate symbols for vectors and their magnitudes
10. Given two vectors in magnitude and direction form, determine the magnitude and direction of their sum.

Modeling with Geometry G-MG

Apply geometric concepts in modeling situations

1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).
2. Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot).
3. Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).

Create equations that describe numbers or relationships CED

A.4. Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.

Reading Standards for Literacy in History/Social Studies 9-10

Key Ideas and Details

1. Cite specific textual evidence to support analysis of primary and secondary sources, attending to such features as the date and origin of the information.
3. Analyze in detail a series of events described in a text; determine whether earlier events caused later ones or simply preceded them.

Integration of Knowledge and Ideas

7. Integrate quantitative or technical analysis (e.g., charts, research data) with qualitative analysis in print or digital text.
9. Compare and contrast treatments of the same topic in several primary and secondary sources.

Range of Reading and Level of Text Complexity

10. By the end of grade 10, read and comprehend science/technical texts in the grades 9–10 text complexity band independently and proficiently.

Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 9-10

Text Types and Purposes

1. Write arguments focused on *discipline-specific content.*
2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

Production and Distribution of Writing

4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Research to Build and Present Knowledge

7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.

Range of Writing

10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Next Generation Science Standards

The projects engage students in the scientific and engineering practices taken from the National Research Council's Framework for K-12 Science Education, Practices, Crosscutting Concepts, and Core Ideas. This is the document upon which the NGSS are based.

These practices are used for two reasons: 1) they parallel the design process utilized in each project, and 2) they serve as the foundation of the NGSS.

The eight science and engineering practices are:
1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Standards for Technological Literacy

Standard 2
Students will develop an understanding of the core concepts of technology.

Standard 3
Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Standard 4
Students will develop an understanding of the cultural, social, economic, and political effects of technology.

Standard 5
Students will develop an understanding of the effects of technology on the environment.

Standard 7
Students will develop an understanding of the influence of technology on history.

Standard 8
Students will develop an understanding of the attributes of design.

Standard 9
Students will develop an understanding of engineering design.

Standard 10
Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Standard 11
Students will develop the abilities to apply the design process.

Standard 12
Students will develop the abilities to use and maintain technological products and systems.

Standard 13
Students will develop the abilities to assess the impact of products and systems.

Standard 14
Students will develop an understanding of and be able to select and use medical technologies.

Standard 17
Students will develop an understanding of and be able to select and use information and communication technologies.

Standard 19
Students will develop an understanding of and be able to select and use manufacturing technologies.

Standard 20
Students will develop an understanding of and be able to select and use construction technologies.

Assessment:

Assessment is both formative and summative. It is an integral part of quality instruction. During the course of each project, one of the teacher's main functions is to work with student groups, keeping track of progress and providing formative assessment in the form of feedback and promoting reflection on the part of students. The focus should be on promoting lifetime learning and 21st century skills. The goal of instruction is to promote abilities in research, problem solving, designing, experimenting, testing, collecting and analyzing data.

Rubrics are used in the assessment process to communicate expectations of quality. Rubrics should be shared with students at the beginning of a project to clarify any misconceptions before beginning their work. Students can then build the skills and gather knowledge to solve the problem presented to the expectations of excellence described.

General Rubrics for Literacy tasks:
Argumentative_Pursuasive
Informational_Explanatory

Individual Project Rubric:
Glider Rubric

Essential Question:

How can we design and create a glider to land at a desired location?

Student Scenario:

An aeronautical engineering firm has contacted you and would like your team to design and test a prototype glider that they would consider building for consumer use. Students will research basic glider design. They will then design and build a glider to fly a specified course, fly the longest or hit a specified target. Students can iterate their designs based upon experimentation.

Deliverables

- Engineering Notebook with reflections, research notes, bibliography, and other processes used in the design
- Sketches and working drawings for the elements of the glider
- Linkage diagram
- Analysis of the structural elements of the glider
- 3D models of the glider elements
- Functioning glider
- Engineering report of the design process
- Presentation for the authentic audience

Daily Plan:

Day 1
Key Question: What are the expectations of the project?

Introduce students to the project by providing them with the Essential Question and the scenario.

Review and discuss with your students the design process, Engineering Notebook and design documentation requirements. Discuss the problem statement, design brief, testing protocol and management plan. Review the elements of a good engineering report with the students. These were all covered in the first project titled *Introduction to the Engineering Design Process* but should be reinforced on a regular basis. All projects depend on the design process and student activities should relate directly.

Have the students form teams of two. Allow the students five minutes to discuss the problem. Students begin by brainstorming ideas in their Engineering Notebooks. The teacher will provide a list of vocabulary terms that students will need to research on their own. The teams can divide the list of terms among team members and share their definitions. All team members are responsible to know all definitions.

Day 2-3
Key Question: How do we get started in the design process?

The teams will be responsible for researching aeronautical principles, center of gravity, generating lift, airframe structures, strength of materials, and analysis.

Links can be found in the Resources section. Teams hold a group discussion on the specifications of the glider design. Students begin sketching and adding lift calculations associated with the glider design. Students add items from their reading to their Engineering Notebooks.

The student teams discuss possible glider features. The teams should decide on design constraints which might include:

- What materials will the glider be made from?
- What are the size limitations of the glider?
- How will it be powered?
- What is the desired target(s) the glider must achieve?
- How will the glider be assembled?
- What adjustments can be made to change the flight path?

The teacher reminds students about the help system to find out how the software accomplishes basic features they might want to incorporate.
https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index

Students can enter terms and view a tutorial for creating certain features. Students can reference specific terms from the vocabulary list for specific commands to be used in the design of the glider.

The teacher will also show students the Siemens Solid Edge Video Resources to allow students to discover further elements to help their designs. Other tutorials in the Resources section are available for use if students struggle.

Engineering Reference Command for designing Gears, CAMs Pulleys etc.

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1323753:index_xid718565

Solid Edge Structural Analysis

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1325275:index_sesim:xid1602403:activity1a

Solid Edge Analysis Videos

- https://www.youtube.com/watch?v=515un5vL-2Y
- https://www.youtube.com/watch?v=AzHT9DC0xaA
- https://www.youtube.com/watch?v=EwubY6Dx964
- https://www.youtube.com/watch?v=z57kz8m3gQo
- https://www.youtube.com/watch?v=I3Q0cQHIxyI

Remind students to record research notes and sources as well as reflections on the day in the Engineering Notebook.

Day 4
Key Question: How do we get started on our individual designs?

Student teams brainstorm needed components of their design and then create their isometric sketches to add to their design brief to include with their sketches. They include preliminary sizes and airspeed requirements including formulas used to evaluate their designs. They then meet with their clients who will need to sign off on the design proposal before solid modeling can begin.

Students can reference Linkage Diagrams, Basic 3D Commands, Creating Drawing Views, Assembly Modeling, Designing and Analyzing Beams and Working with Bodies for specific commands to use in the glider equipment design. Students can reference web links, videos, and tutorials at any time during the process of the design.

Day 5-7
Key Question: How can we begin to make our glider?

Students record sketches and reflections in the Engineering Notebook. Once the students feel they have a solution to the glider design that meets the requirements, consider how the design will be tested before building.

Teams discuss their proposed glider and how to achieve the design given the approved sketch. Students work together to brainstorm ideas and begin to narrow their vision of the solution. Divide the work of creating the 3D solid model of the pieces needed and the plan to assemble the glider. Utilize the division of work in the creation of the project management plan.

Teams are reminded to continually check their 3D components of the designs with the team to ensure accurate sizes. Teams discuss how the various designs work and that the designs created will meet the glider requirements. Student teams also discuss how the designs will be assembled.

Day 8-9
Key Question: How can we put our new designs together?

Student teams conduct meetings to review all designs created so far. They look at the criteria and testing protocols. They discuss which design they wish to use as the team final design. It could be a single design or contain elements of several designs. Once the decision is made the students create a plan for creating the team prototype. They need to create a design that incorporates their ideas. Once the final plan is created they will create individual parts in Solid Edge and assemble them into assemblies. The teams discuss the final testing of their prototypes and how that will be achieved.

Students create the final plans and begin 3D printing any necessary components and cut foam board to shape from their patterns. Students begin to assemble their glider from the parts created following the plans. Students record any changes in their designs and enter reflections in their Engineering Notebooks.

Day 10-12
Key Question: How can we take our designs apart to demonstrate how they are made?

Key Question: How do we build and test our designs?

Students assemble their gliders from the materials following the plans. When students encounter problems assembling their designs they must discuss how they will resolve the issue and change the design.

Students record any changes in their designs and enter reflections in their Engineering Notebooks.

As students finish assembling their gliders they can test them to see if they fly as predicted. Teams identify sources of problems and redesign parts as needed.

Day 13-14
Key Question: How do we organize our thoughts in a presentation to the class?

The student teams discuss and finish any changes they need to make.
The teacher will discuss with the teams how to optimally present their ideas.

Students discuss the outline of the presentation to the client. The deliverables could be in the form of a dimensioned working drawing pictorial representation with balloons and bill of materials and/or a 3D printed prototype as well as the final testing data and demonstrations. Students should prepare an engineering report about the process of designing their connector and how the components all fit together. The students should be required to write the introduction, provide results including graphics, and form a conclusion including an acknowledgement section reporting the source of information. Students decide how to divide the work to create a team report.

Students should be constructing their designs, testing and adjusting as they go.

Day 15
Key Question: How do we convey our ideas?

Students can present their solutions to the class one at a time. Students display the completed glider and demonstrate how it functions. Students discuss changes they would consider if they had time to create another iteration of their design.

In the end, all students can reflect on their work by giving and receiving feedback on how they could possibly improve their designs

Vocabulary:

Ailerons
Center of gravity
Chord
Drag
Elevator
Force
Gravity
Lift
Loading
Pitch
Propulsion
Rib
Roll
Rudder
Spar
Thrust
Torque
Wing
Yaw

Resources:

CAD Tutorials

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012424/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012420/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012430/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012447/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012454/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012455/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012420/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012460/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012430/index.html
- http://niveshandnisheeth.blogspot.com/2016/11/content-list-videos-solid-edge-st9.html
- https://docs.plm.automation.siemens.com/tdoc/se/109/se_help#uid:index_xid718565:xid721892

Assembly Tutorials

- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012424/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012454/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012455/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012460/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012451/index.html

Solid Edge Structural Analysis

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1325275:index_sesim:xid1602403:activity1a

Solid Edge Analysis Videos

- https://www.youtube.com/watch?v=515un5vL-2Y
- https://www.youtube.com/watch?v=AzHT9DC0xaA
- https://www.youtube.com/watch?v=EwubY6Dx964
- https://www.youtube.com/watch?v=z57kz8m3gQo
- https://www.youtube.com/watch?v=I3Q0cQHIxyI

Solid Edge Robotics and Mechanisms Course

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku

Engineering Reference Command for designing Gears, CAMs Pulleys etc.

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1323753:index_xid718565

Engineering Reports

- http://web.mit.edu/me-ugoffice/communication/technical-writing.pdf
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/writing_engineering_reports.html
- https://www.youtube.com/playlist?list=PLDAAF7A8FD5CD582C&feature=plcp
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/mechanical_engineering_writing_enhancement_program/report_writing.html
- https://owl.purdue.edu/owl/subject_specific_writing/professional_technical_writing/technical_reports_and_report_abstracts/reports_proposals_and_technical_papers.html

Glider

- http://www.amaflightschool.org/diy/how-build-indoor-catapult-launch-glider-science-olympiad
- http://www.amedeo-itn.eu/uploads/files/AMEDEO_Glider_Instructions&Template-BalsaWood.pdf

- http://www.ericbrasseur.org/glider_physics.html?i=1
- https://www.rcgroups.com/forums/showthread.php?1587275-Foamboard-Scratchbuild-University
- http://www.instructables.com/id/Foam-RC-Airplane/
- http://mikeysrc.com/Scratch-Built-Aircraft.html
- https://www.rcgroups.com/forums/showthread.php?1138106-60-span-motor-glider-OSG!
- http://www.instructables.com/id/Foamboard-RC-Glider/
- https://www.youtube.com/watch?v=I_atJwXxcrU
- https://www.youtube.com/watch?v=a5tPq0sYlNs
- https://www.youtube.com/watch?v=kDBAYe6iQhU
- https://www.youtube.com/watch?v=ZsiaPTo8ds4

Material Properties

- http://www.matweb.com
- http://www.engineeringtoolbox.com/material-properties-t_24.html
- http://www.technologystudent.com/joints/matprop1.htm
- http://www.makeitfrom.com/
- http://web.mit.edu/course/3/3.225/book.pdf

Solid Edge Instructional Videos

Introduction to Mechanisms

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-01-introduction/VJ-5mlGyO?topic=1

CAM and Follower

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=1

Beginning CAM Motion

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=2

Common CAM Types

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=1

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=2
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=3

CAM Physical Motion

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-04-cam-vice-lock-scissors/4JThnbf1d?topic=2

Circular vs. Arc

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-04-cam-vice-lock-scissors/4JThnbf1d?topic=3

Four Bar Mechanisms

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=1
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=2
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=3
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=4
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=4

Motion Concepts

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-09-motion-concepts/NytArMfyu?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-09-motion-concepts/NytArMfyu?topic=1

Assembly Example-Rowboat Video Collection

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/rowboat-mechanism-in-solid-edge/EJaWFRQRP

Project: Child’s Toy

Introduction:

Goals of a good toy design for young children include developing interest, creativity, and imagination. Toy designers work to make toys visually appealing, safe, durable, and often with no gender in mind. Ask the students to think about favorite toys as younger children. What were the reasons these toys were enjoyed so much?
In this project, students will use their knowledge of toys and mechanisms to design and assemble a 3D model of a young child's toy with several moving parts.

Purpose of the Project:

The purpose of this toy design is to let the students create an open-ended design with one or more moving or animated pieces. The animated toy brings together many features in the software, assemblies, exploded drawings, simple machines, and mechanisms that include motion. The students can choose a theme that is of interest and then some forms of mechanical movements that would entertain the consumer.

Concepts:

- Utilize mathematical analysis, scientific inquiry, and engineering design to develop solutions to open ended problems.

- Select and defend a material for use in a product, explaining material properties and characterization, based upon manufacturing processes, chemical composition, internal defects, temperature, previous loading, dimensions, and other factors.
- Apply the design process in the design of a mechanical system.
- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.
- Design a system of elements that manage power to accomplish a task that involves defined movement.
- Access, generate, process, and transfer information using appropriate technologies.

Outline:

Documentation
  Engineering Notebook
  Documentation of toy to be designed
Modeling
  Creation of 3D model
  Assembly of 3D model
  Exploded drawing of 3D models
  Design renderings and pictorial exploded drawings
  Construct 3D model of child's toy project
Communication
  Presentation of design solutions

Standards:

Career and Technical Standards

Engineering Design Process

- Create and maintain an Engineering Notebook for daily reflections, research and prototype creation documentation.
- Apply the design and problem solving process as an iterative process incorporating sciences, mathematics and engineering to optimally convert resources to meet a stated objective.
- Communicate solutions utilizing technical writing skills including correct spelling, proper grammar and dependent vocabulary.
- Assume and carry out a role in the smooth running of a team working toward the solution of a problem.
- Assemble a quantitative plan for successful completion of the project.
- Assume leadership roles and responsibility for decisions making as part of a team.
- Analyze costs of resources necessary for product production.

Sketching

- Create sketches utilizing basic shapes such as lines circles and ellipses.
- Apply isometric and orthographic sketches to add clarity to design.

- Create necessary sketches to communicate basic ideas during the design process.

3D Solid Modeling/Fabrication and 3-D Printing

- Apply geometric relationships between lines and shapes to create a mathematical database to describe design ideas.
- Create solid models utilizing concepts of Parametric Modeling.
- Analyze models for appropriate engineering design features needed.
- Develop strategies for the creation of solid models for the rapid creation of design solutions.
- Apply the concepts of digital prototyping to accelerate the time frame between ideation and completed project.
- Access, generate, and transfer information using appropriate technologies.
- Design and create a model using additive manufacturing technology sometimes called a rapid prototyping system.
- Apply principles of rapid and less costly product development including the application of new materials.
- Utilize rapid prototyping/additive manufacturing to create highly complex parts designed with a CAD system.

Renderings/Working Drawings/ Design Presentations

- Create renderings to communicate design ideas and engineering principles to the customer.
- Produce a final pictorial rendering of a design concept utilizing light, texture and shading.
- Apply rendering techniques to create final design presentations for the customer.

Assembly Modeling/Documentation/Exploded Assemblies/Bill of Materials

- Conduct model documentation as the process of recording details such as size, material composition, and instructions for assembling, installation and servicing, analysis, development process that describes a model for the purpose of communication of ideas.
- Create a bill of materials to communicate materials and other information about a design.

Reverse Engineering/Engineering Features

- Apply the principles of design for manufacturing enabling the efficient and effective production of products.
- Apply the green principles of design for eventual disassembly and resource recovery.
- Investigate activities that a business conducts with the intention of making a discovery that can either lead to the development of new products or procedures, or to improvement of existing products or procedures and to know the new approaches of rapid development and deployment that saves time and is more efficient.

- Disassemble a product into its parts, utilize precision measurement to create sketches, drawings and models of the product and identify the basic processes, systems, designs, and materials used in the manufacture of the product.

Simple Machines

- Utilize mathematical analysis, scientific inquiry and engineering design to develop solutions to open ended problems.
- Access, generate, process, and transfer information using appropriate technologies
- Apply the engineering design process in the creation of a mechanical system.
- Read and analyze detailed descriptions of machinery and provide a concise summary for documentation purposes.
- Assign mathematical relationships to analyze mechanical advantage.
- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.

Mechanical Systems

- Utilize mathematical analysis, scientific inquiry and engineering design to develop solutions to open ended problems.
- Access, generate, process, and transfer information using appropriate technologies.
- Apply the engineering design process in the creation of a mechanical system.
- Read and analyze detailed descriptions of machinery and provide a concise summary for documentation purposes.
- Assign mathematical relationships to schematics to apply forces.
- Apply problem solving methodology in the creation of unique solutions to mechanical motion problems.
- Design a system of elements that manage power to accomplish a task that involves defined movement.

Structures/Forces

- Create models that are mathematical or physical systems that are set up to obey certain specified conditions having behavior intended to understand or evaluate a design system.
- Conduct model analysis using Finite Element Analysis (FEA) and simulations to produce a detailed examination of the elements, structure and behavior of a system under certain conditions.
- Assign mathematical relationships to schematics to apply forces.
- Conduct a systematic study of a structure by applying a load to determine the performance of the structure design, the structure members, and the structure materials as determined through the relationship between applied force and the corresponding deflection.
- Apply the knowledge from a stress and strain curve to a design solution.
- Analyze the strength of materials under various types of loading to predict system behavior.

- Calculate the normal loads on a structure when in use including a factor for extreme conditions plus an additional typical added factor for safety.
- Analyze complex structures by breaking them down into components.
- Test scale models to verify the strength predictions made from mathematical models.

Engineering Systems

- Utilize mathematical analysis, scientific inquiry and engineering design to develop solutions to open ended problems.
- Defend a selected material for use in a product, explaining material properties and characterization, based upon manufacturing processes, chemical composition, internal defects, temperature, previous loading, dimensions and other factors.

College and Career Readiness Math Standards

Number and Quantity

15. Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
16. Define appropriate quantities for the purpose of descriptive modeling.
8. Recognize vector quantities as having both magnitude and direction. Represent vector quantities by directed line segments, and use appropriate symbols for vectors and their magnitudes
11. Given two vectors in magnitude and direction form, determine the magnitude and direction of their sum.

Modeling with Geometry G-MG

Apply geometric concepts in modeling situations

1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).
2. Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot).
3. Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).

Create equations that describe numbers or relationships CED

A.4. Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.

Reading Standards for Literacy in History/Social Studies 9-10

Key Ideas and Details

1. Cite specific textual evidence to support analysis of primary and secondary sources, attending to such features as the date and origin of the information.

3. Analyze in detail a series of events described in a text; determine whether earlier events caused later ones or simply preceded them.

Integration of Knowledge and Ideas

7. Integrate quantitative or technical analysis (e.g., charts, research data) with qualitative analysis in print or digital text.
9. Compare and contrast treatments of the same topic in several primary and secondary sources.

Range of Reading and Level of Text Complexity

10. By the end of grade 10, read and comprehend science/technical texts in the grades 9–10 text complexity band independently and proficiently.

Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 9-10

Text Types and Purposes

1. Write arguments focused on *discipline-specific content.*
2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

Production and Distribution of Writing

4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Research to Build and Present Knowledge

7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.

Range of Writing

10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Next Generation Science Standards

The projects engage students in the scientific and engineering practices taken from the National Research Council's Framework for K-12 Science Education, Practices, Crosscutting Concepts, and Core Ideas. This is the document upon which the NGSS are based.

These practices are used for two reasons: 1) they parallel the design process utilized in each project, and 2) they serve as the foundation of the NGSS.

The eight science and engineering practices are:
1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Standards for Technological Literacy

Standard 1
Students will develop an understanding of the characteristics and scope of technology.

Standard 2
Students will develop an understanding of the core concepts of technology.

Standard 3
Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Standard 4
Students will develop an understanding of the cultural, social, economic, and political effects of technology.

Standard 7
Students will develop an understanding of the influence of technology on history.

Standard 8
Students will develop an understanding of the attributes of design.

Standard 9
Students will develop an understanding of engineering design.

Standard 10
Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Standard 11
Students will develop the abilities to apply the design process.

Standard 12
Students will develop the abilities to use and maintain technological products and systems.

Standard 13
Students will develop the abilities to assess the impact of products and systems.

Standard 14
Students will develop an understanding of and be able to select and use medical technologies.

Standard 17
Students will develop an understanding of and be able to select and use information and communication technologies.

Standard 19
Students will develop an understanding of and be able to select and use manufacturing technologies.

Standard 20
Students will develop an understanding of and be able to select and use construction technologies.

Assessment:

Assessment is both formative and summative. It is an integral part of quality instruction. During the course of each project, one of the teacher's main functions is to work with student groups, keeping track of progress and providing formative assessment in the form of feedback and promoting reflection on the part of students. The focus should be on promoting lifetime learning and 21st century skills. The goal of instruction is to promote abilities in research, problem solving, designing, experimenting, testing, collecting and analyzing data.

Rubrics are used in the assessment process to communicate expectations of quality. Rubrics should be shared with students at the beginning of a project to clarify any misconceptions before beginning their work. Students can then build the skills and gather knowledge to solve the problem presented to the expectations of excellence described.

General Rubrics for Literacy tasks:
Argumentative_Pursuasive
Informational_Explanatory

Individual Project Rubric:
Child's Toy Rubric

Essential Question:
How can we design a new and exciting animated children's toy?

Student Scenario:
A toy manufacturer has contacted your engineering design team to come up with some prototype animated toy designs for a brand-new toy line to be introduced later in the year. The new toy will have several moving parts that will entertain the user. Your team will design the mechanism that causes motion and print parts to assemble into a working scale prototype.

The research and learning activities are designed to help students:

- Create sketches to communicate to a group
- Use mathematical formulas to aid in the design of a product
- Apply mechanical systems to create movement
- Utilize specific software features to create a solid model of their idea.
- Communicate their solution to their peers.

Deliverables:

- Engineering Notebook with reflections, research notes, bibliography and other processes used in the design.
- Sketches and working drawings for the elements of the toy design
- Analysis of the structural elements of the toy design
- 3D model of the toy as well as an animation of the toy in use
- Engineering report of the design process
- Presentation for the authentic audience

Daily Plan:
Day 1
Key Question: What are the expectations of the project?

Introduce students to the project by providing them with the Essential Question and the scenario.

Review and discuss with your students the design process, Engineering Notebook and design documentation requirements. Discuss the problem statement, design brief, testing protocol and management plan. Review the elements of a good engineering report with the students. These were all covered in the first project titled *Introduction to the Engineering Design Process* but should be reinforced on a regular basis. All projects depend on the design process and student activities should relate directly.

Have the students form teams of two. Allow the students five minutes to discuss the problem. Students begin by brainstorming ideas in their Engineering Notebooks. The teacher will provide a list of vocabulary terms that students will need to research on their own. The teams can divide the list of terms among team members and share their definitions. All team members are responsible to know all definitions.

Day 2-4
Key Question: How do we get started in the design process?

The teams will be responsible for researching mechanisms, existing toys, strength of materials, and analysis. Links can be found in the Resources section. Students begin sketching ideas for their toy design. Students add items from their reading to their Engineering Notebooks.

The teacher reminds students about the help system to find out how the software accomplishes basic features they might want to incorporate.
https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index

Students can enter terms and view a tutorial for creating certain features. Students can reference specific terms from the vocabulary list for specific commands to be used in the design of toy mechanism.

The student teams discuss possible toy features. The teams should decide on design constraints which might include:

- What material will the toy be made from?
- How many parts will the toy have?
- What age group is the toy designed for?
- Can your new toy adapt to existing toys?
- Will it be part of a set of toys?
- Will it appeal to all genders?

.
Student teams discuss the specifications of the toy and the mechanisms to be included. Students list the criteria and constraints of the toy they will be designing. Teams research the existing toys and discover information about work and types of mechanisms and transfer of power. Teams will define mechanisms and how they will fit into the inside of the toy to create motion.

The teacher will also show students the Siemens Solid Edge Video Resources to allow students to discover further elements to help their designs. Other tutorials in the Resources section are available for use if students struggle

Solid Edge Robotics and Mechanisms Course

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku

Engineering Reference Command for designing Gears, CAMs Pulleys etc.

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1323753:index_xid718565

Solid Edge Structural Analysis

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1325275:index_sesim:xid1602403:activity1a

Solid Edge Analysis Videos

- https://www.youtube.com/watch?v=515un5vL-2Y
- https://www.youtube.com/watch?v=AzHT9DC0xaA
- https://www.youtube.com/watch?v=EwubY6Dx964
- https://www.youtube.com/watch?v=z57kz8m3gQo
- https://www.youtube.com/watch?v=I3Q0cQHIxyI

Remind students to record research notes and sources as well as reflections on the day in the Engineering Notebook.

Day 5-6
Key Question: How do we get started on our individual designs?

Students are provided the activity Linkage Diagrams. Student teams learn to create linkage diagrams to represent the mechanisms they wish to create. Student teams brainstorm needed components of their design and then create their isometric sketches and linkage diagrams to add to their design brief. They include measurements with their linkage diagrams and include formulas used to evaluate their designs. They then meet with their clients. The clients will need to sign off on the design proposal before they begin solid modeling.

Students can reference Linkage Diagrams, Basic 3D Commands, Creating Drawing Views and Assembly Modeling , Designing and Analyzing Beams and Working with Bodies for specific commands to use in the toy design. Students can reference web links, videos and tutorials at any time during the process of the design.

Teams discuss how their toys should be tested. The teams decide what components they will test and what test results will be acceptable.

Day 7-8
Key Question: How can we begin to make our toy design?

Students record sketches and reflections in the Engineering Notebook. Once the students feel they have a mechanical toy design that meets the requirements, they should consider how they will test the design before they begin designing and building.

Teams discuss their proposed toy and how to achieve the design given the approved sketch. Students work together to brainstorm ideas and begin to narrow their vision of the solution. Divide the work of creating the 3D solid model of the pieces needed and the plan to assemble the mechanical toy. Utilize the division of work in the creation of the project management plan.

Teams are reminded to continually check their 3D components of the designs to ensure accurate sizes. Teams discuss how the various designs work and that the designs created will meet the requirements of the toy. Student teams also discuss how the designs will be assembled and how the mechanism will operate.

Day 9-10
Key Question: How can we put our new designs together?

Student teams conduct meetings to review all designs created so far. Students review the criteria and testing protocols. They discuss which design they wish to use as the team final design. It could be a single design or contain elements of several designs. Once the decision is made the students create a plan for creating the team prototype. They need to create a design that incorporates their ideas. Once the final plan is created they will create individual parts in Solid Edge and assemble them into assemblies. The teams discuss the final testing of their prototypes and how that will be achieved.

Students create the final plans and begin 3D printing the necessary components and assemble their scale model of the mechanical toy from the printed parts. Students record any changes in their designs and enter reflections in their Engineering Notebooks.

Day 11-13
Key Question: How can we take our designs apart to demonstrate how they are made?

Students assemble their 3D mechanical toy from the materials following their plans. When students encounter problems assembling their designs they must discuss how they will resolve the issue and change the design.

Students record any changes in their designs and enter reflections in their Engineering Notebooks.

Day 14-15
Key Question: How do we organize our results in a presentation to the class?

The student teams discuss and finish any changes they need to make.
The teacher will discuss with the teams how to optimally present their ideas.

Students discuss the outline of the presentation to the client. The deliverables could be in the form of a dimensioned working drawing pictorial representation with balloons and bill of materials and/or a 3D printed prototype as well as the final testing data and demonstrations. Students should prepare an engineering report about the process of designing their toy and how the components all fit together. The students should be required to write the introduction, provide results including graphics, and form a conclusion including an acknowledgement section reporting the source of information. Students decide how to divide the work to create a team report.

Day 16
Key Question: How do we convey our ideas?

Students can present their solutions to the class one at a time. Students display the completed toy and demonstrate how it functions. Students discuss changes they would consider if they had time to create another iteration of their design.

In the end, all students can reflect on their work by giving and receiving feedback on how they could possibly improve their designs

Vocabulary:

Articulation
Ball joint
Bell Crank
Cam
Compression
Crank
Crank and slider
Eccentric
Efficiency
Flywheel
Follower
Force
Gear
Joint
Lever
Linear motion
Linkage
Linkage diagram
Links
Oscillating motion
Pulley
Reciprocating motion
Rotary motion
Spring
Tension

Torque
Universal joint
Work

Resources:

CAD Tutorials

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:index
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012424/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012420/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012430/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012447/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012454/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012455/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012420/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012460/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012430/index.html
- http://niveshandnisheeth.blogspot.com/2016/11/content-list-videos-solid-edge-st9.html
- http://media.plm.automation.siemens.com/goplm/Introduction-FEA.zip
- http://media.plm.automation.siemens.com/goplm/Introduction-Mechanical-Systems.zip

Assembly Tutorials

- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012424/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012454/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012455/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012460/index.html
- https://docs.plm.automation.siemens.com/data_services/resources/se/2020/se_help/training/en_US/xid1012451/index.html

Solid Edge Structural Analysis

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1325275:index_sesim:xid1602403:activity1a

Solid Edge Analysis Videos

- https://www.youtube.com/watch?v=515un5vL-2Y
- https://www.youtube.com/watch?v=AzHT9DC0xaA
- https://www.youtube.com/watch?v=EwubY6Dx964
- https://www.youtube.com/watch?v=z57kz8m3gQo
- https://www.youtube.com/watch?v=I3Q0cQHIxyI

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- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku

Engineering Reports

- http://web.mit.edu/me-ugoffice/communication/technical-writing.pdf
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/writing_engineering_reports.html
- https://www.youtube.com/playlist?list=PLDAAF7A8FD5CD582C&feature=plcp
- https://owl.purdue.edu/owl/subject_specific_writing/writing_in_engineering/mechanical_engineering_writing_enhancement_program/report_writing.html
- https://owl.purdue.edu/owl/subject_specific_writing/professional_technical_writing/technical_reports_and_report_abstracts/reports_proposals_and_technical_papers.html

Gear Ratio

- https://www.youtube.com/watch?v=D_i3PJIYtuY

Material Properties

- http://www.matweb.com
- http://www.engineeringtoolbox.com/material-properties-t_24.html
- http://www.technologystudent.com/joints/matprop1.htm
- http://www.makeitfrom.com/
- http://web.mit.edu/course/3/3.225/book.pdf

Mechanisms

- http://www.technologystudent.com/cams/camdex.htm
- http://www.technologystudent.com/cams/link1.htm
- http://www.technologystudent.com/gears1/geardex1.htm
- http://www.technologystudent.com/cams/crkslid1.htm
- http://www.brockeng.com/mechanism/index.htm
  http://www.physicsgames.net/game/Mechanism.html

Animated Mechanisms

- http://www.mekanizmalar.com/

Toy Ideas

- https://www.youtube.com/watch?v=vEiCRSExGxM
- http://re.trotoys.com/article/12-great-mechanical-toy-plans/
- http://www.toysfromtimespast.com/
- https://www.youtube.com/watch?v=djKB4yqp63s
- https://www.youtube.com/watch?v=uz8TV7gkeT0
- https://www.youtube.com/watch?v=RbbG4h1z8sM
- https://www.youtube.com/watch?v=654oDEHKq9I

Solid Edge Instructional Videos
Introduction to Mechanisms

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-01-introduction/VJ-5mlGyO?topic=1

CAM and Follower

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=0

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=1

Beginning CAM Motion

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=2

Common CAM Types

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=1
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=2
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=3

CAM Physical Motion

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-04-cam-vice-lock-scissors/4JThnbf1d?topic=2

Circular vs. Arc

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-04-cam-vice-lock-scissors/4JThnbf1d?topic=3

Four Bar Mechanisms

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=1
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=2
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=3
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=4
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=4

Motion Concepts

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-09-motion-concepts/NytArMfyu?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-09-motion-concepts/NytArMfyu?topic=1

Assembly Example-Rowboat Video Collection

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/rowboat-mechanism-in-solid-edge/EJaWFRQRP

Activities

The activities are arranged in the order of the curriculum. They can be accessed from this page to make it easier for students to have them on their computers.

SIEMENS

Ingenuity for life

Sketching Activity

Purpose:

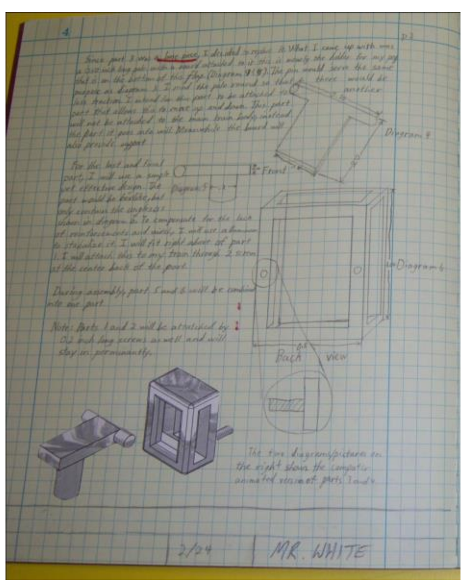
The primary objective of a sketch is effective communication. One of the most difficult things is to evaluate your work through someone else's eyes. Put yourself in the position of the person who must interpret your sketch. If you have trouble finding the right piece of information, someone else will not be able to either. Sketches are used for planning, design, and visualization. Frequently, several people share ideas on the same sketch. Sketches are frequently used to create field drawings to record important information.

Equipment:

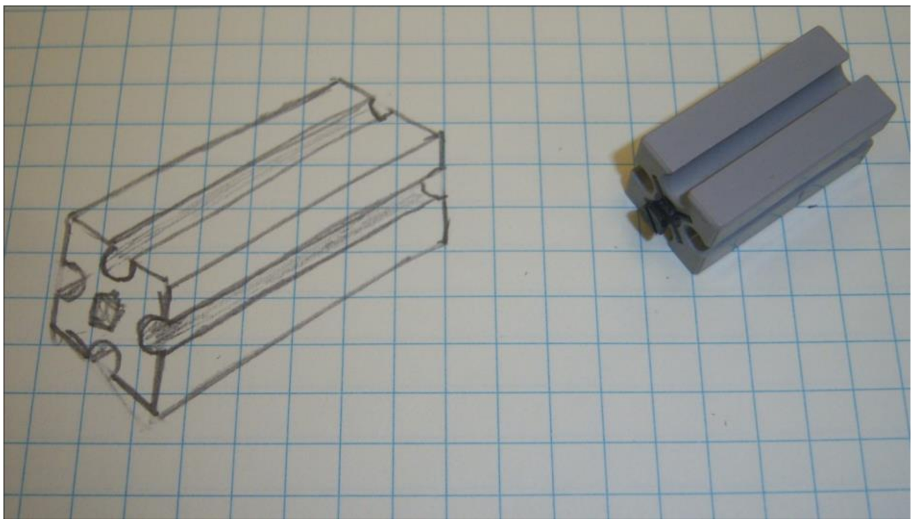
Pencil
Engineering notebook

Procedure:

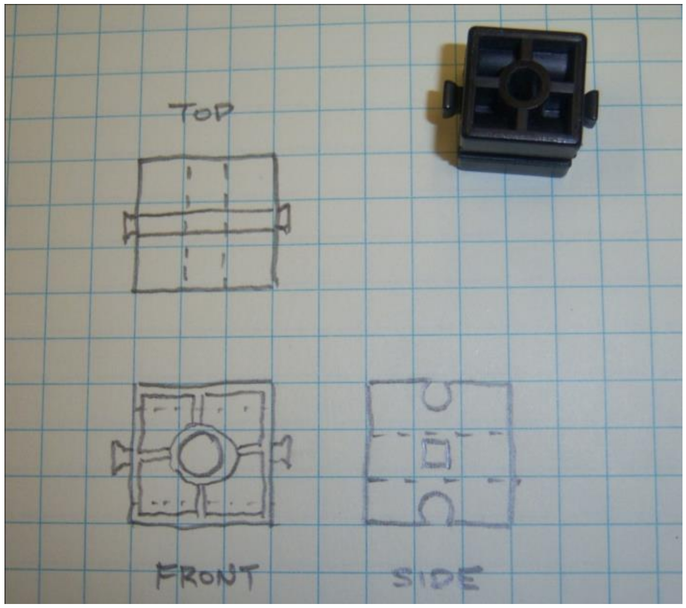
All sketching should be done in the engineer's notebook with a pencil. No other tools are needed. Sketches containing notes are considered annotated sketches. Below is an example of an annotated sketch in an engineer's notebook.



There are many different ways to sketch objects in your notebook. We always use pencil and we want to make the object or design look as real as possible. The first object to sketch should be something that has simple shapes. The one below is a rectangular block. This sketch below is called isometric, and it shows 3 sides at once. Each side is drawn approximately 30 degrees up from the horizon. Please be careful to pay attention to size and proportion. Try sketching a block in an isometric view on your own. Students can also sketch another block of their choice in an isometric view.



The next most common way to sketch objects in our notebook, is called multiview or orthographic. This is where we look at each side of the block straight on and sketch it as we see it. The lower left view is called a front view and should be the most descriptive. The view on top is the top view and the view on the right is the right side view. The short dashed lines are called hidden lines and indicate something is there but cannot be seen in that view. Now let’s try sketching a mutiview of your building block. Please keep all the views placed properly paying attention to size and proportion. Students can also sketch another block of their choice. Final sketches should be shown to the instructor for approval.



Conclusion:

Try sketching other objects using both graph paper and isometric graph paper. Once you have the sketch done on the graph paper try to create the same sketch without the graph paper.

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Creating Sketches for 3D Modeling

The power of 3D CAD modeling systems is the ability to create a digital prototype that behaves similarly to an actual model. Digital prototyping provides a tool to quickly try a variety of materials and shapes to discover how the design should change to meet certain parameters.

The analysis will only be as accurate as the 3D model. 3D models begin with an accurate 2D image or profile. When creating 3D models we are really building a mathematical database which is using advanced formula to capture our intent and creating visualizations for us. Once the model is created we can digitally apply materials to see how the object will behave under applied forces, temperature, electrical current, and a host of other factors. This ability saves a lot of time in the design of new products. Later we can export the 3D models to a printer to create objects from what we design. This allows designers to try parts together and spot problems before designing an entire manufacturing run.

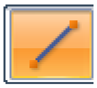
Since the models begin as sketches, it is important to create the sketches as accurately as possible. This section is about the creation of sketches as well as defining them as completely as possible. A fully defined sketch cannot change its shape orientation or position. The term “fully constrained” is used when that condition is met. Geometry is constrained in two basic ways. The first is geometric relationships. Geometric relationships control the orientation of an element with respect to another element or reference plane and the relationships enforce the rules you want your initial sketch to follow. These rules might include parallel lines, perpendicular lines or axes, tangent or concentric circles, etc. Having the geometric relationship defined can simplify your work. For example, you can define a tangent relationship between a line and an arc. If the adjoining elements change, the tangent relationship does not. Geometric relationships control how a sketch changes during editing.

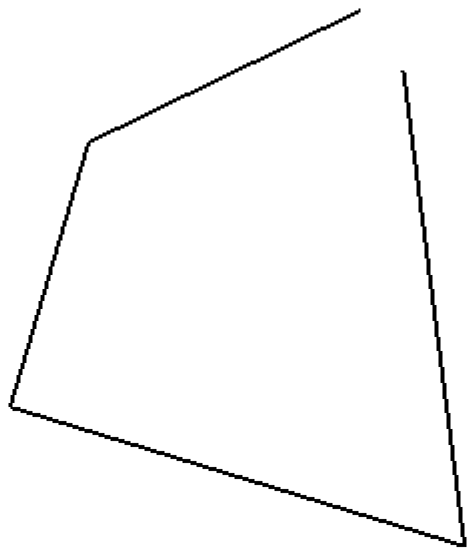
The second way geometry is constrained is establishing dimensional relationships. A dimension assigns and maintains a dimensional value to an individual element or establishes a relationship between multiple elements. A label, consisting of text, lines, and arrows, represents dimensions graphically. The combination of geometric relationships and dimensions accurately depict a sketch.

The exercises below will concentrate on learning how to describe a sketch. It is important to remember there is no one right way to create or establish the relationships in a sketch.

Sketch 1

Begin a new Solid Edge part.

Use the Line  command from the Sketching section of the ribbon and create the shape shown below.



Use your Esc key to exit the sketching command.

Place the cursor over a corner. Left click (hold) and drag the shape around. Notice that you can move each corner, even to the point of changing its shape.

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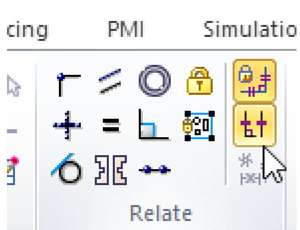
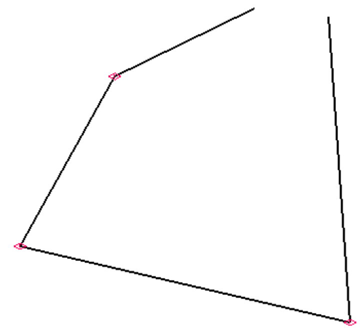
Relationships:

To see which relationships are working on your sketch, click on the Show Relationship handles on the Relate section of the ribbon.

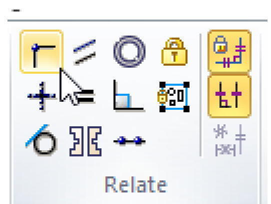


This will show which relationships exist in the drawing. In the picture below, a red square at each corner indicates the lines are meeting at the corner.



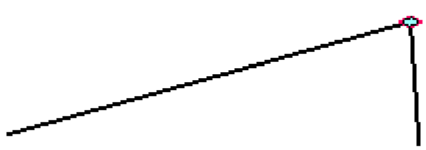
The first step is to complete the shape.

Select Connect from the Relate section of the ribbon.

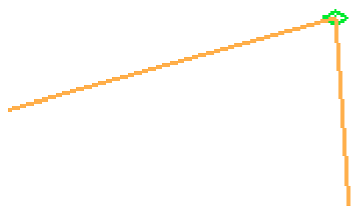


Select the endpoint of one line. You will see the endpoint mark appear on the screen.

Then select the endpoint of the other line. The two endpoints now make up a corner and the connect relationship handle appears.



If any handles appear other than the squares on the corner, delete them. To delete a relationship, highlight the individual handle, right click and select delete. Be sure the handle is highlighted. A common mistake is to erase the line and not the handle. Use the Ctrl key and the Z (Ctrl Z) at the same time to undo the last action if changes are necessary.



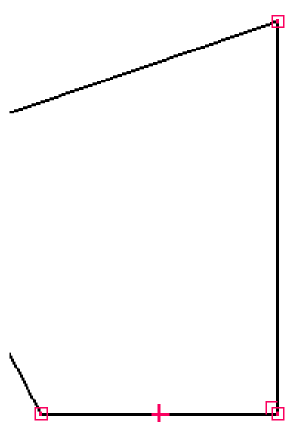
Adding More Relationships:

Choose Horizontal/Vertical from the Relate section of the ribbon. Click on the bottom line of your sketch.

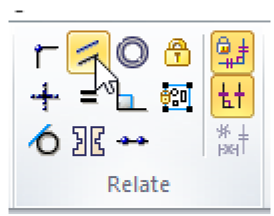
The line should now be horizontal and you will see a + in the middle of the line. This shows there is an additional relationship present. If you double click on a line you should be able to drag the line to different locations. The bottom line will always be horizontal no matter where you move it.

Add a Perpendicular relationship between the bottom line and the line on the right by selecting perpendicular from the relate section of the ribbon.

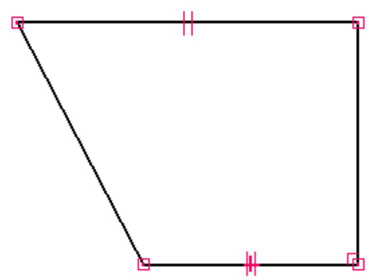
Now the line on the right shows a perpendicular relationship to the bottom line.



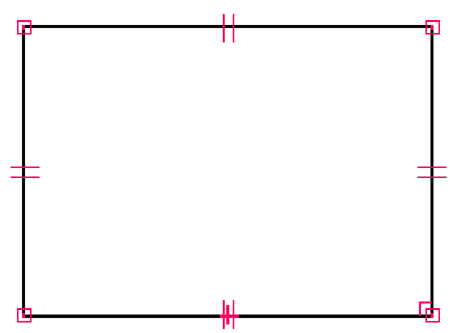
Add a Parallel relationship between the bottom line and the top line.



This adds the parallel marking to the bottom and top lines.

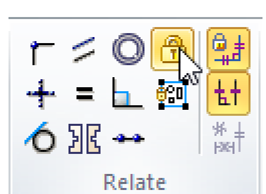


Select a relationship to make the line on the left a vertical line. There are a few you can use. Select one that will allow you to add the relationship to make the shape a rectangle.

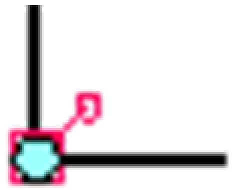


This is now a rectangle that cannot be dragged into any other shape other than a rectangle. You can move it around the screen and change the relationship between the sides.

We can fix a point on the rectangle so it cannot move. Select the Lock from the Relate section of the ribbon.



Select the lower left corner of the rectangle. You will see something that looks like a pin appear. You will not be able to drag the corner.



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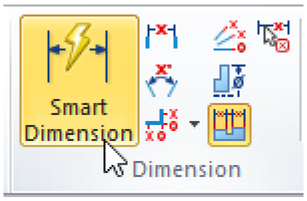
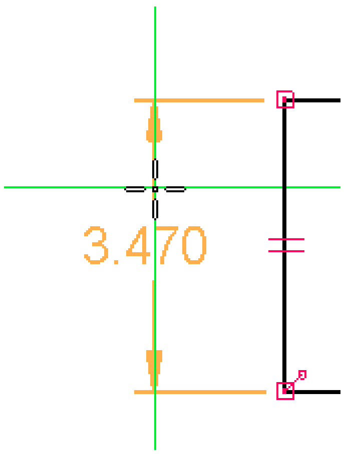
Adding Dimensions:

We can use dimensional relationships to further define the shape. The dimensions work in concert with the geometric relationships. Select Smart Dimension from the Dimension section of the ribbon.

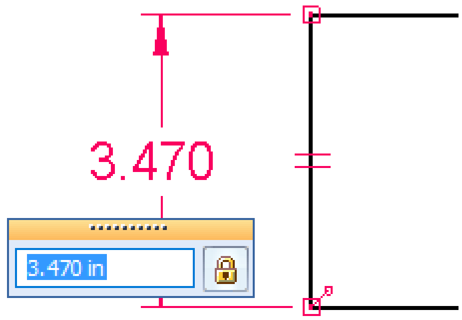


Select the vertical line on the left. Move the mouse off the line and see a dimension appear and follow your mouse.



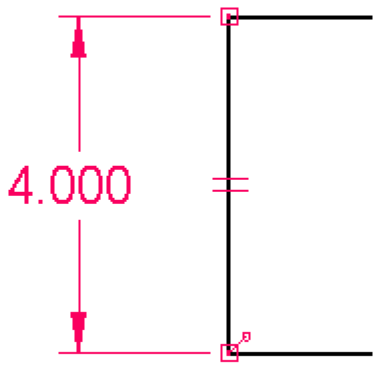
Left click to place the dimension on the screen.

A dialog box will open and allow you to enter in a value.

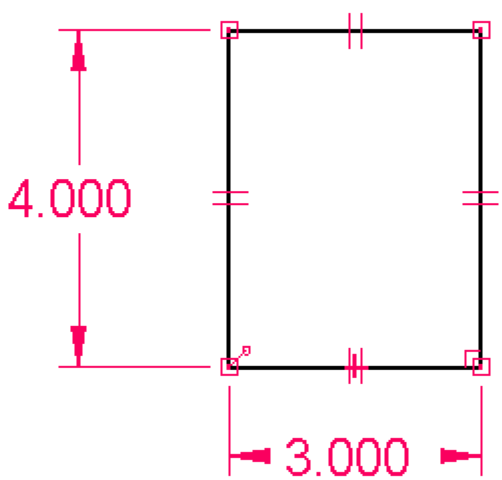


Enter the value 4 and hit the enter key.

See the sketch change shape and the dimension change to 4.



Now select the bottom line and change the dimension to 3.



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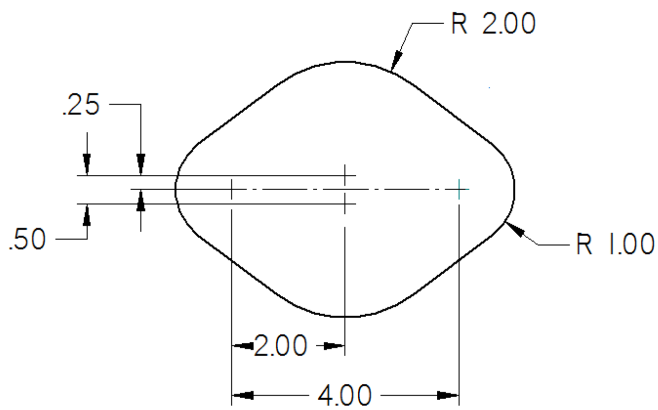
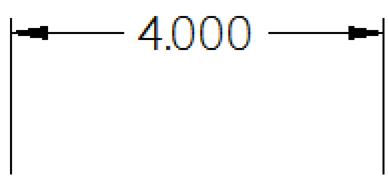
Sketch 2

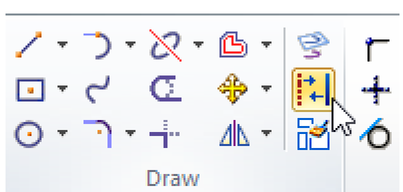
Begin a new Solid Edge part. We will be creating a sketch to resemble the one below.



In a complex shape designers will frequently utilize geometry to aid in the construction. Study the drawing above. You will see the centers of the round ends are spaced 4 apart. Begin by drawing a line segment. Add a dimension so it is exactly 4 long.



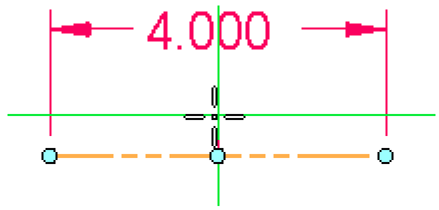
Since this line is only used for construction and will not be part of the sketch we will change the line into a construction line. Highlight the line by clicking on it. Select Construction from the Draw section of the ribbon.



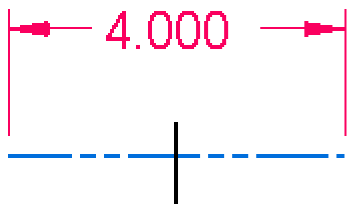
The line changes character. It now is made from two short dashes followed by a long dash. This tells experience designers this is a line used to set up needed geometry.

The centers for the curves at the top and bottom of the shape will be .25 above and below the center and centered.

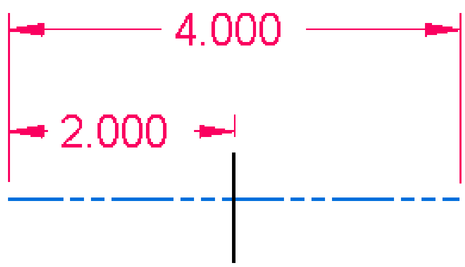
Select the Line command and come close to the existing construction line. The line will indicate where the center is.



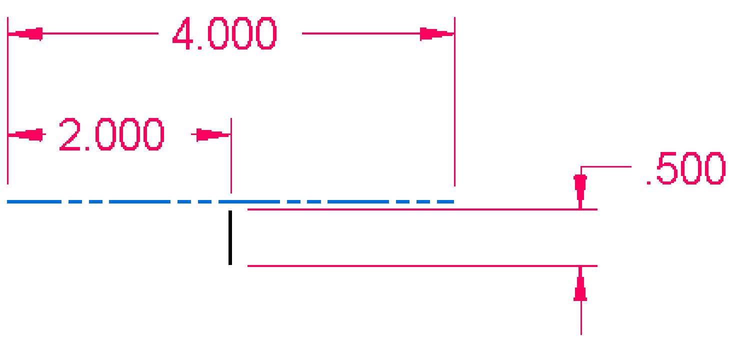
Draw a line through the center.



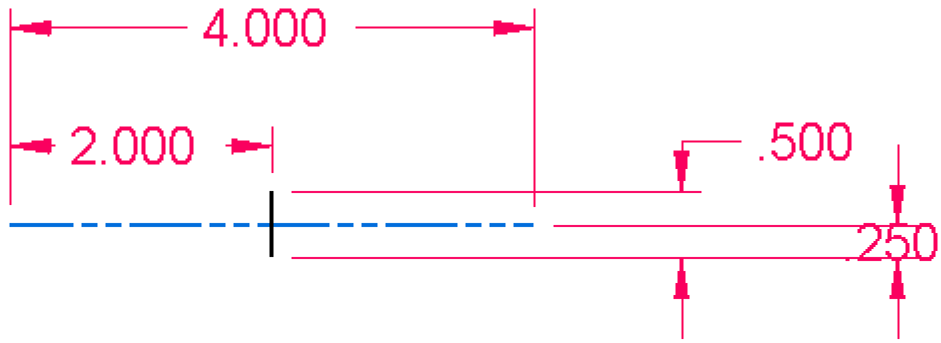
Select Distance Between from the dimension section of the ribbon. Select the end of the horizontal line and then the vertical line you just drew. Place the dimension below the 4 but above the line.



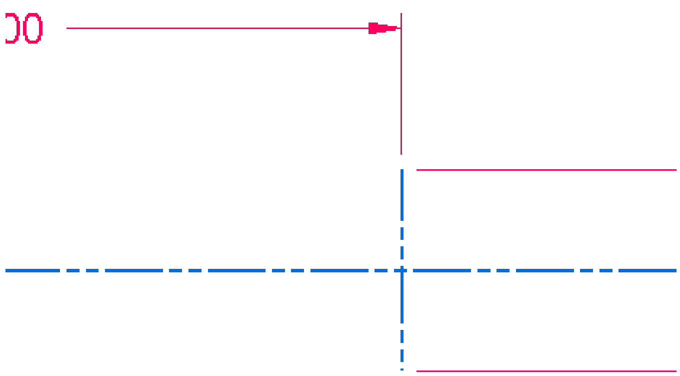
If you drew the line through the center point the program assumed you wanted a bisector so the dimension should be accurate. If it is not you should change it. We need to be sure the line is ½ long with the endpoints .25 on either side of the center line.



Add the .25 dimension from the end point of the line and the horizontal line.



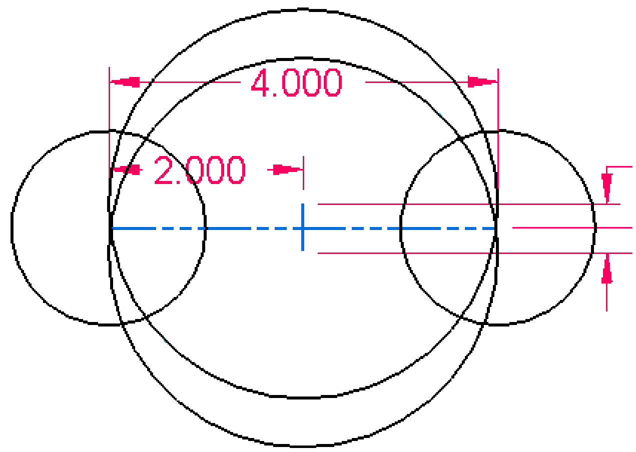
Convert the vertical line into a construction line. It is a small line so you might not see that it is a construction line until you zoom in.



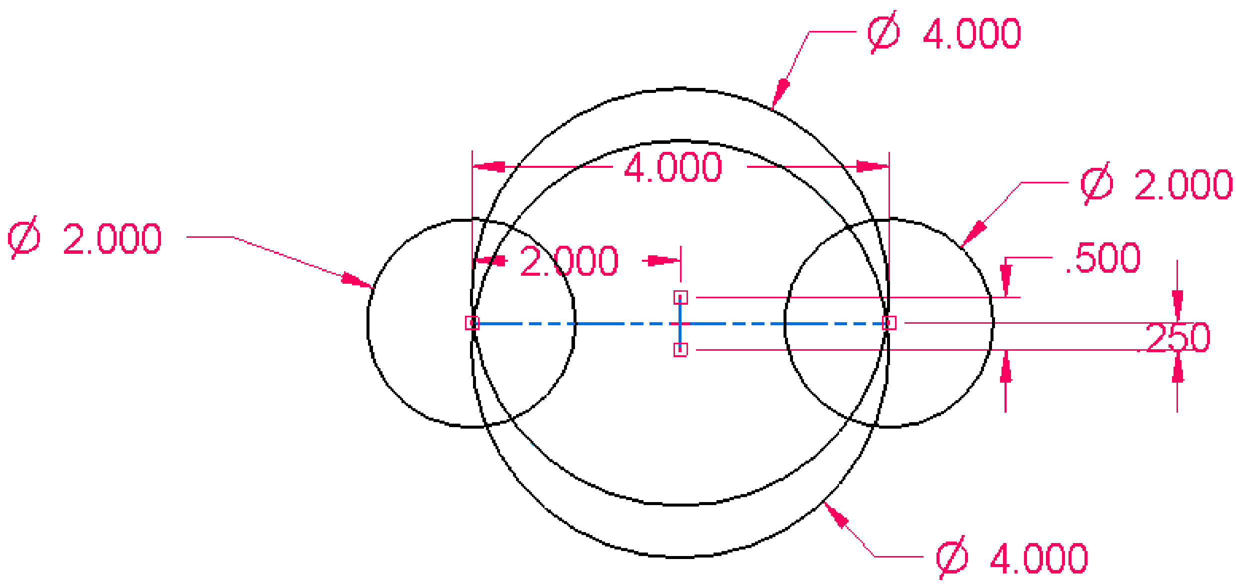
Select the Circle tool from the Draw section of the ribbon.

In the dialog box enter 2 for the radius of the circle. Click on each end of the vertical line to place the circle at the above and below the line. They will overlap. Hit the escape key to exit the circle command.

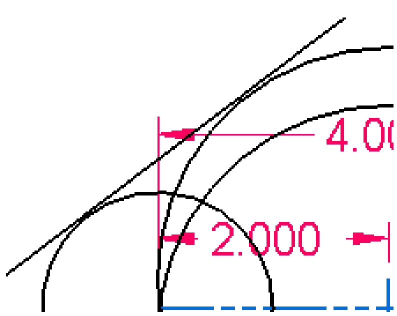
Repeat the process using the radius of one inch to place the circles at each end of the horizontal line.



Use the smart dimension tool to add dimensions to each circle. This will prevent them from changing size later.

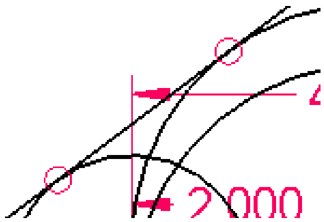


We now create a line that is tangent to each circle. Select the line command. Sketch a line from the circle on the left to the top circle. Don't worry if the line isn't tangent. We will add that relationship to be sure it is what we want.

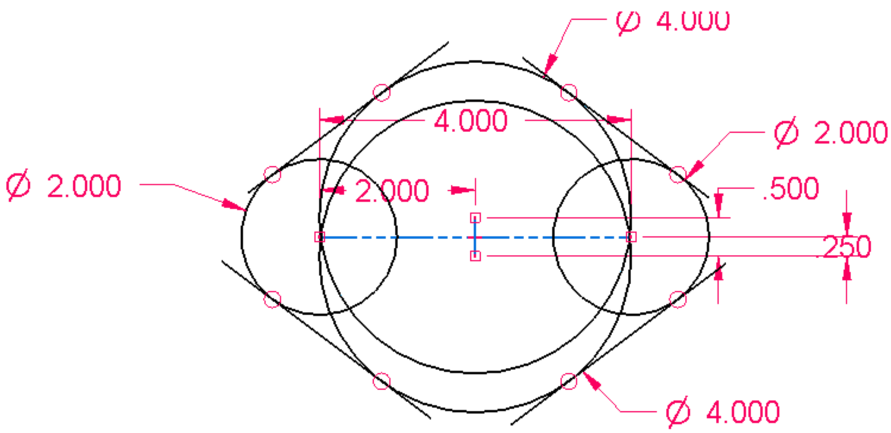


From the Relate section of the ribbon highlight the Tangent relationship.

Select the line and then the circle on the left. Then select the line and the top circle. The line might not move much but it will show the tangent handle.

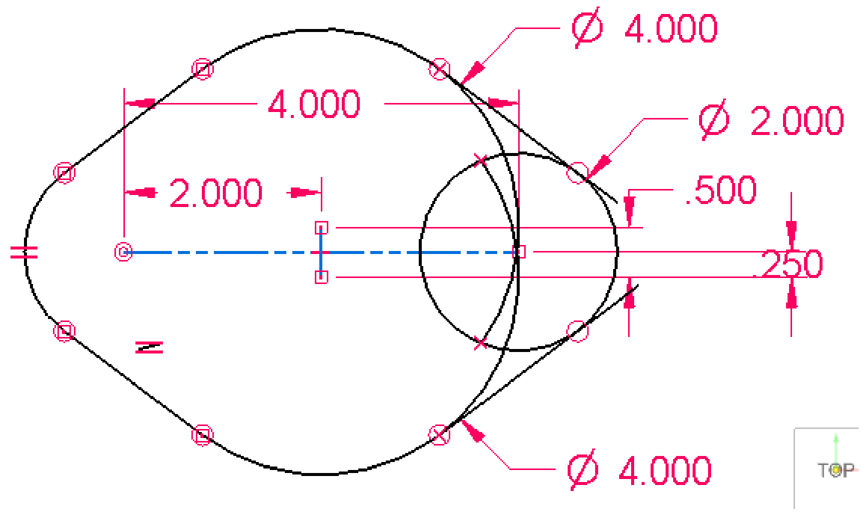


Repeat the process for each line and circle.

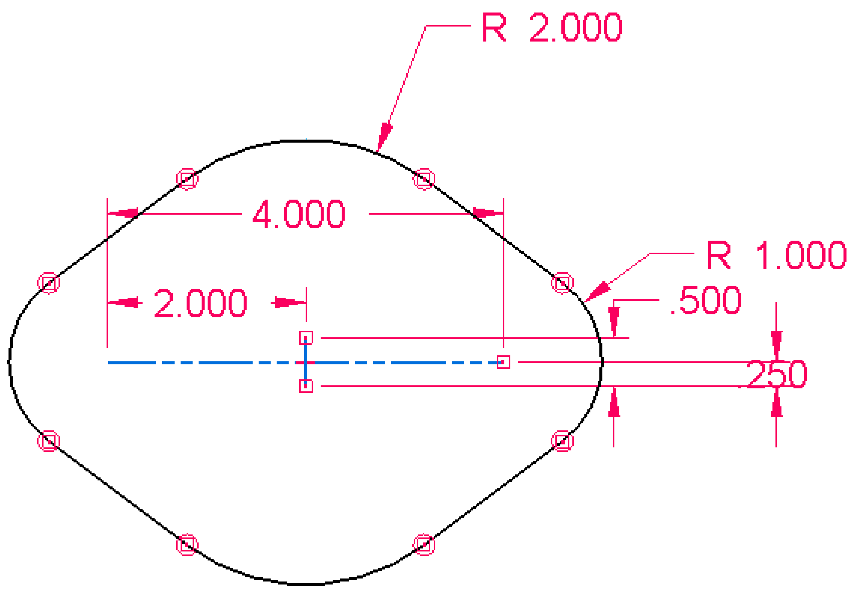


Now use the trim command found in the draw section of the ribbon.

Select the parts of the geometry not needed. Use the Ctrl Z combination as a shortcut for Undo if necessary.



The finished sketch should resemble the one below.



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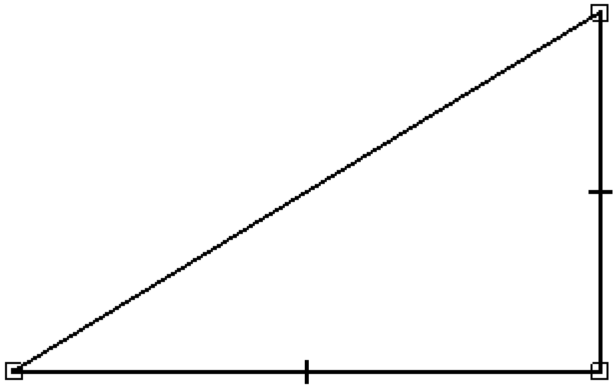
Creating and Printing a Triangle

There are numerous ways to approach modeling. Some will take more time, but there is no one correct way.

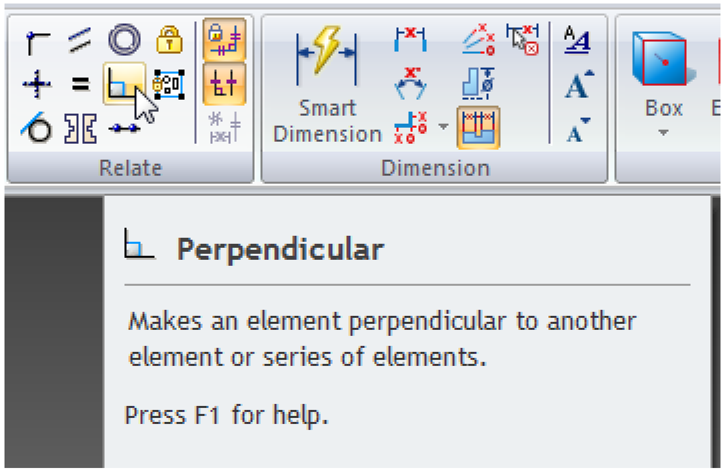
Creating a 3D model involves the creation of solids by adding mass or subtracting mass. The model will only be as accurate as the sketch. Sometimes you will need to create multiple sketches to create objects. This example creates a single sketch to accomplish the entire extrusion all at once. This approach requires more time in sketch mode and complicates the initial sketch.

Creating the shape

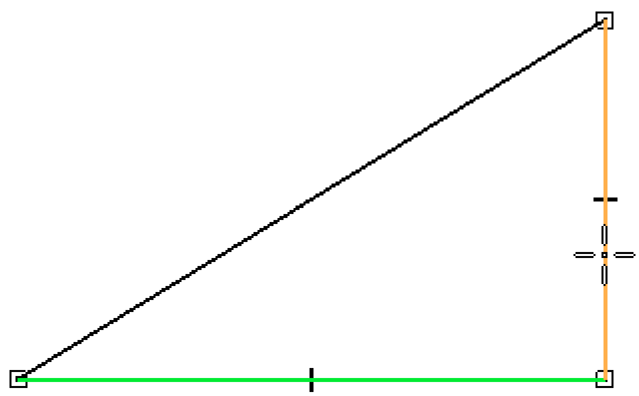
In Solid Edge create the triangle shape.



It is important to constrain the shape to the exact size and shape of a 30-60-90 triangle. Constraints consist of geometric relationships and dimensions. One approach is to begin with geometric relationships. In this case we know one angle must be 90 degrees. From the Relate section of the ribbon select the Perpendicular Constraint.



Highlight the vertical line and then the horizontal line.

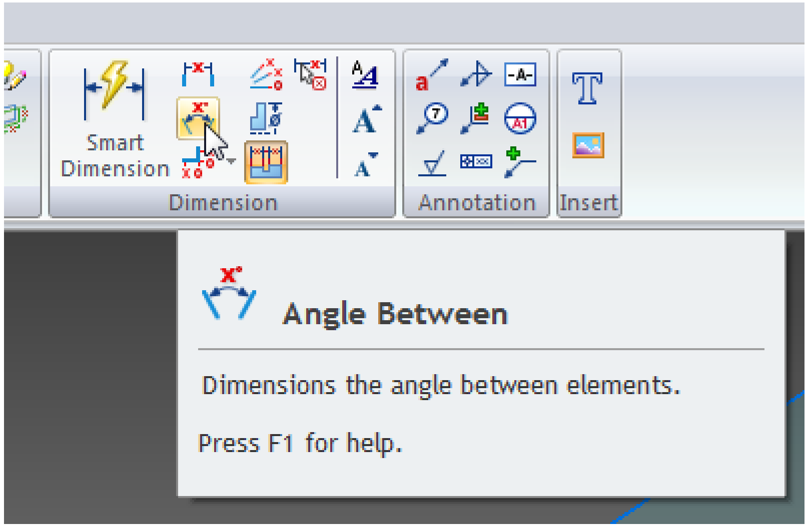


This will add a constraint symbol of perpendicular in the corner.

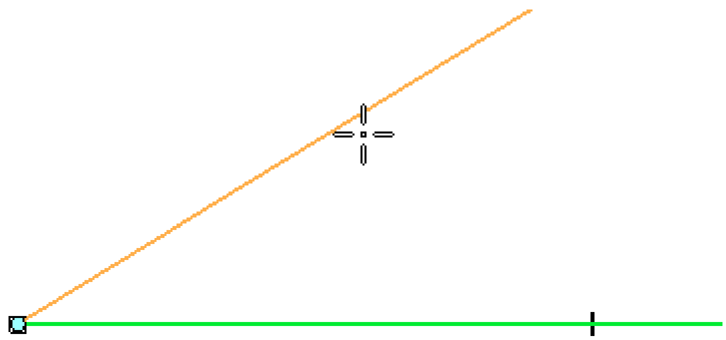
In this case it is a 30-60-90 degree triangle so now apply dimensional constraints. Similar triangles have equal measure angles. So in this instance begin by adding a dimension of 30 degrees to one angle.

Adding Dimensions

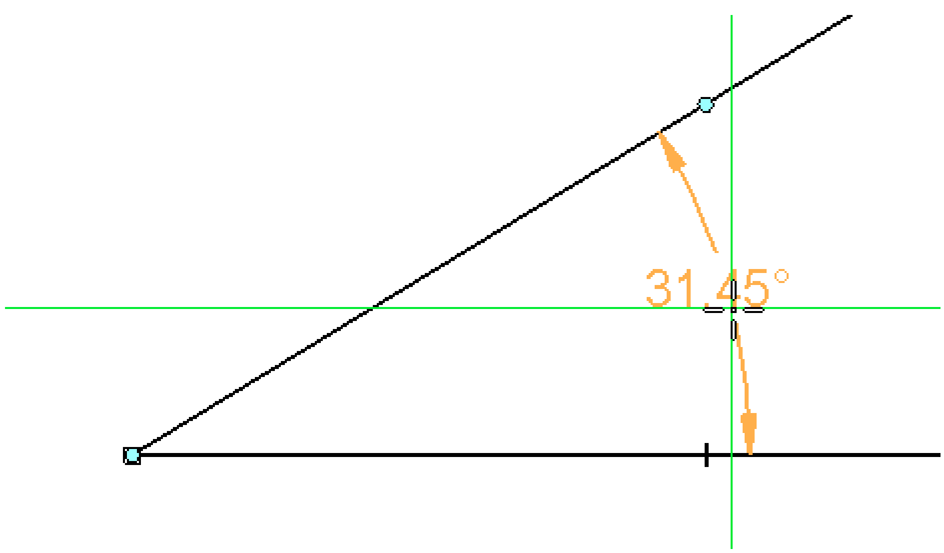
From the Dimension section of the ribbon, select the icon for Angle Between.



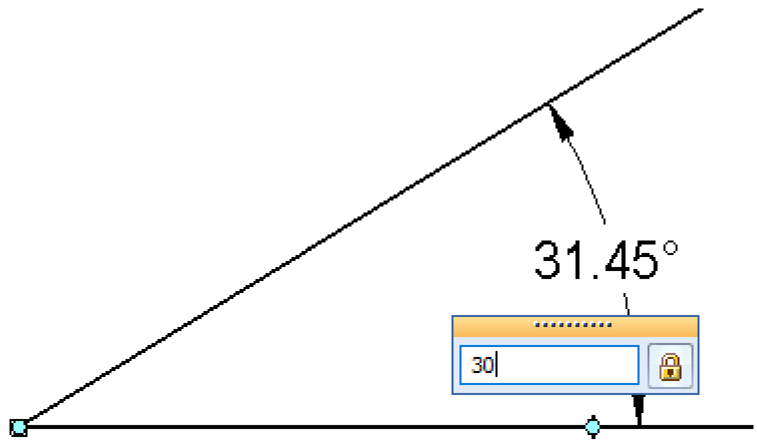
Select the base and the hypotenuse for the two lines.



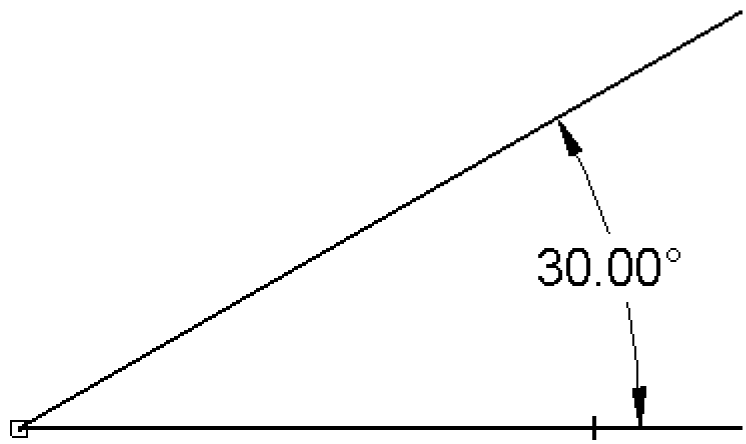
Click between the lines to place the dimension.



Select the area by the angle to get the window to enter the angle desired. In this case it is 30 degrees so enter 30 in the box.



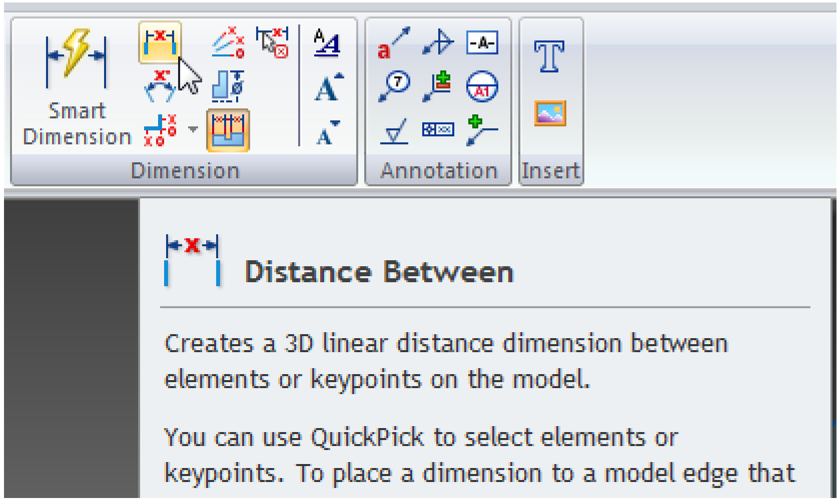
Hit the enter key and this will adjust the shape to provide the desired angle.



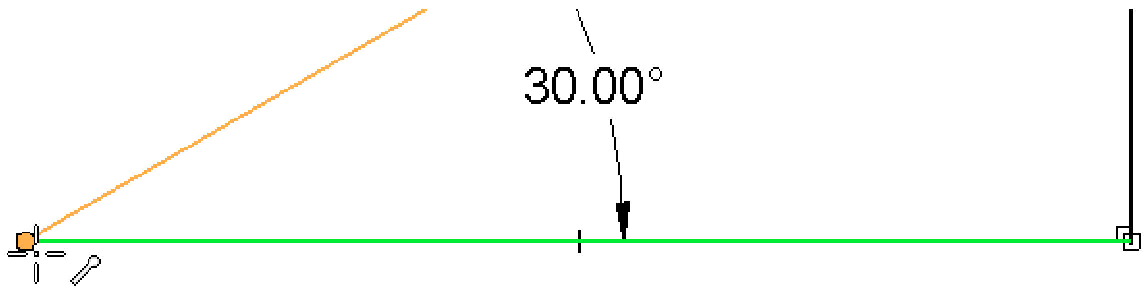
The triangle is now the desired shape. We can scale this up or down and it will always be a 30-60-90 triangle.

The next step is to add the dimension of the base so it is the correct size. Use 10 inches for the length of the base of the triangle.

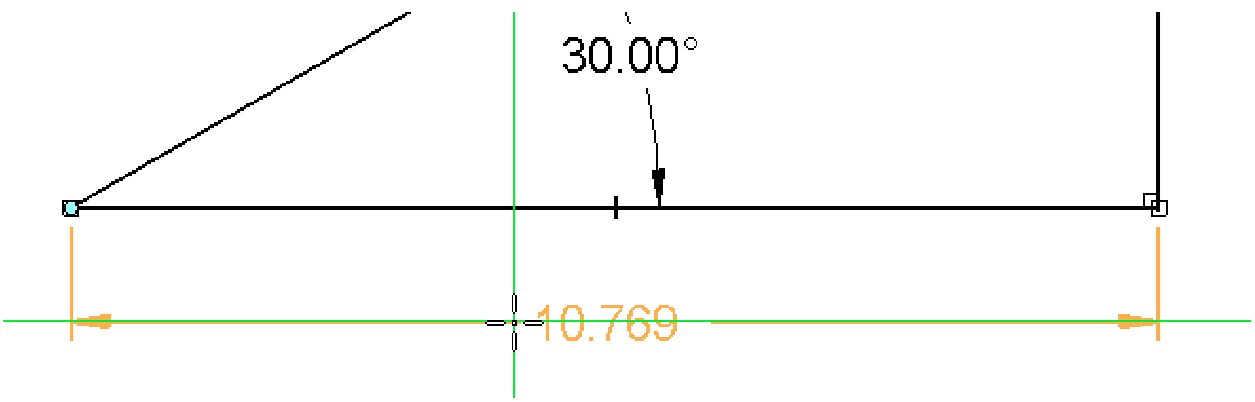
You could use the smart dimension icon or in this example we will select the icon for the Distance Between. This will allow us to pick the two points.



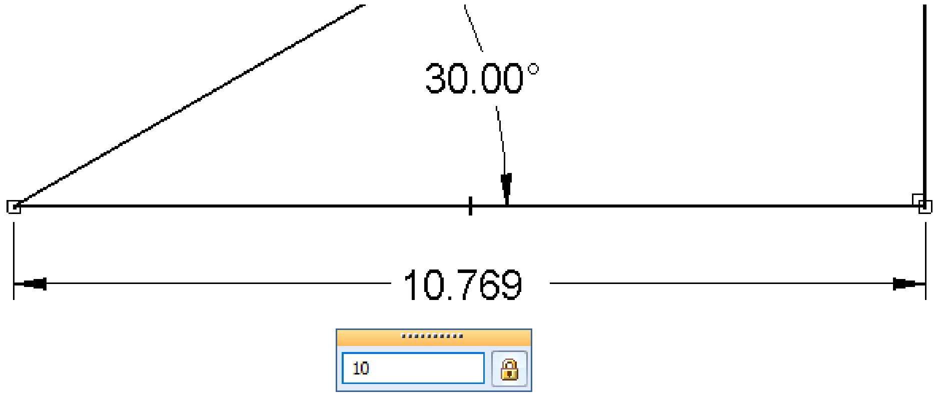
Select the end points of the line.



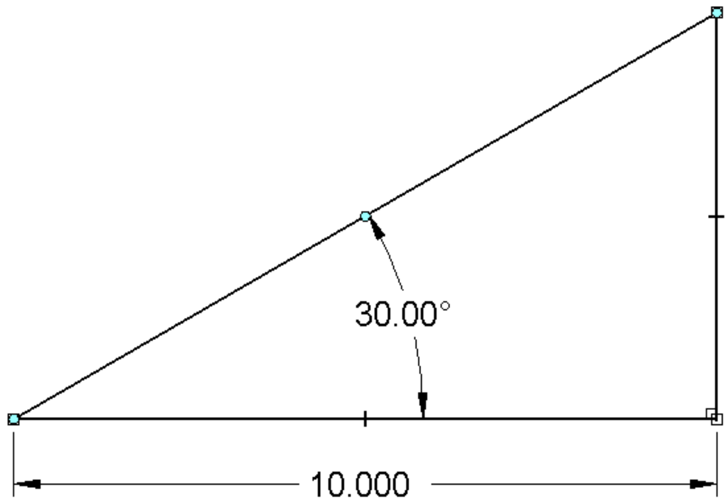
After selecting the second point, travel off the triangle to place the dimension.



Now enter the 10 inches.



Hit the enter key. This will fully constrain the triangle as defined.



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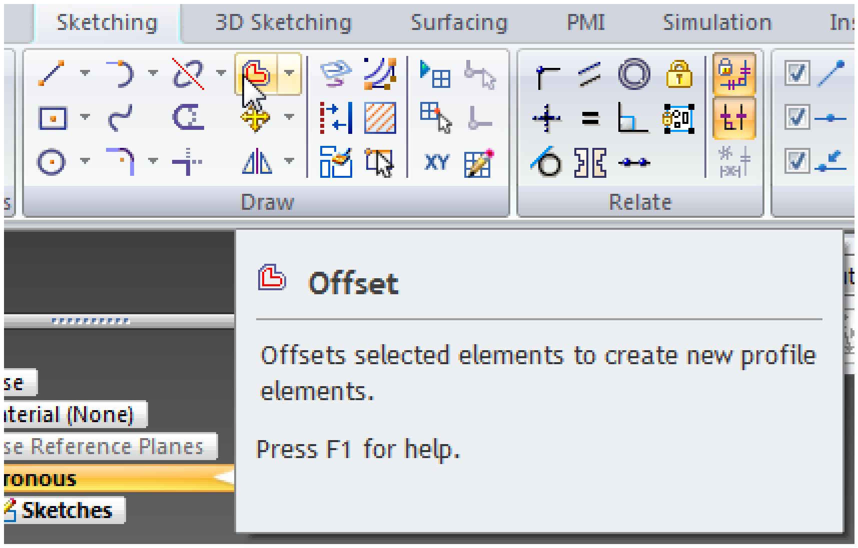
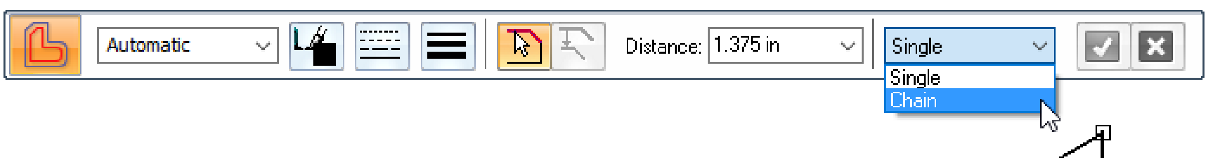
Offset

Looking at your triangle again we notice there is also an inner triangle.

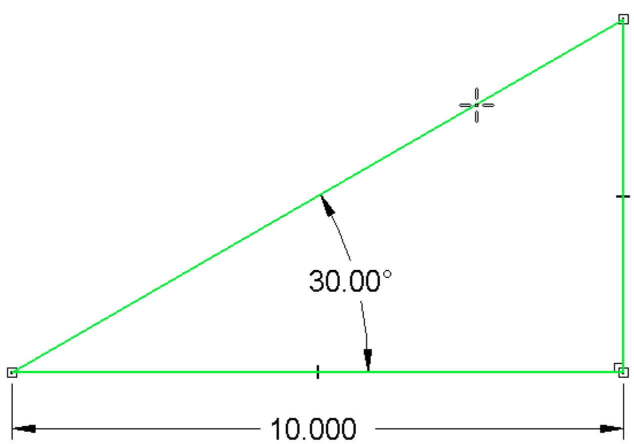
This triangle is similar to the large one. It has the same angle relationship but smaller sides. Measuring the distance we find the inner triangle is 1 3/8 inches from the outside edges. To begin creating this shape we can use Offset from the Draw ribbon.



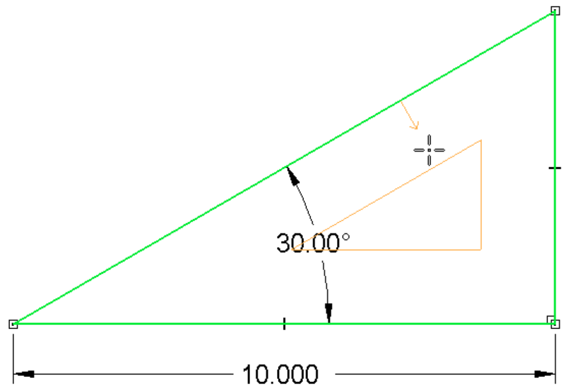
This brings up the Offset dialog box. In this case enter 1.375 in the distance window and Chain in the selection box.



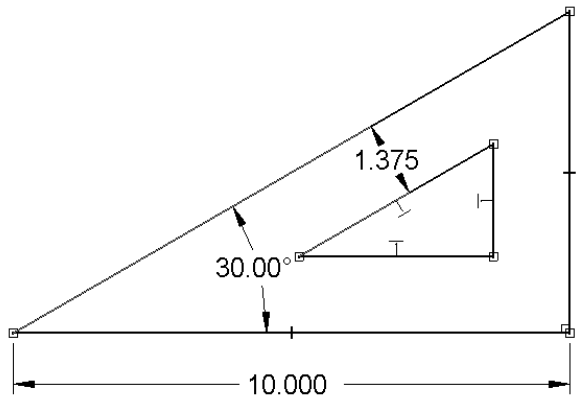
Next select any of the lines of the triangle. This selects all the sides at once. If the setting had been left on Single, the three lines would be selected individually.



Right click your mouse to let the program know you are finished selecting and then click inside the triangle to let the program know this is the side you want.



Once the triangle appears select the escape key to finish.



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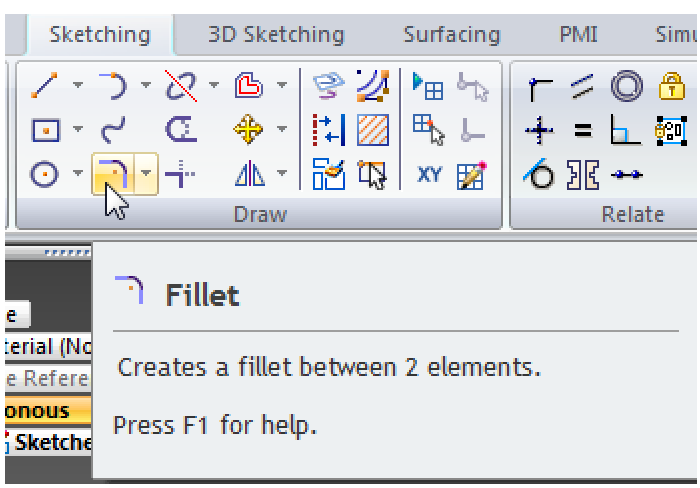
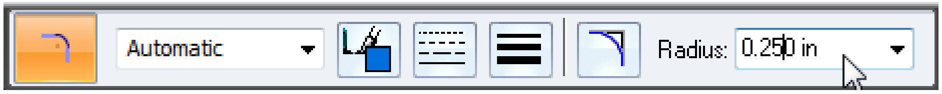
Adding Fillets

The corners of the inside triangle are rounded. Objects tend to break at sharp inside corners so we apply a feature known as a fillet.

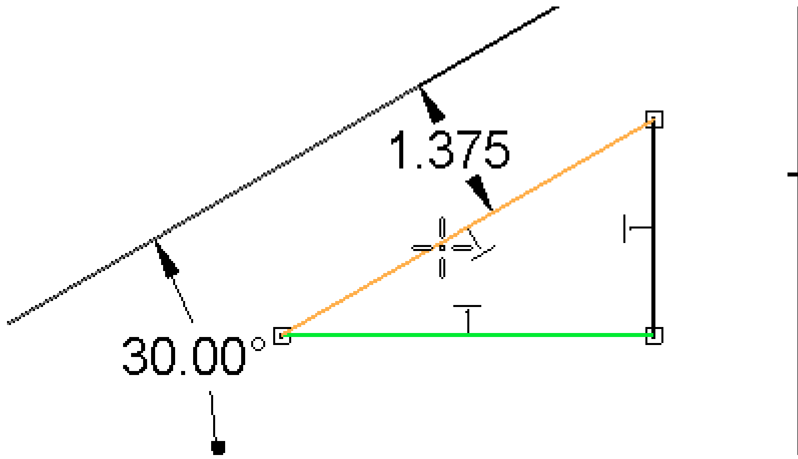
From the Draw toolbar select Fillet.



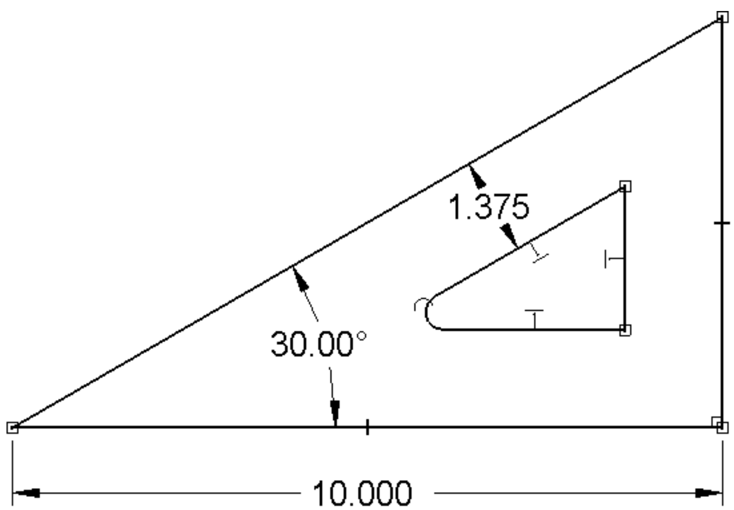
This will bring up the Fillet dialog box. Set the Radius to .250



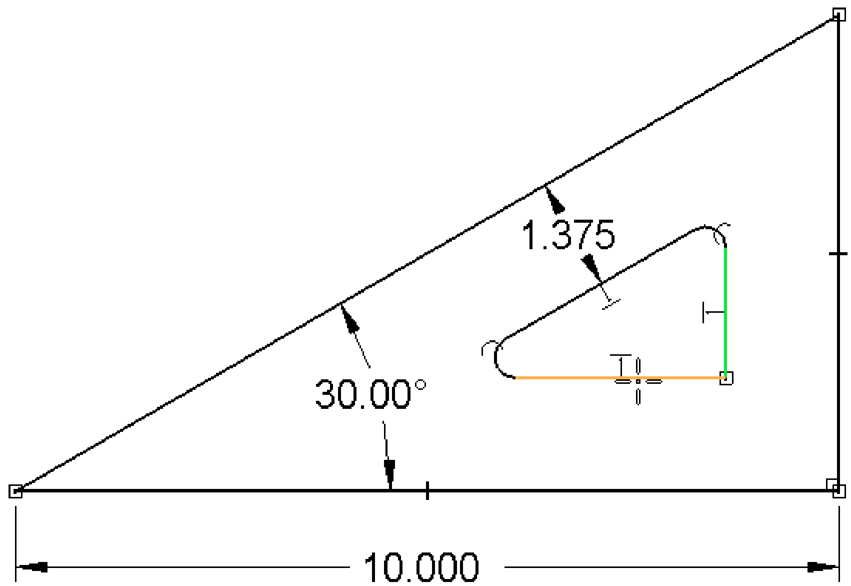
Now select the base line of the inner triangle. Try to stay twice the distance of the fillet away from the corner. It prevents some problems. After selecting the base of the inner triangle select the hypotenuse.



Once the hypotenuse is selected the fillet appears.



Select the hypotenuse in the middle and then select the opposite or height of the triangle. Repeat the process to add the third fillet.



Hit the escape key to exit the command.

We now have a fully constrained sketch.

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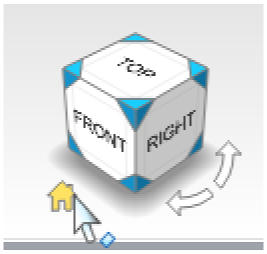
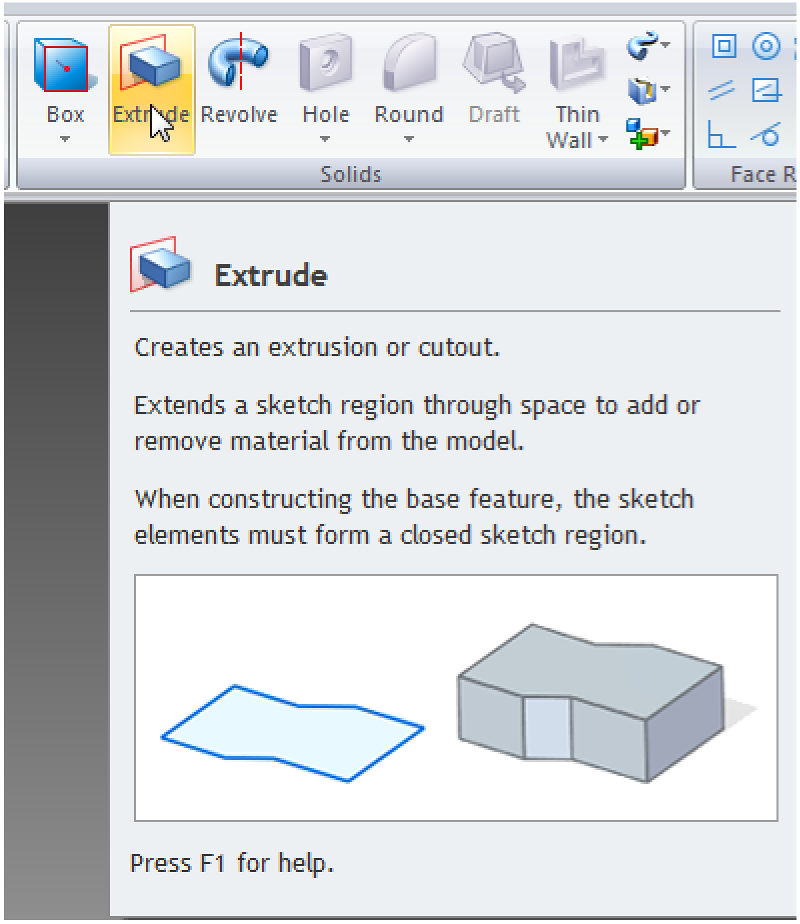
Extruding the Triangle

Enter the isometric view by selecting the home button on the quick view cube.

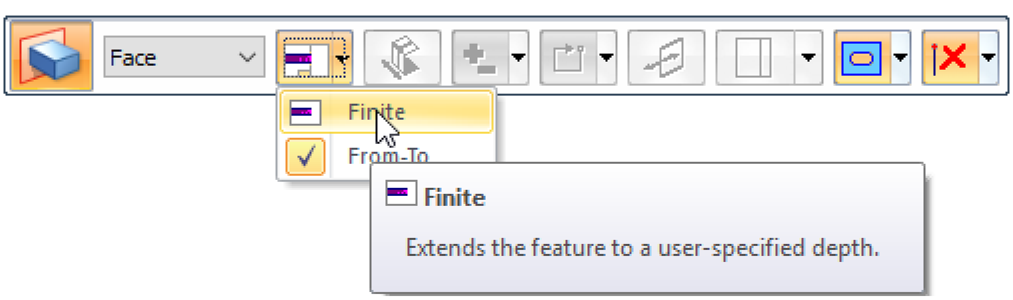


Select extrude from the Solids section of the ribbon.

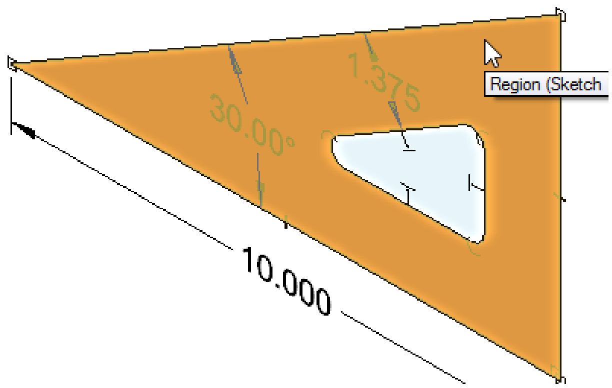


On the Extrude dialog box select Face for the selection option. This will allow you to select what you want with one click. If you used chain you would have to select both the outer and inner triangles, and single would require you to select every line and curve.

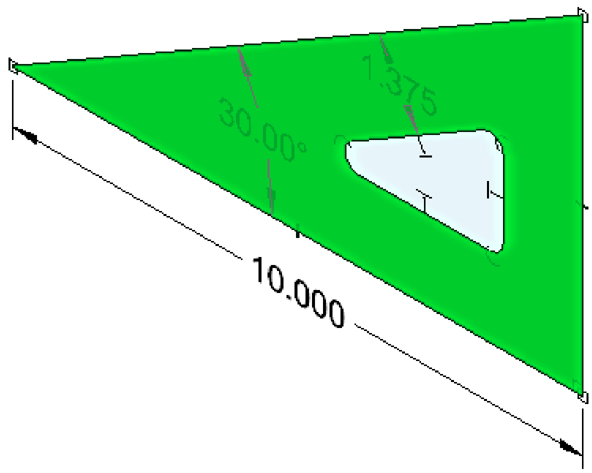
Then set the extrusion extents to Finite. This will allow you to enter a distance.



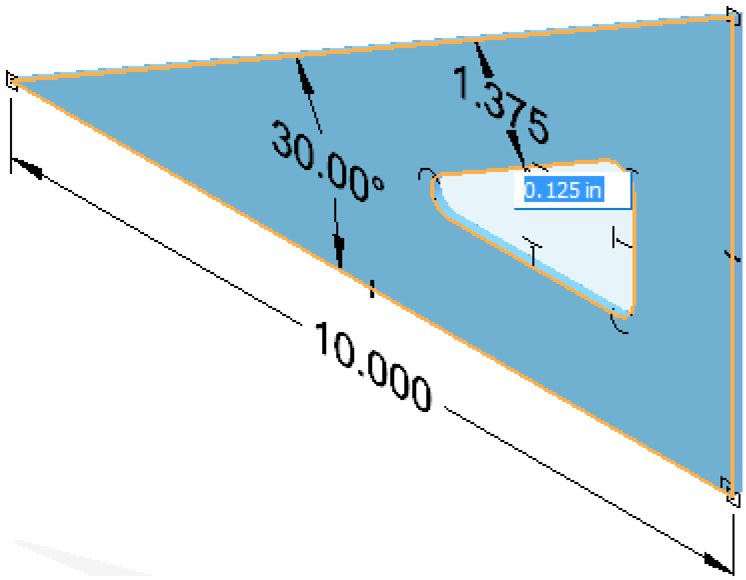
Now slide your mouse over the sketch. Select the desired shape by clicking on it.



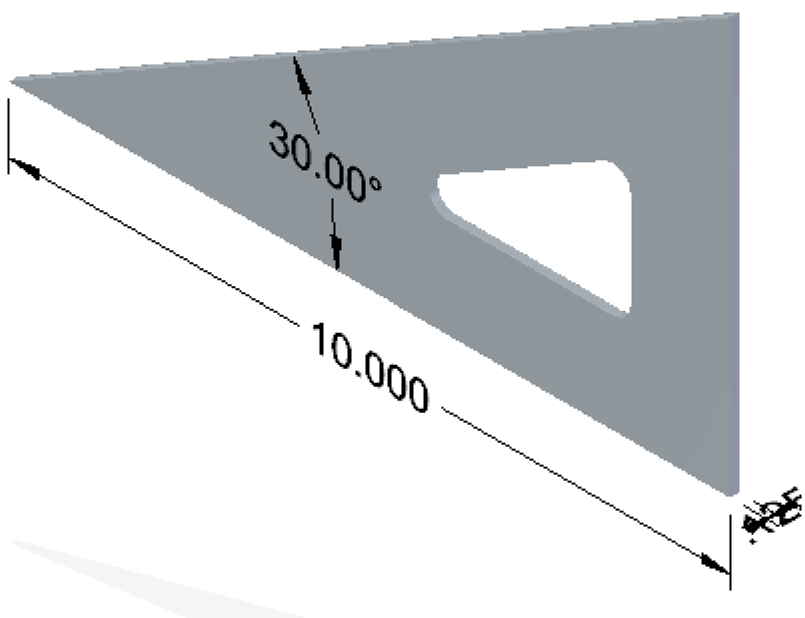
It will show your selection highlighted.



Right click to finish the selection and then enter in the desired z dimension. In this case it is .125

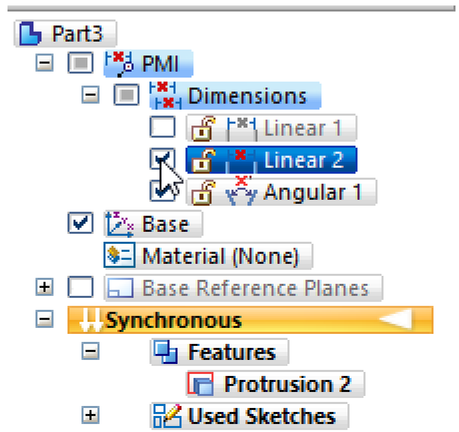


Hit the enter key and your model should look similar to the one below.

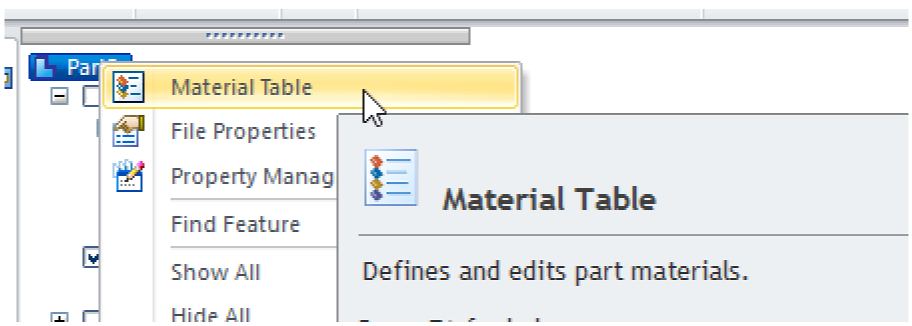


Double right click on a dimension

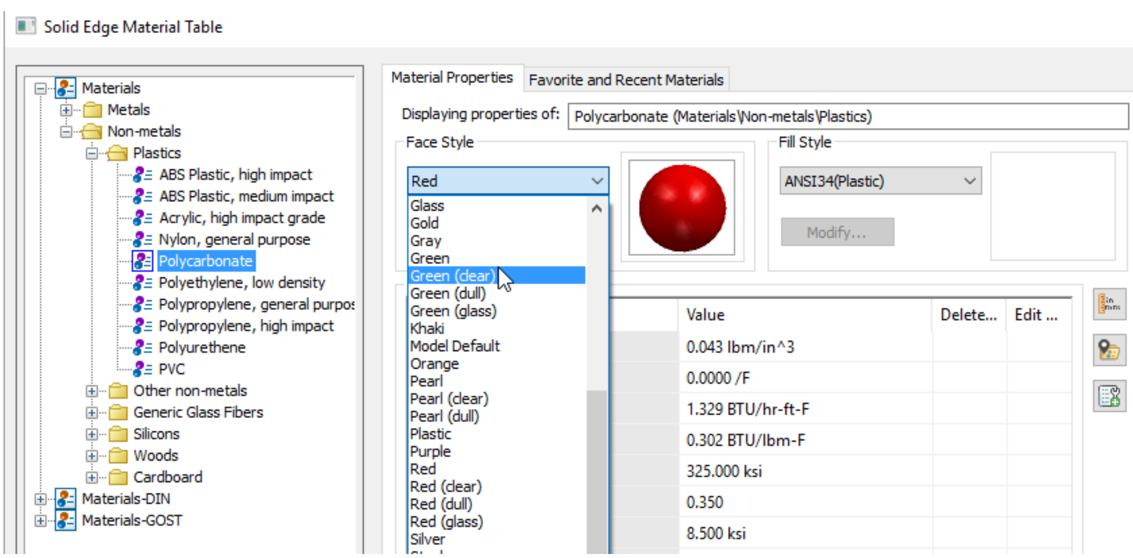
This will cause the dimensions to appear in the path finder at the right of the screen. Uncheck the dimensions to hide them from view.



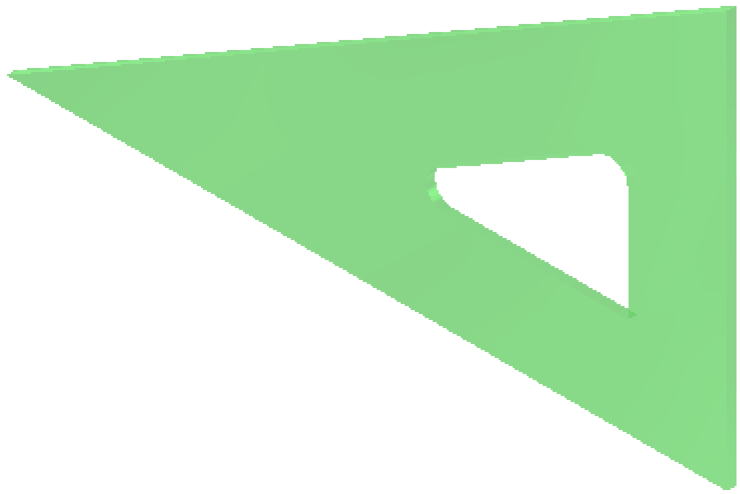
Right click on the Part name in the path finder. Select the option for Material Table.



This is a tool that will allow the selection of a specific material and color for the part. Expand the non-metals and then plastics. Select polycarbonate and then select a color from the face style section.



Select apply to model and save changes.



Personalizing your Triangle

Return to the front view of the triangle.

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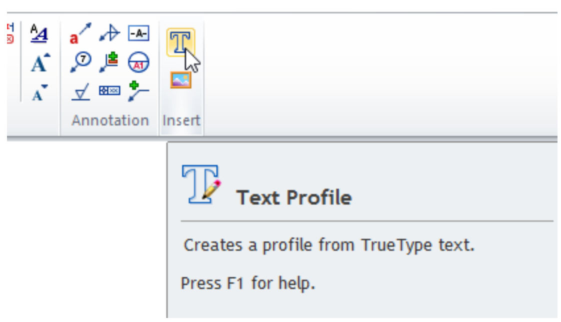
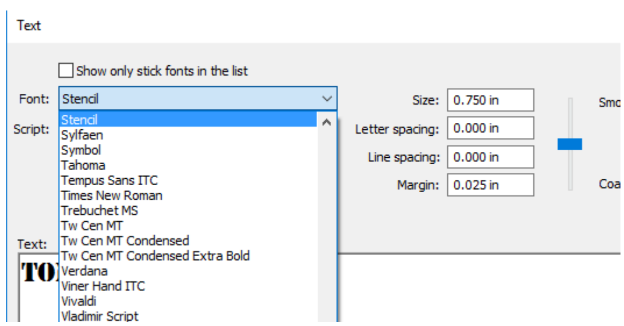
Adding Text

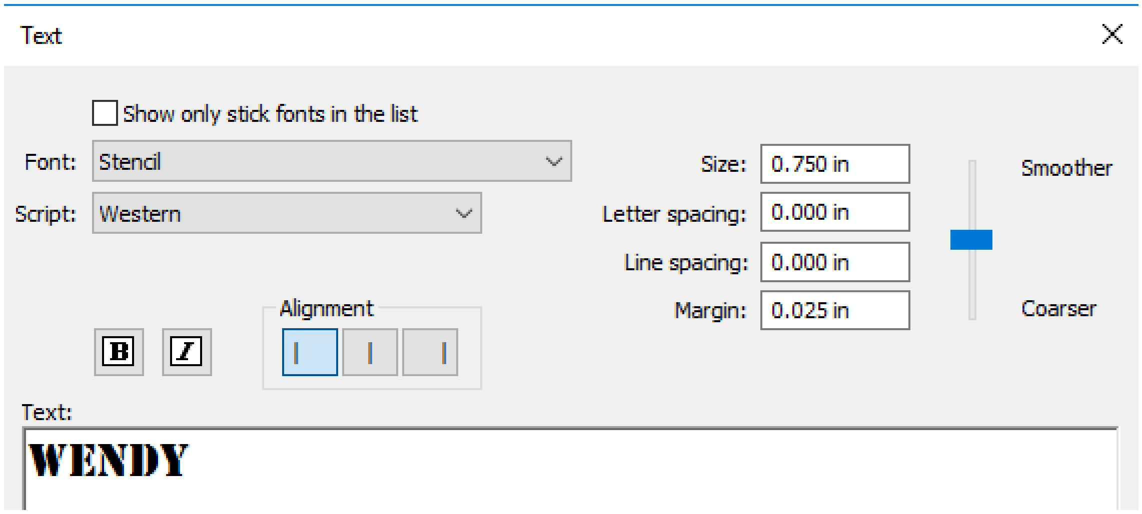
From the Insert section of the sketching ribbon select text profile.



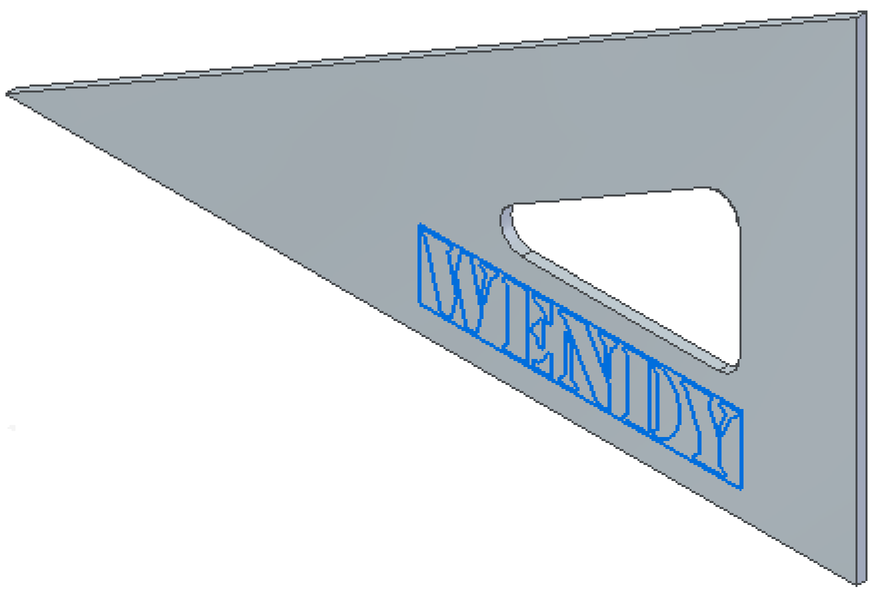
The text box opens. This example is using Stencil as the font. Size and other features of the text can be manipulated. When printing text there are a couple things to remember. Keep the font simple and make it larger than you think necessary.



The desired text is entered. In this case the text is the designer's name.

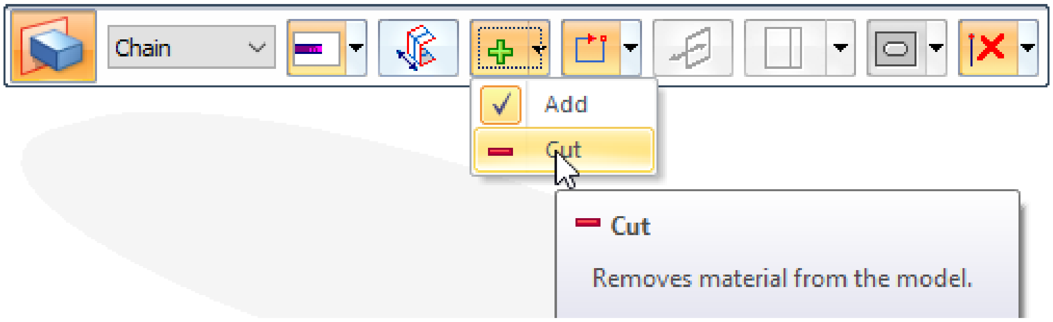


Select OK. The text will move with your mouse cursor. Use the (F3) key to lock into the desired plane. Left click to place the text.

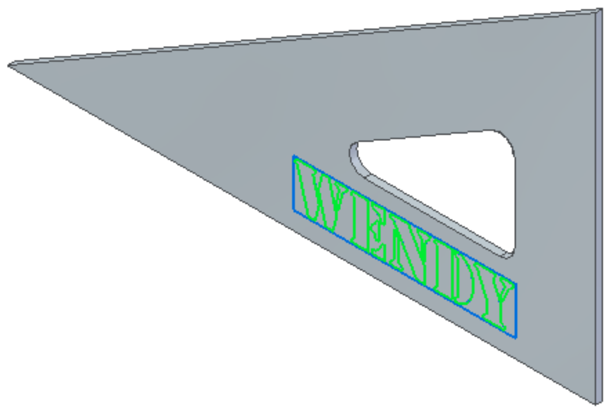


Place your triangle back into 3D by selecting the home icon of the quick view cube. Select the extrude command from the solids section of the main ribbon.

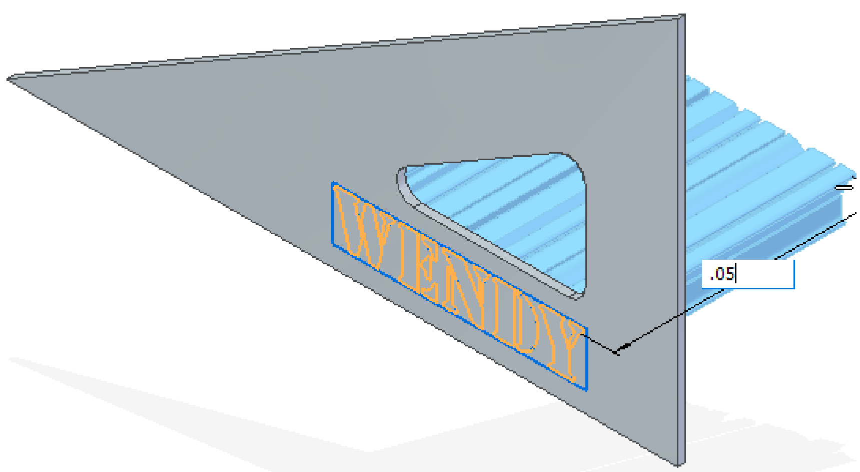
Change the settings to Chain for a selection and then change the method to cut if you want the text indented into the triangle instead of being raised.



Click on the text and it should highlight.



Right click to end the picking. Use a distance of .05



Save your file.

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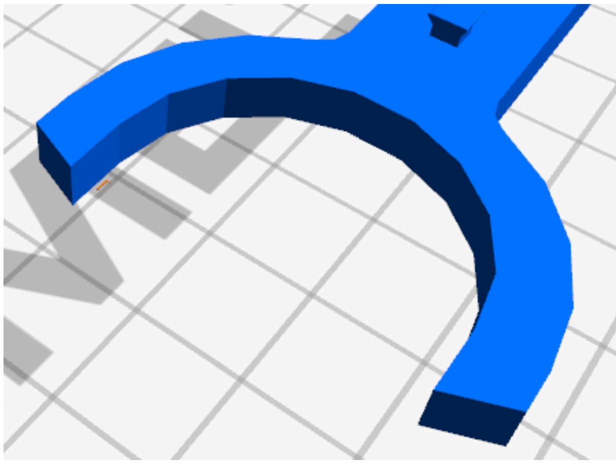
Exporting Data to the Printer

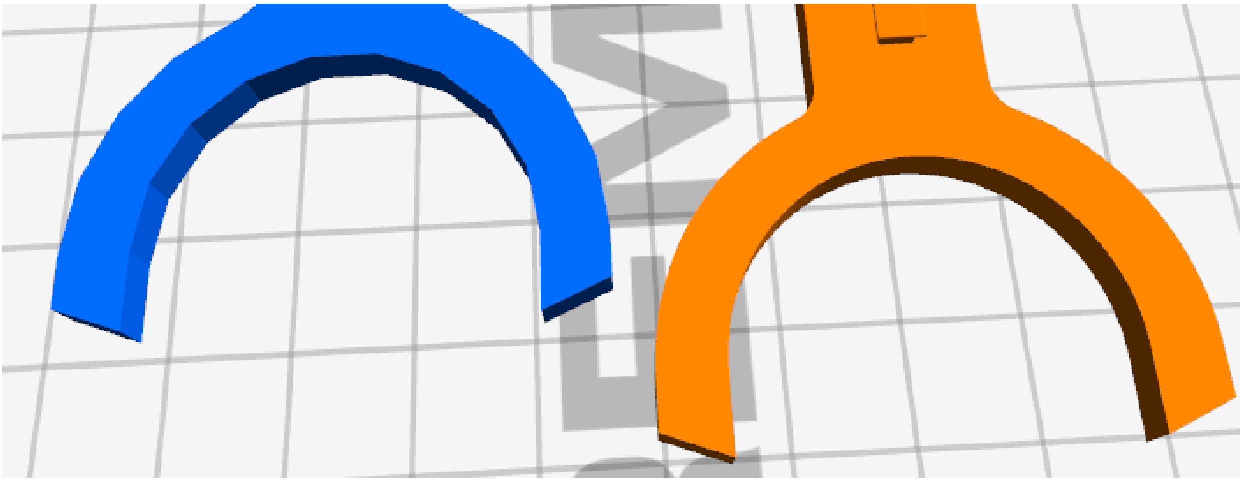
Transfer the data from the solid to a format read by the slicing programs available for 3D printers. Many companies have a proprietary slicing program but they all work by taking a solid object and slicing it into layers. The layers are then printed one upon the next until the entire shape is visible. Decisions are made pertaining to how thick each layer will be and whether the layers are solid or honeycombed. In addition a decision is made regarding the most efficient orientation of the part before printing. Scaling the part and assuring the part is actually located on the bed is another function handled by the slicing programs. In the example that follows a printer from the Dremel line is used but the printers all will behave similarly.

When the design of the part is finished, it will be necessary to export the data in a format that contains the information. The most common format is the STL file. The STL file stores the information. 25 years ago 3D printers were incredibly expensive. One popular format was the Stereo Lithography printers. A LASER was used to sinter or cure the resin with head generated by the laser one layer at a time. The plastic was almost $1,000 a quart. Some think STL was short for the Stereo Lithography printers. The image below was from a file printed on a Stereo Lithography printer.

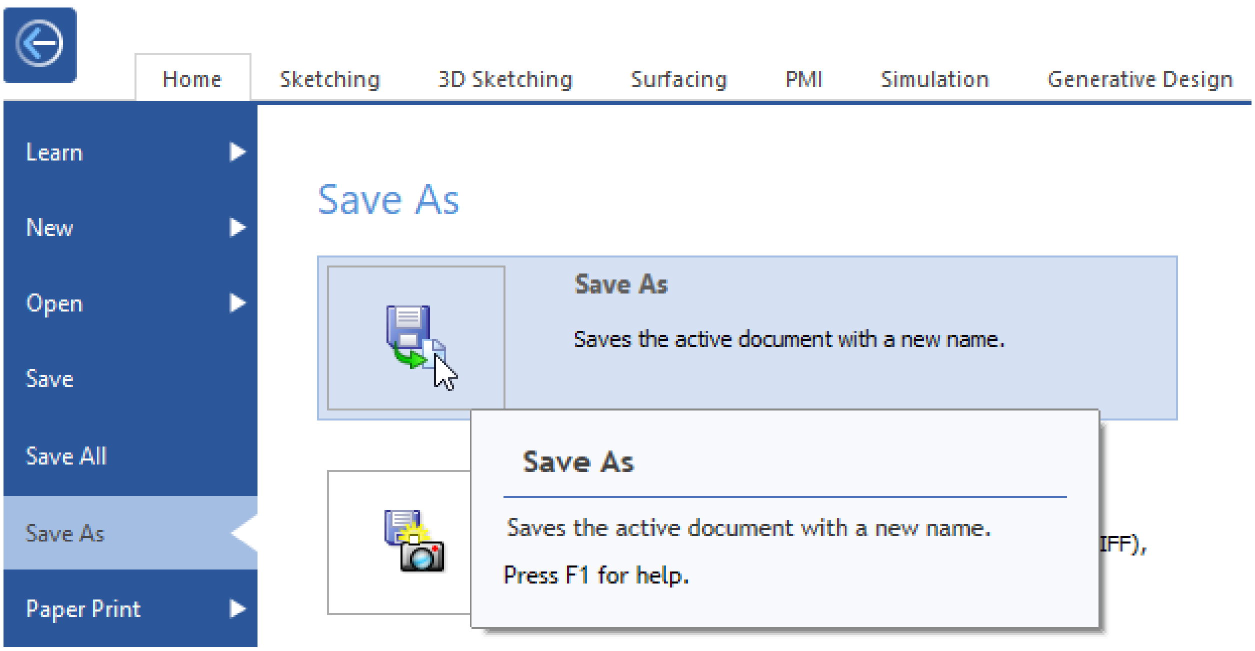
The process involved importing information from CAD programs. These programs exported the data in terms of surfaces in a process of tessellation. The data about the surface was exported in connected triangles. Today some describe the STL file as the Standard Triangle Language. When the file is saved, the data is stored in the format requested and in the resolution requested. The resolution has a big effect on printing. If you think of a wheel being broken into triangles, you come to the conclusion that a triangular representation of the wheel will have a series of chords that form the outer surface of the wheel. The export settings can make chords smaller if higher resolution is set. The picture below was exported with low resolution. You can see the chords on the curves. Keeping the file size small means the curves are sacrificed.

.

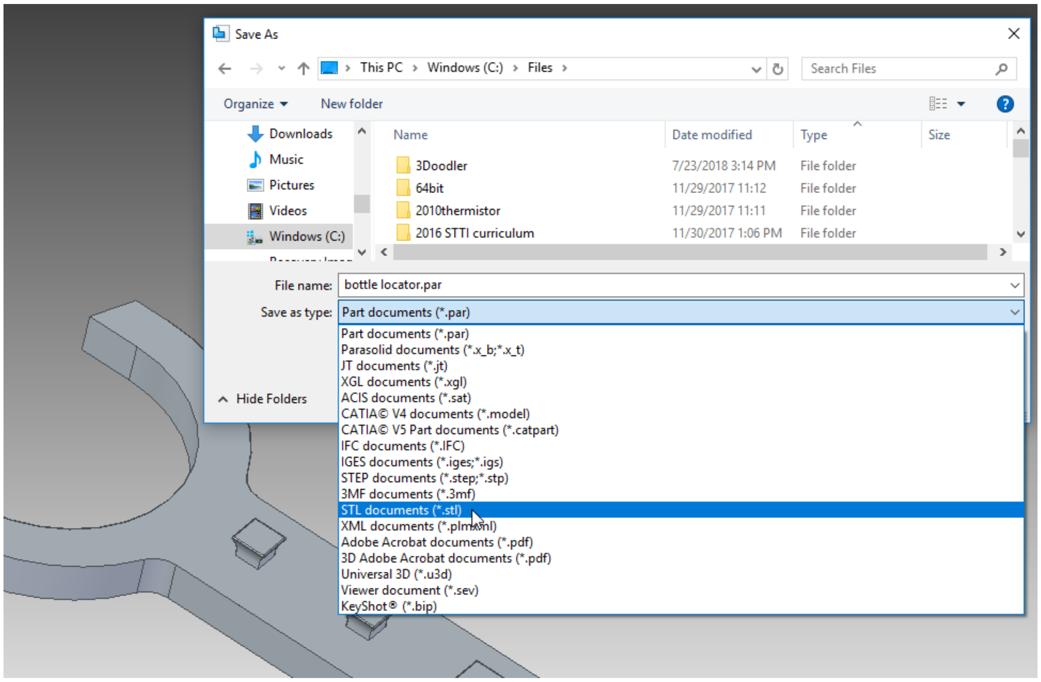
With a really fine resolution, the curves will be smooth but the file size will be quite large. In the picture below the part on the right was exported with finer detail at higher resolution. The curve is much smoother. The file size was 15 times the size of the original.



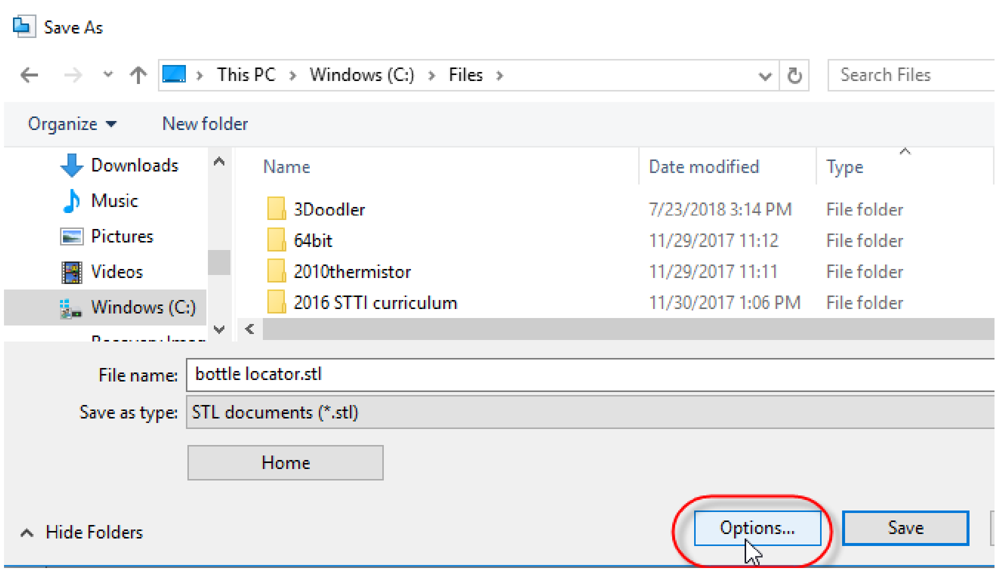
Exporting a file from a CAD program such as Solid Edge is a simple process. Once the part is finished select Save As from the application button at the top left of the user interface.



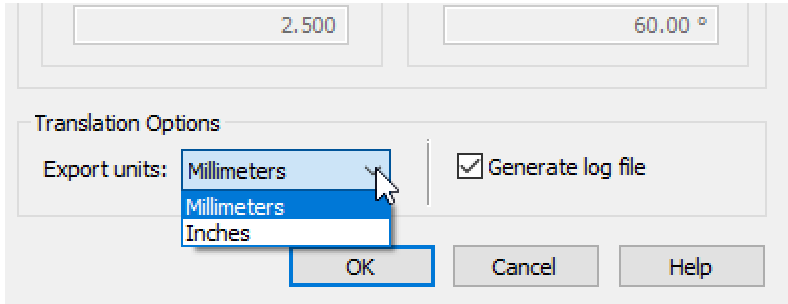
Once the Save As dialog box opens, select the option for STL from the save as type section.



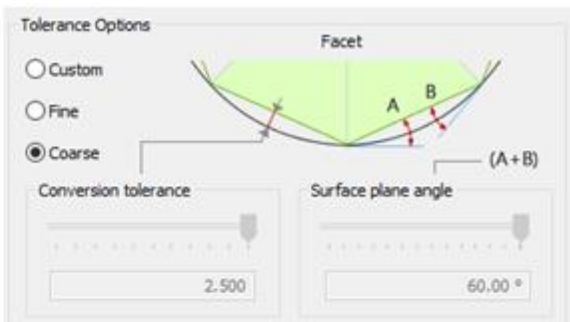
Look for the options menu. It will be located next to the Save and Cancel buttons at the bottom of the dialog box.

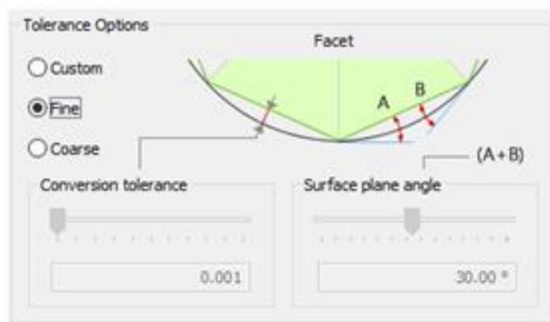


This will bring up the export options for the STL file. If the part was drawn in inches and the printer reads mm then it will be necessary to change the export units at the bottom of the dialog box.

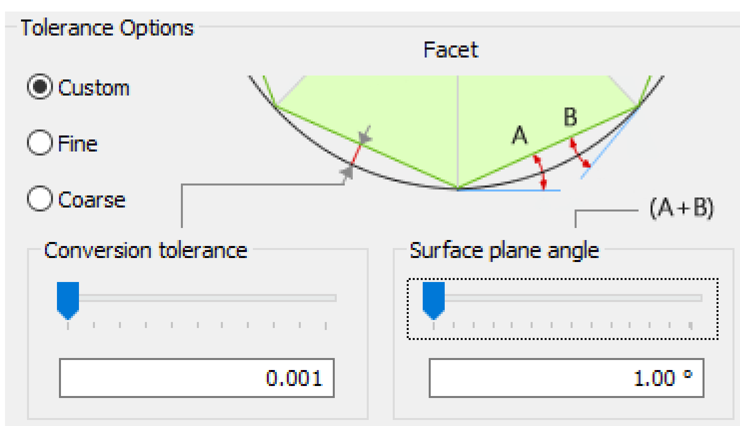


To adjust the resolution, use the Tolerance Options section of the dialog box. The two images below show the difference between course and fine settings for Conversion tolerance and Surface plane angles. These are preset but will give you an idea of the differences.





Notice the surface plane angle on Coarse is 60º while the Fine setting is 30º. By entering the Custom area you can enter in a smaller angle if needed.



When satisfied with the tolerance options and the settings match your printer, select the OK button at the bottom of the dialog box.

Slicing Program

Transfer the data from the solid to a format read by the slicing programs available for 3D printers. Many companies have a proprietary slicing program but they all work by taking a solid object and slicing it into layers. The layers are then printed one upon the next until the entire shape is visible. Decisions are made pertaining to how thick each layer will be and whether the layers are solid or honeycombed. In addition a decision is made regarding the most efficient orientation of the part before printing. Scaling the part and assuring the part is actually located on the bed is another function handled by the slicing programs. In the example that follows, a printer from the Dremel line is used but the printers will all behave similarly.

3D printers are CNC (computer numeric control) machines. Each layer is defined. The NC file contains G&M code used by CNC machines. Each combination of letters and numbers provides control information to the brain of the printer. This file tells it where to move the printer head, the temperature needed, and how much plastic to extrude. The picture below is an example of the code slicing programs produce.

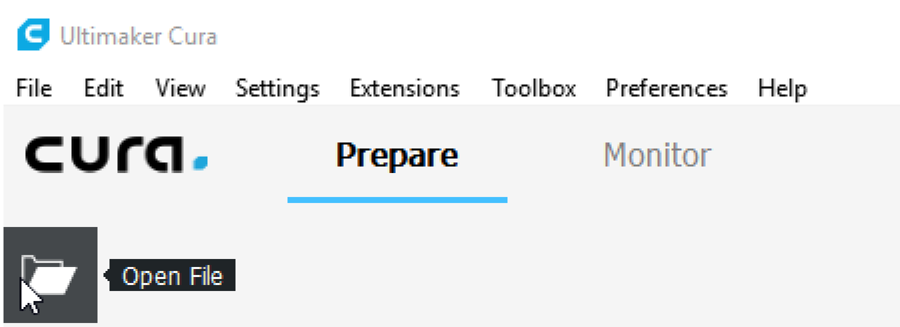
```
L▯M104 S220 T0G90G28M132 X Y Z AG1 Z100 F3300G1 X-110.5 Y-74 F6000M6 T0M106M907 X100 Y100 Z40 A80G1 Z0.6
F3300G4 P2000M108 T0G1 F1200.000 E-1.50000G1 Z0.300 F7200.000G1 X16.691 Y12.810 F7200.000G1 E0.00000
F1200.000G1 X15.881 Y13.810 E0.08942 F1200G1 X15.091 Y14.680 E0.17107G1 X14.171 Y15.570 E0.26001G1 X13.461
Y16.190 E0.32550G1 X12.441 Y16.980 E0.41514G1 X11.221 Y17.810 E0.51767G1 X10.411 Y18.300 E0.58345G1 X9.041
Y19.010 E0.69066G1 X7.871 Y19.530 E0.77962G1 X6.991 Y19.860 E0.84493G1 X5.811 Y20.230 E0.93085G1 X5.131
Y20.410 E0.97973G1 X3.781 Y20.710 E1.07581G1 X3.111 Y20.820 E1.12299G1 X2.181 Y20.940 E1.18814G1 X0.901
Y21.030 E1.27730G1 X0.081 Y21.050 E1.33429G1 X-0.949 Y21.030 E1.40587G1 X-2.409 Y20.920 E1.50760G1 X-2.879
Y20.860 E1.54053G1 X-4.349 Y20.600 E1.64425G1 X-5.269 Y20.380 E1.70998G1 X-6.389 Y20.060 E1.79091G1 X-7.259
Y19.760 E1.85485G1 X-8.449 Y19.290 E1.94375G1 X-9.309 Y18.890 E2.00965G1 X-9.979 Y18.540 E2.06217G1 X-11.089
Y17.900 E2.15120G1 X-11.749 Y17.480 E2.20556G1 X-12.519 Y16.930 E2.27131G1 X-13.439 Y16.210 E2.35248G1 X-
14.169 Y15.580 E2.41948G1 X-15.039 Y14.740 E2.50350G1 X-15.689 Y14.050 E2.56937G1 X-16.519 Y13.060 E2.65913G1
X-16.879 Y12.600 E2.69972G1 X-17.759 Y11.320 E2.80765G1 X-18.249 Y10.510 E2.87342G1 X-18.699 Y9.700 E2.93781
```

What follows is an example of the process done with a slicing program called Cura. Other programs are available and work with great similarity to this one.

Setting up the Slicing Program

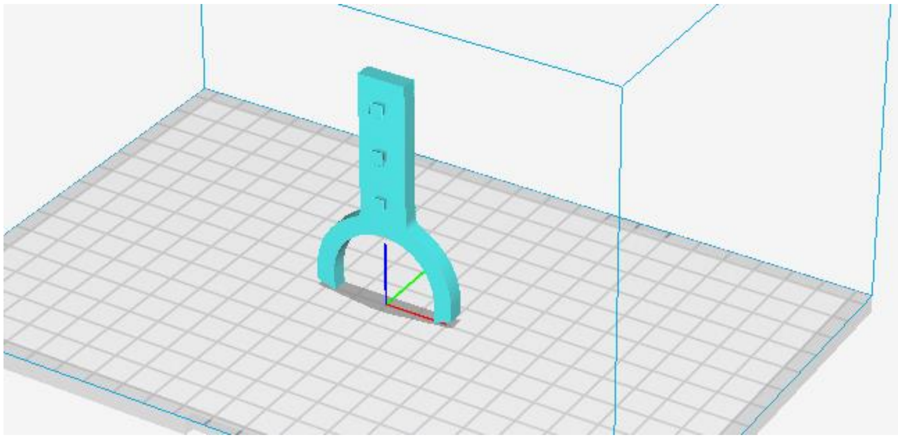
The procedure is similar with most slicing programs. The file is imported and then sized, scaled, and rotated to print the part the designer envisioned. When creating the part the actual size of the object was not a consideration for printing. If you wish to print a prototype it will be necessary to adjust the size in the slicing program.

Open Cura, the Slicing program.



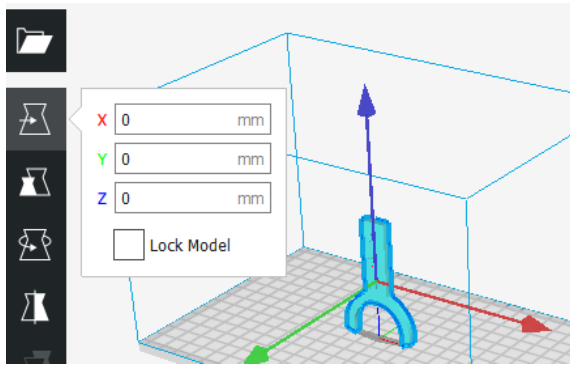
On the left side of the screen is the icon for Open File. Open the STL file you saved from Solid Edge.

This will import the file you created. It will display the build area and the file. You can see the file below on the build plate.

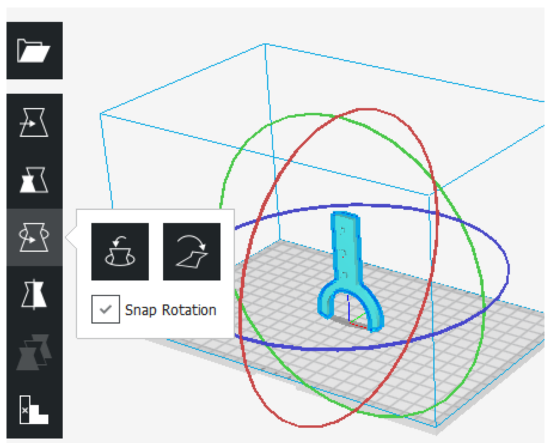


This might not be in the best orientation to print. There are the pins on one surface. The back is basically flat. The more contact with the base, the more stable the print is. If the level of the plate is not quite correct, the part might come loose from the build area. When that happens it might create quite a mess if not caught right away.

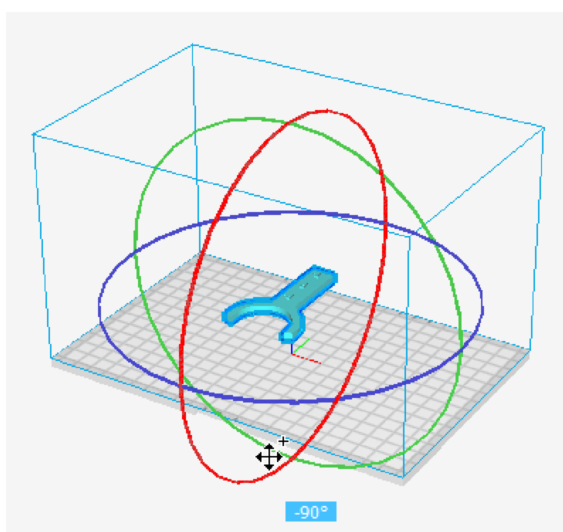
We can manipulate the model by using the tools on the left of the screen. The three major tools used to orient the part are the top 3. From the top they are Move, Scale, and Rotate.



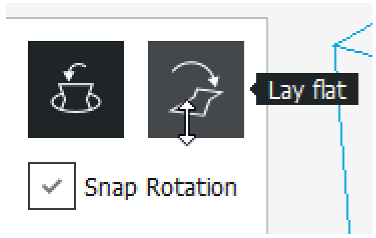
Since the model was exported in the correct size, it will not be necessary to scale the part to fit. It is important to have the part in the correct orientation for printing. Select the Rotation tool.



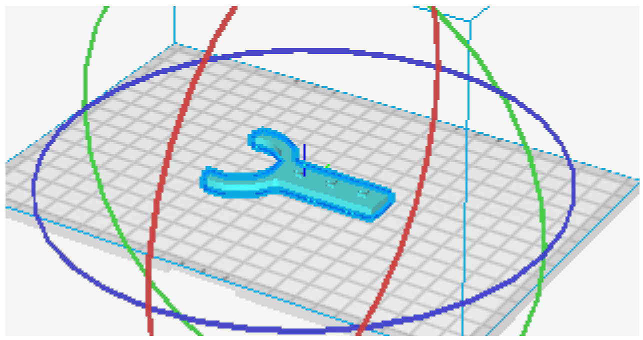
In this example we will rotate with the red rotational wheel. As you rotate with the snap rotation on you will see a report of degrees. In this example -90º is what we wanted.



Once you let go of the wheel the part will settle on the base. If this is close but not quite enough use the Lay flat tool.



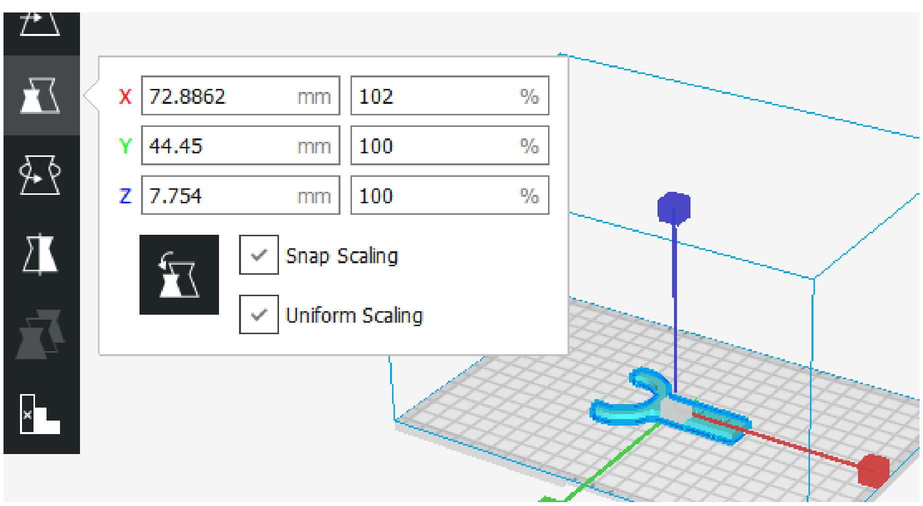
Continue rotating the part until it is in the orientation you want.



The scale and move tools are very intuitive. You can utilize them if you want.

For example, the pins on this one might not fit quite right. You could decide that if it was 2% larger, then the pins will lock into the slot the way your original design called for. Rather than returning to Solid Edge to redesign we can reprint using the Scale tool.

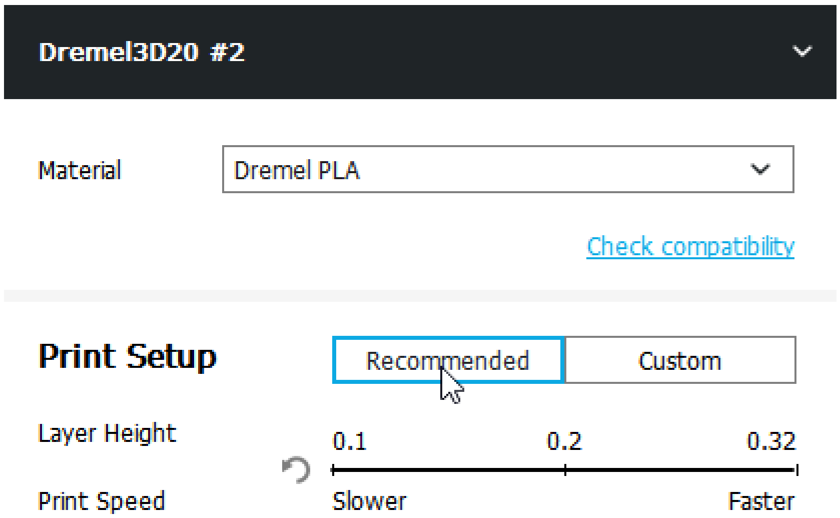
In this case you would utilize the scale tool. You could enter in the desired amount. With the uniform scaling checked it will scale all axis the same.



Rotate the view to be sure the part is on the plate. Holding the mouse wheel down and moving the mouse will pan the view. Holding the right mouse button down will allow you to rotate the view.

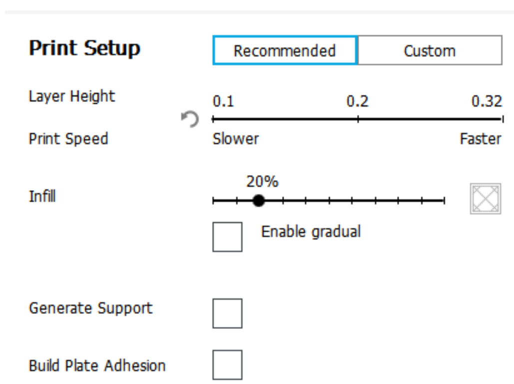
Print Setup

The next step requires the setup of the parameters for the printer. The fastest way to print is to select the Recommended settings in the print setup area.

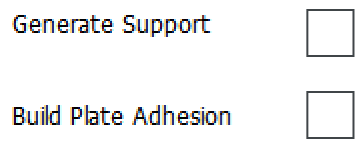


Slicing

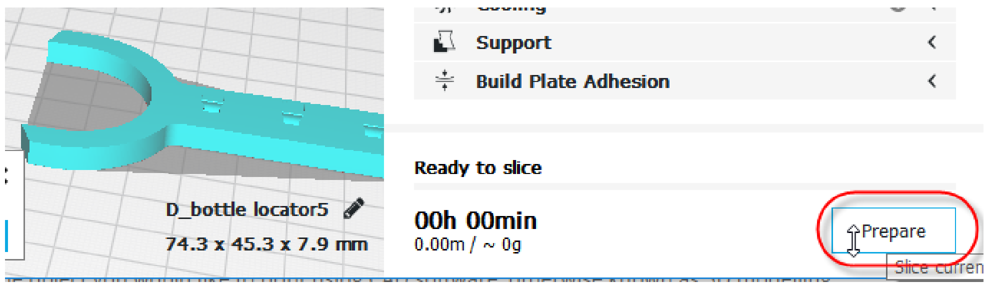
For this example, the recommended settings are used.



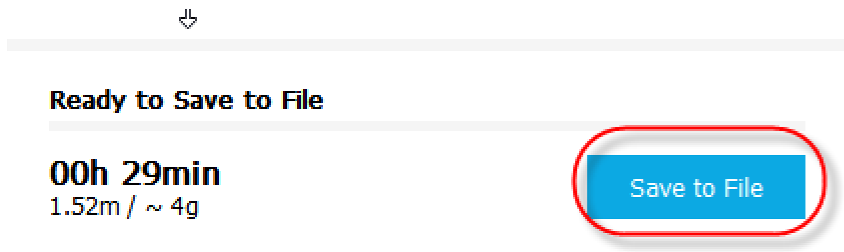
This plate fits well to the bed. If the part you are printing is smaller, you can check the icon for build plate adhesion. This prints a wide layer under the part. If your parts have overhangs or open area underneath you can check the box for generate support. This is a thin layer of material that is laid down to support structures above them. These are removed after printing, sometimes with needle nose or diagonal pliers.



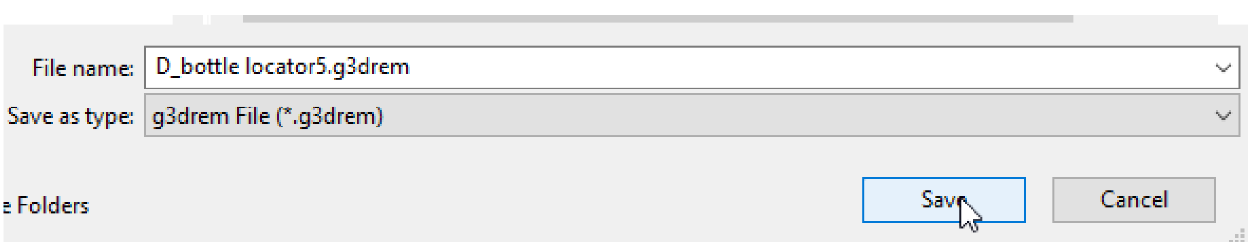
Select the Prepare button at the bottom of the screen.



Once prepare is selected the computer slices the object according to the parameters in the profile. It then presents a summary of the process. In this instance the program is reporting that it will take almost ½ hour to print and use about a meter and a half of filament. It will weight in the neighborhood of 4 grams. Select the option to Save to File.



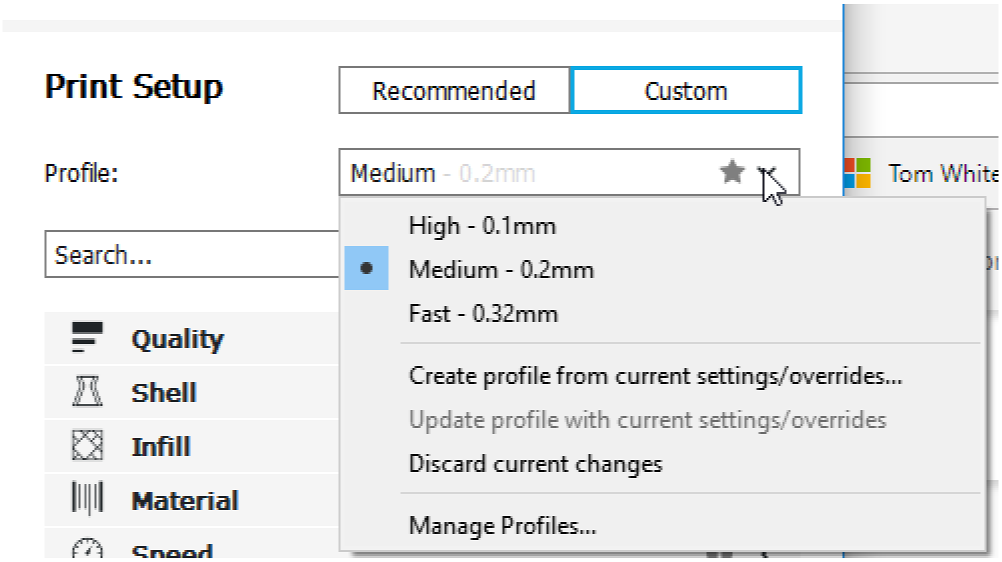
Save the file to a location you can find again later. In this case the printer is a Dremel 3D20 so it needs the .g3drem extension.



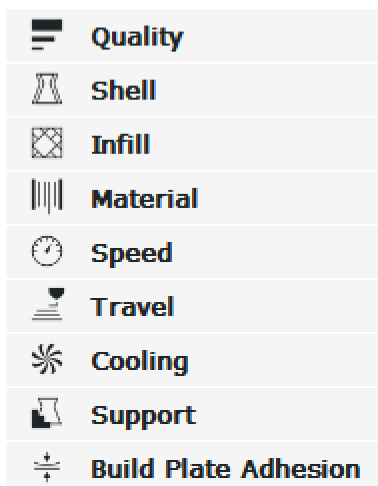
You can now take this file to your printer.

Advanced Settings

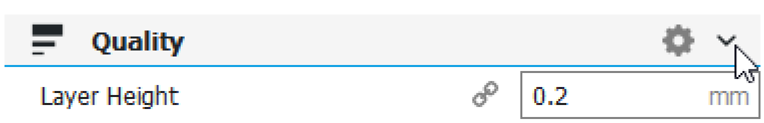
If you select the custom option you can begin to change the parameters. The medium option for resolution is the one that is shown under the Recommended tab.



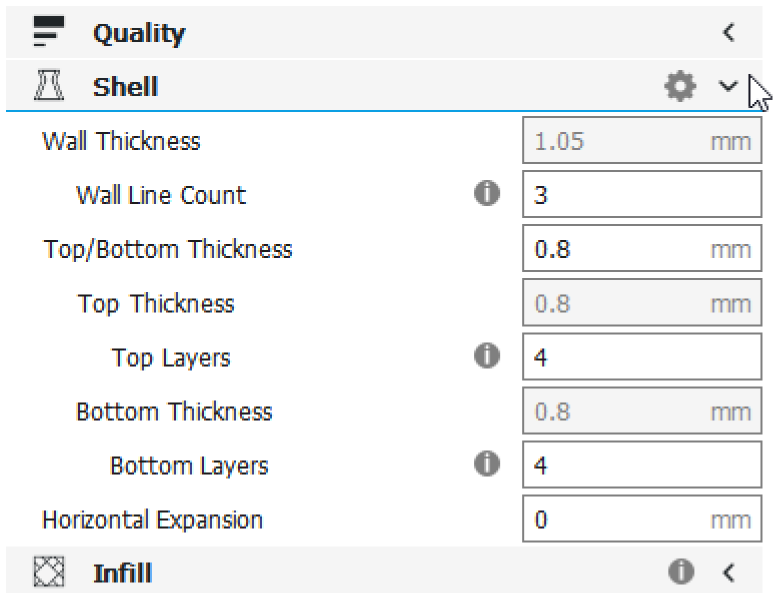
The high setting will give smoother results but it will take twice as long. The fast option will not be a great prototype but sometimes you only want a concept. Individual settings can be changed to your liking and saved as a profile. The various options are shown below. Each can be expanded to select what is desired.



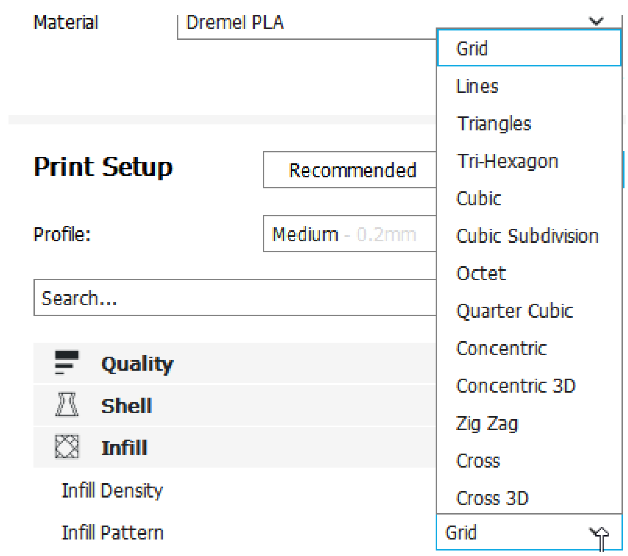
Quality will allow you to set the height of the layer. If you wanted a .22mm layer you can enter that in the window.



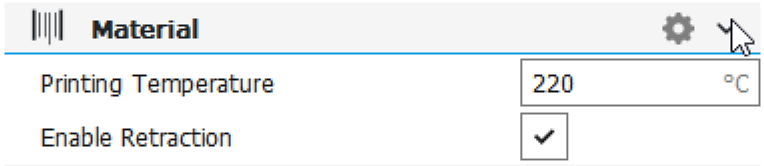
Shell is the area where you describe how many solid layers the model will have. The walls in this example will have three solid layers on the outside while the top and bottom will have 4. This is important as you might want to be sure the top layers look good and are strong but an entire model printed as a solid would take forever and use a lot of material.



Infill is a pattern that allows support of the layers on top but reduces the amount of material used. This setting allows the selection of the amount of infill and the pattern used. The orientation of the pattern changes on each layer.



The material setting allows for the adjustment of the printing temperature. 220ºC is the recommended setting for the Dremel PLA filament. Other filaments might have a different recommendation.



There are more settings you can adjust. The more you read the help manuals and print, the better control you will have over the print quality.

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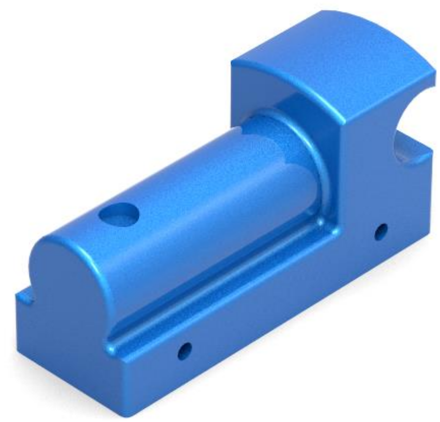
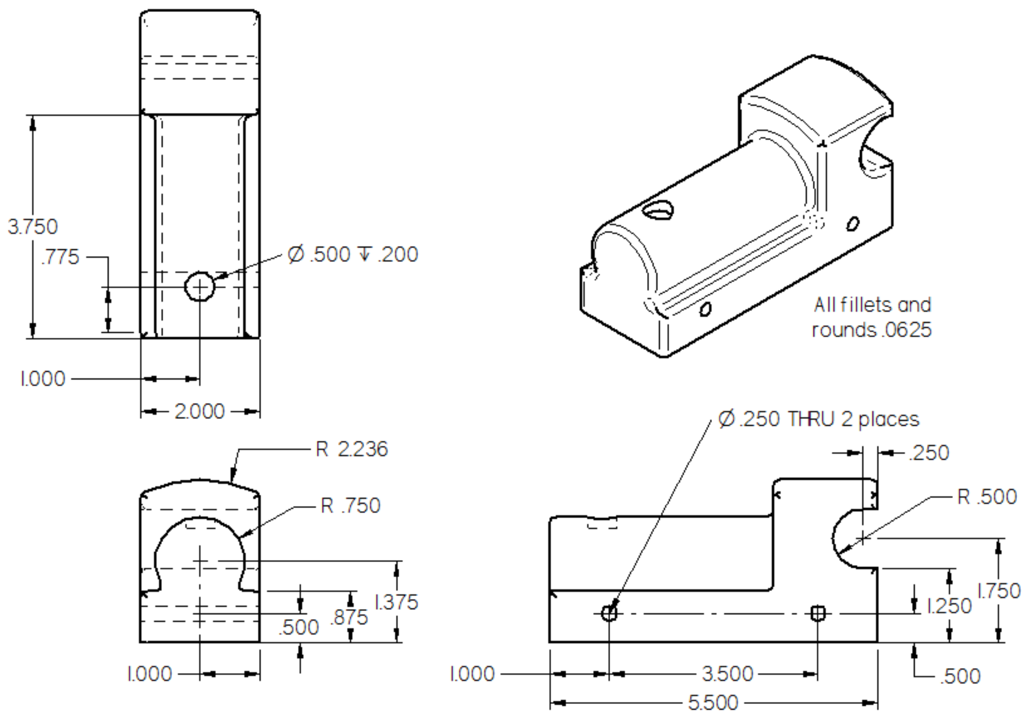
Basic 3D Commands

Creating parts in a 3D solid modeling software program follows set procedures. Any 3D shape begins with a 2D shape and then the shape is translated into a solid model. In a previous exercise you used a 2D shape and extruded it. The extrusion process uses the original shape and copies it in a third dimension. A circle becomes a rod. A square becomes a rectangular prism. There are other ways to create 3D shapes. These exercises are designed to introduce some of them and to provide a sense of how various shapes can be combined to produce what is needed. The following exercises demonstrate one way of creating the shapes. There is no one correct way.

Extrusions

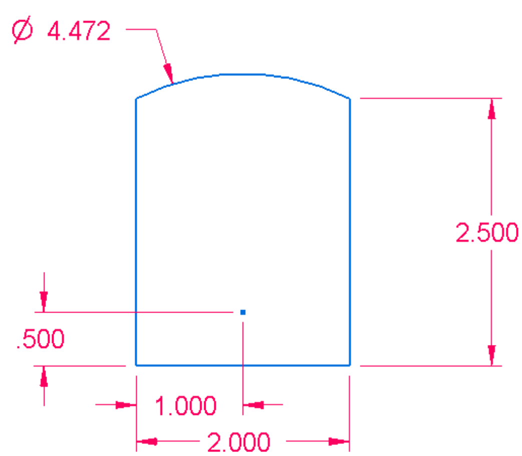


Geometric Requirements



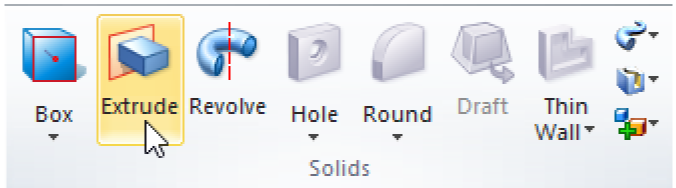
Instructions:

Begin with a new part file. Create a sketch similar to the one shown below of a train body.

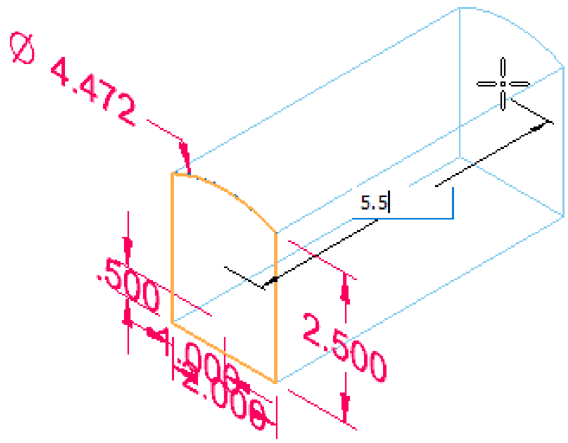


Extrusions:

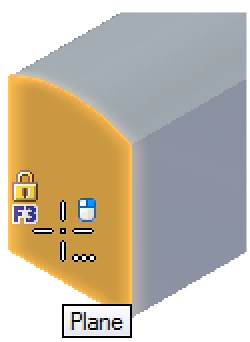
Select the Extrude tool from the Solids section of the Home ribbon. Select F1 to display the Help menu.



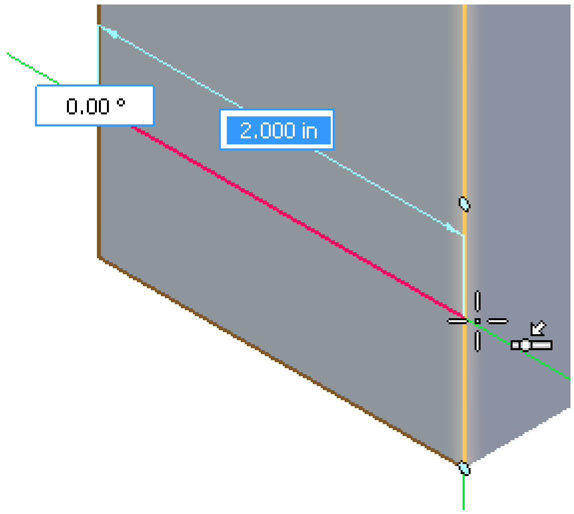
Use Face for the selection and select your sketch. Extrude a distance of 5.5.



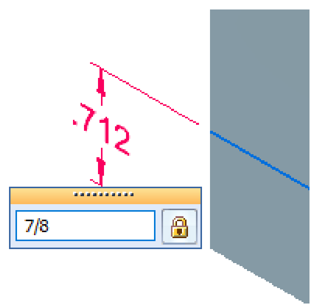
Next draw a line across the front of the train body. Select the line tool and hover over the front of the train body. When it highlights use the (F3) key to lock on the front of the train.



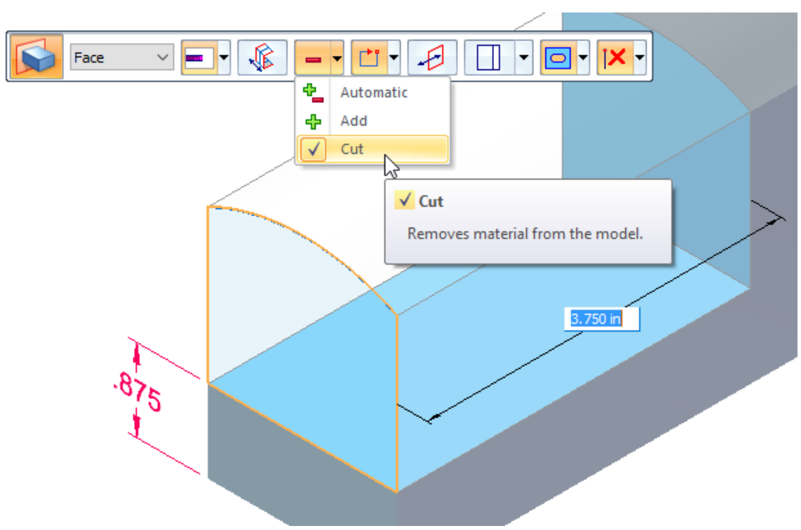
Look for the handle that indicates the cursor is on the line.



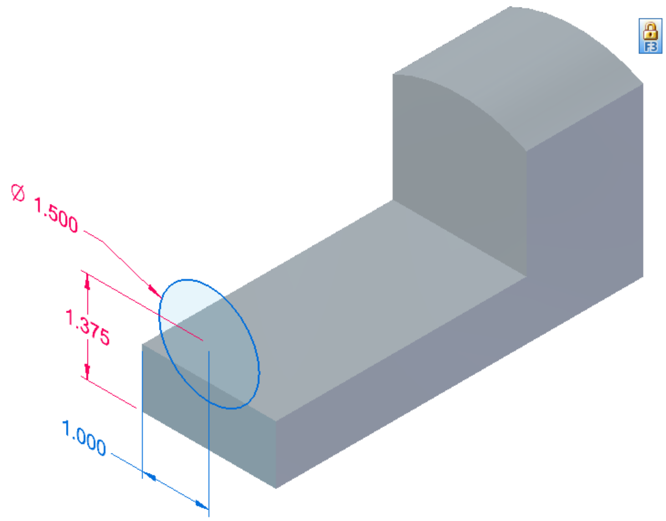
Dimension the line 7/8 from the bottom line.



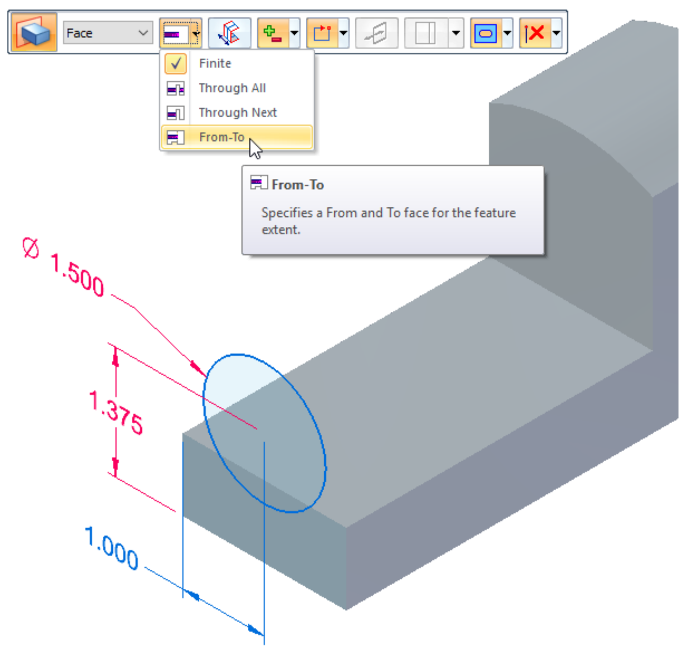
Use extents for the limits and cut (minus sign) for the operation. Use 3.75 for the distance.



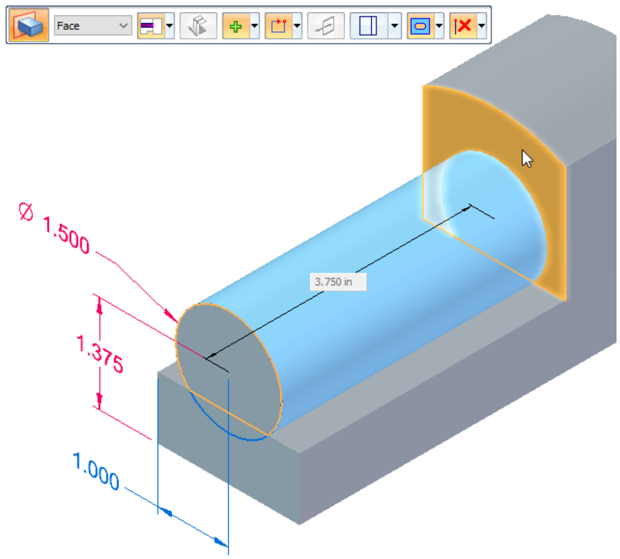
Sketch a circle on the front of the train body. Be sure to use F3 to lock the plane on the front. Add dimensions to the circle center as follows: 1” from the side and 1.375 from the bottom. Set the diameter to 1.5.



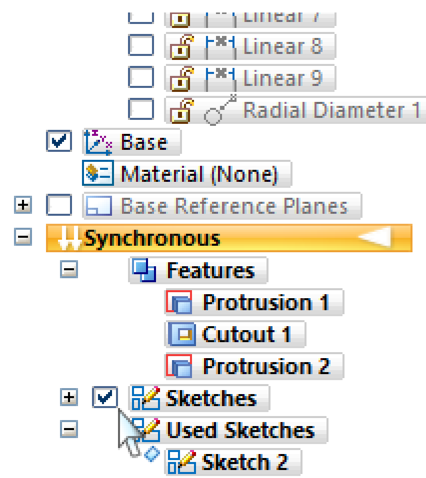
Extrude the sketch. Use Join for the operation and From-To for the extents. This will enable the selection of the starting and stopping point of the extrusion.



Highlight the upper part of the circle. Right click to accept. When prompted select the vertical surface behind the sketch.



The computer will then extend the shape and stop at the surface. Don't worry that the sketch moves. On the left side of the screen in the synchronous section of the tree uncheck the sketches to hide the sketch.



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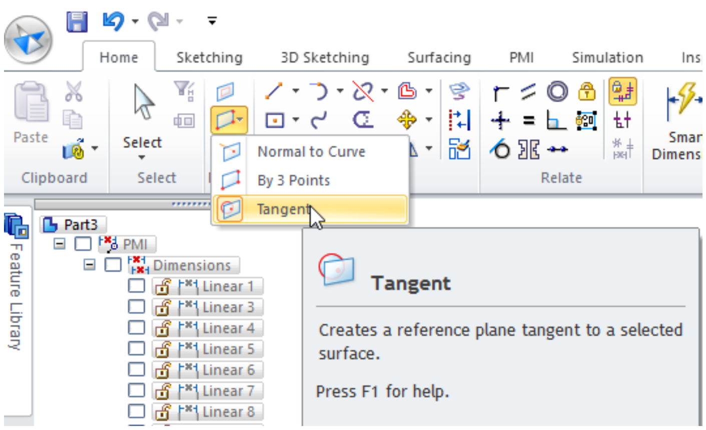
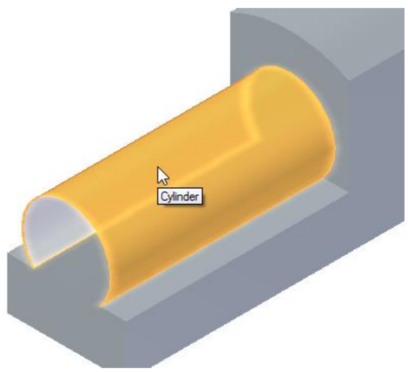
Creating a Plane:

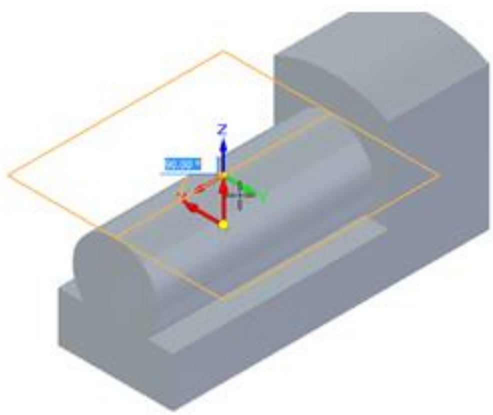
There are instances when a sketch must be created where there is no existing solid face. To get the sketch where it is needed, we create a plane. From the Home ribbon, select Tangent from the Planes section. Select F1 to see the Help section on creating a tangent plane.

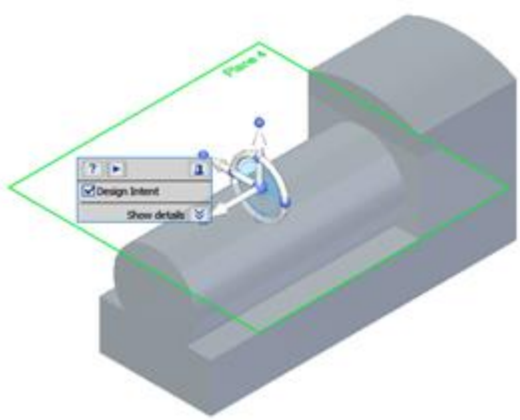


Select the cylinder on the front of the train body.

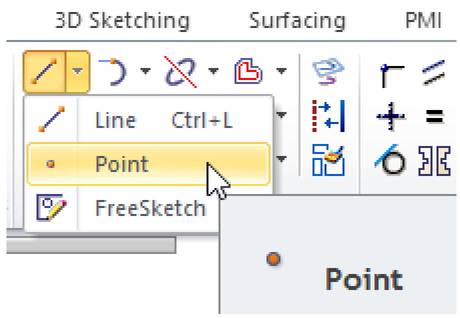


Set the angle to 90 degrees. Click on the top of the cylinder to keep the plane on the top.

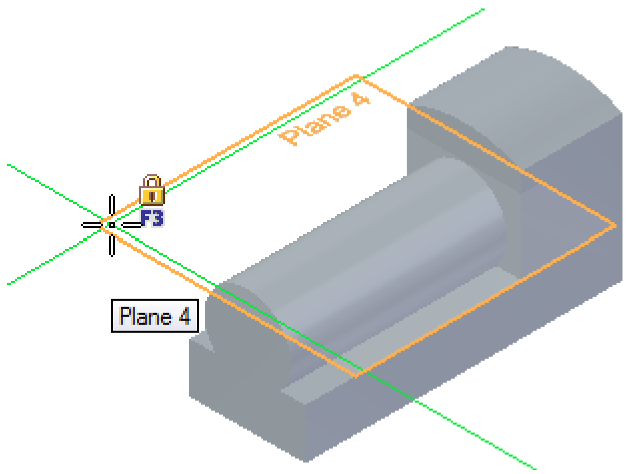




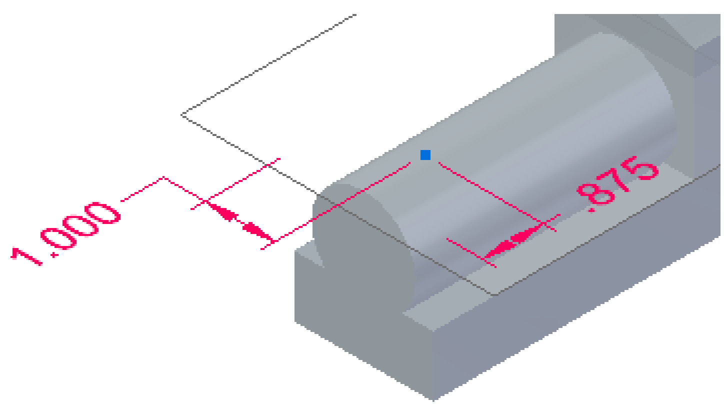
Use the Point command found under the Line command in the Draw section of the ribbon.



Hover over the edge of the plane until it highlights and lock the drawing plane using the F3 key.



Once you lock the plane in place, switch to the top view.
Click to place the point close to where you want it. Dimension the Hole Center 7/8 inch from the front of the train and 1 inch from the side.



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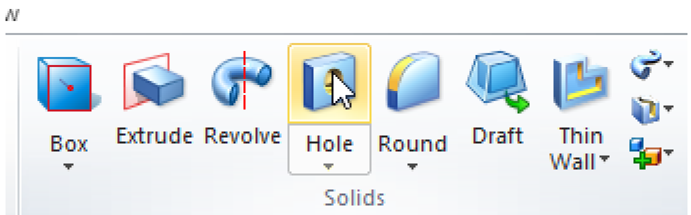
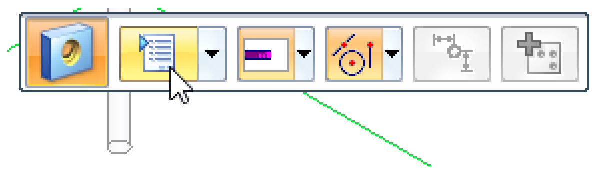
Hole:

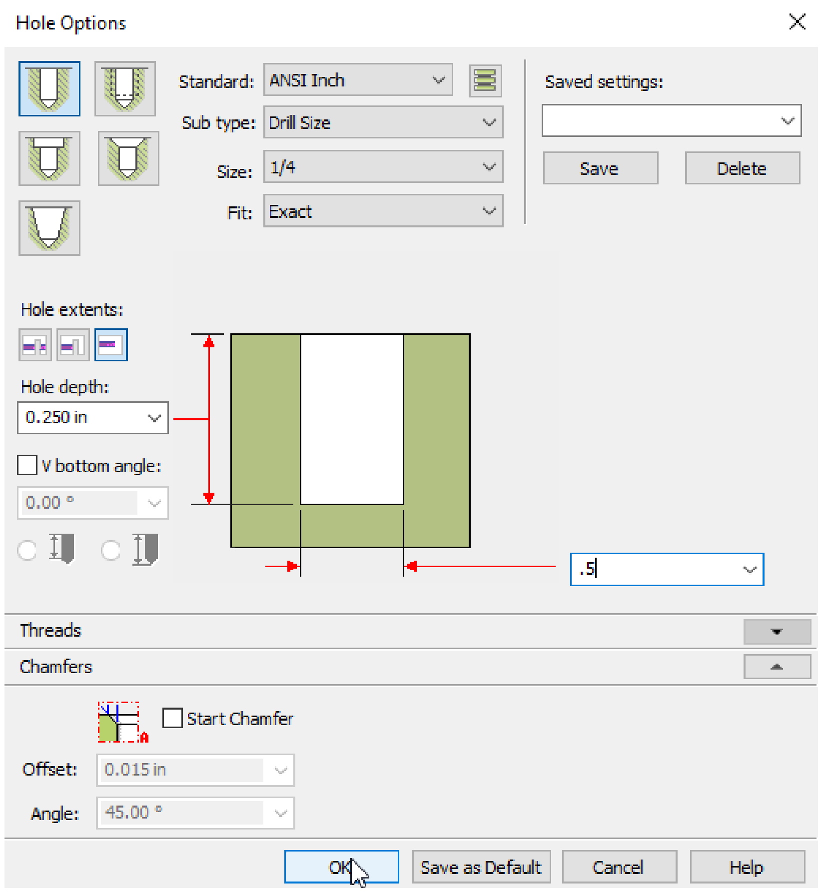
Select Hole from the Solids area of the ribbon.



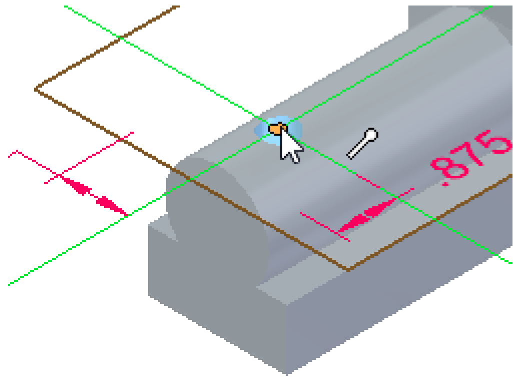
F1 will provide a lot of information about creating various types of holes.

From the Hole dialog box select the settings option.

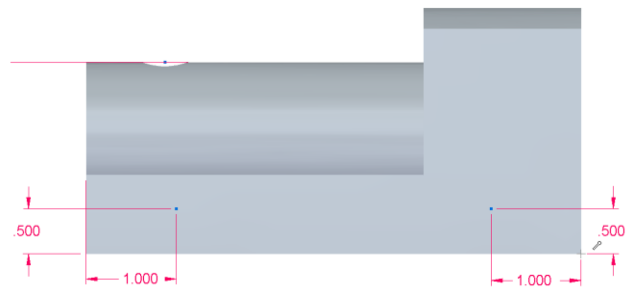




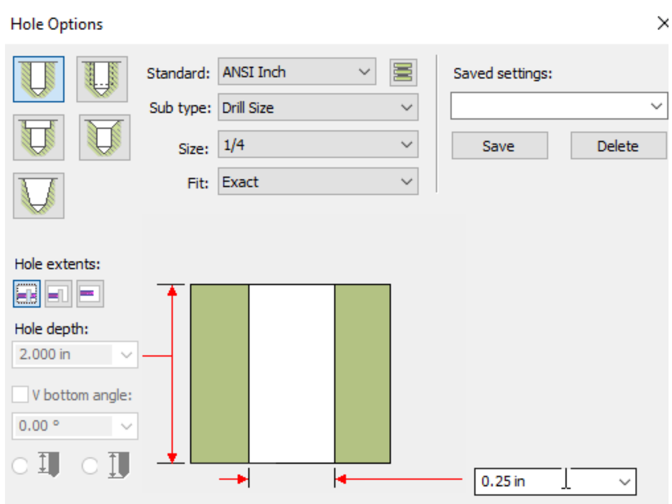
Set the hole depth to .25 and the diameter to .5. Select OK and click on the point drawn.



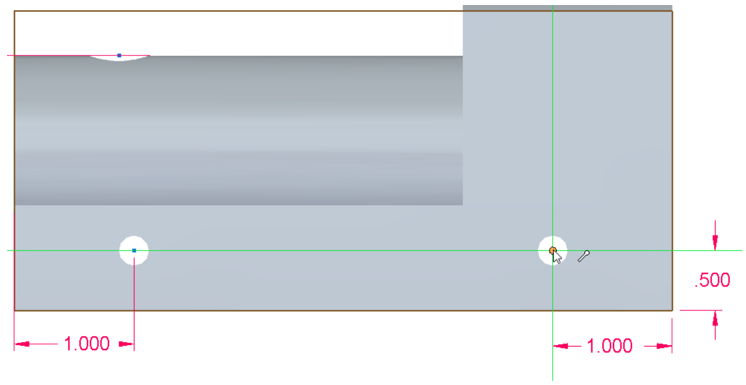
Change the view to the side of the train body and place two points. Dimension the points ½ inch from the bottom and 1" from each end. The measurements will be critical when assembling your train. Be sure it is dimensioned correctly.



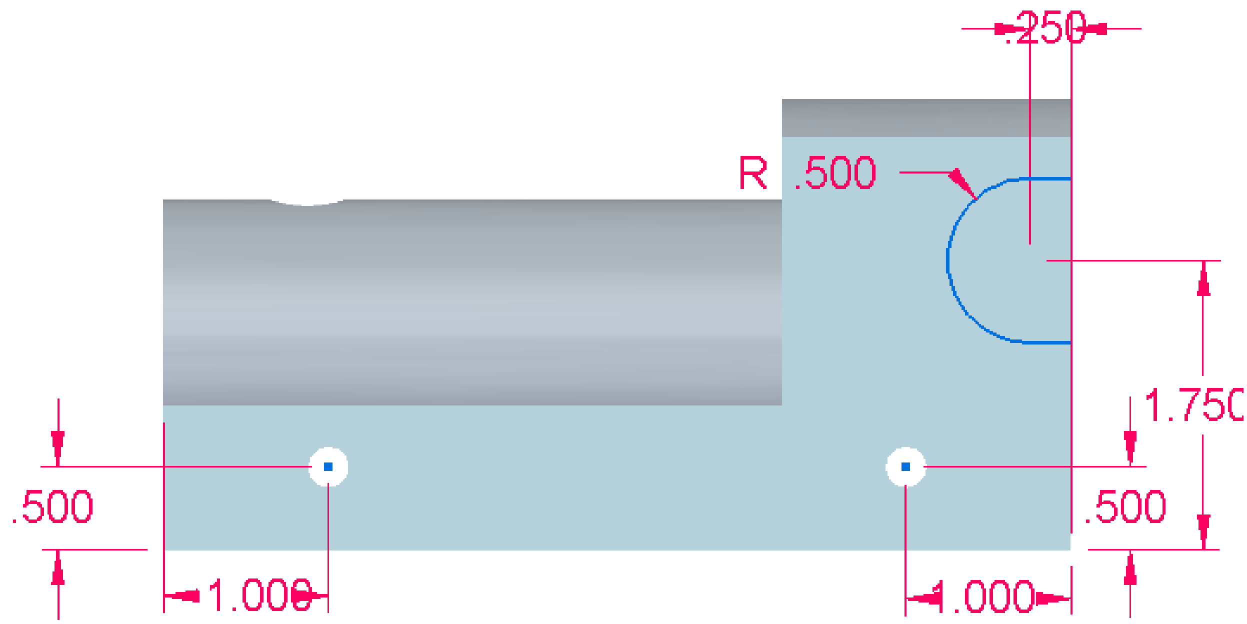
Use the hole command and make the holes .25 in diameter and Through all for the extents.



Place a hole on each point created. Be sure the handle indicates that the hole is correctly placed.



Sketch the notch for the back of the train body. Extrude the sketch using Cut for an option and Through all for the termination.



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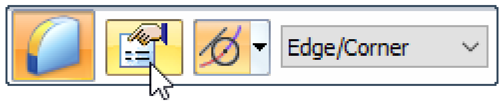
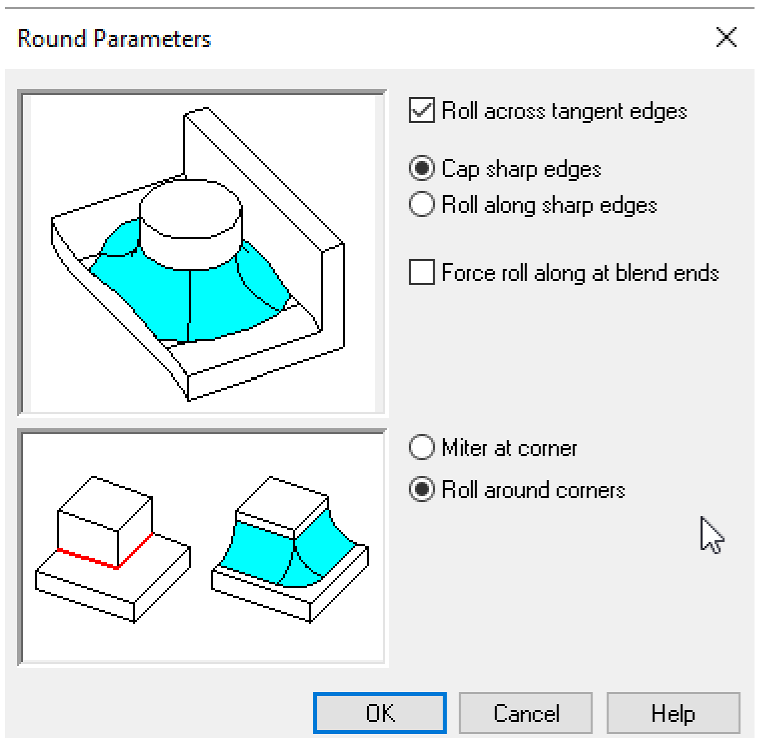
Fillets and Rounds:

Fillets and rounds are used to connect planes smoothly with an arc that is tangent to the surfaces. An inside corner is a fillet and an outside corner is called a round. In actual application fillets and rounds help reduce the stress on an object as square corners are prone to breaking and chipping. Software frequently uses the same term for both operations although engineers know the important difference between the two. For more information, select the Round command from the Solids section of the ribbon and press F1 to access the help menu.

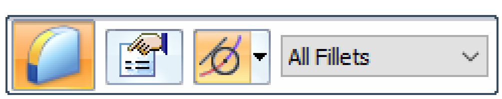
In the Round dialog box select the icon for Parameters.



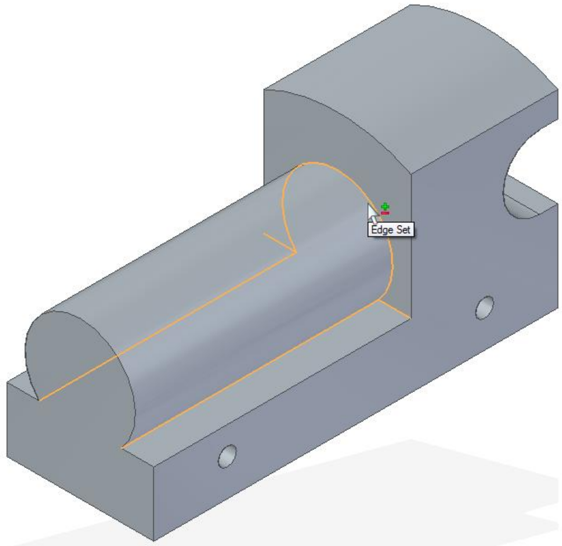
Select the following options for the Round command.



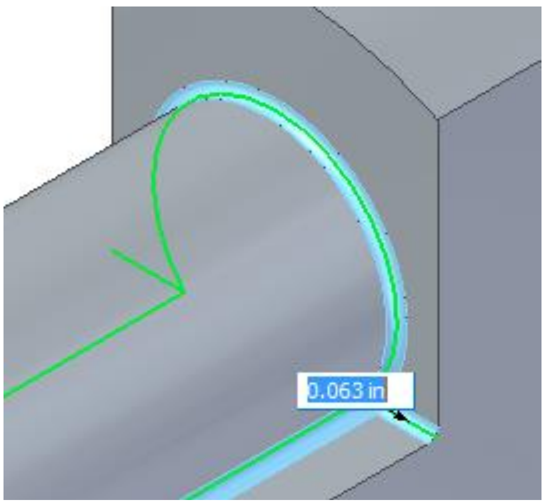
Select All Fillets for an option.



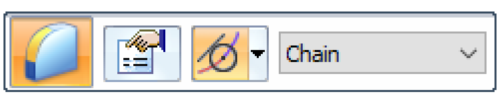
This command will find all the elements that are connected together that would get a fillet.



Use .0625 for the radius of the round.

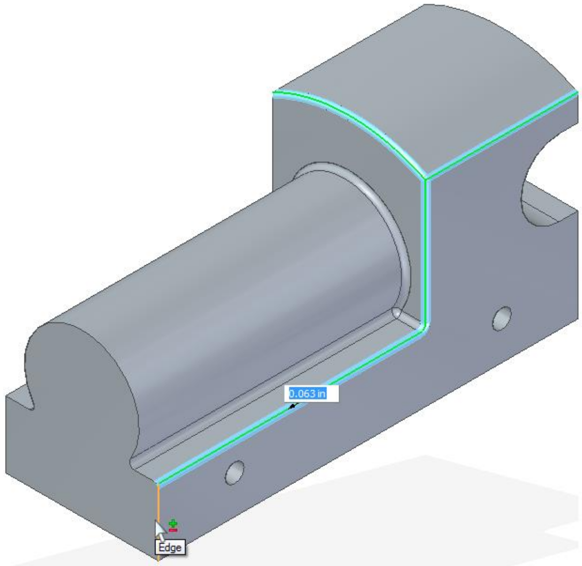


Return to the Round dialog box and select Chain for an option. This will select all lines that are connected. We want to round all the corners but not the holes for the wheels.



Select all the lines that make up the edges of the train engine.

As you select the lines the rounds will appear.



Set the radius to .0625.
Save your file

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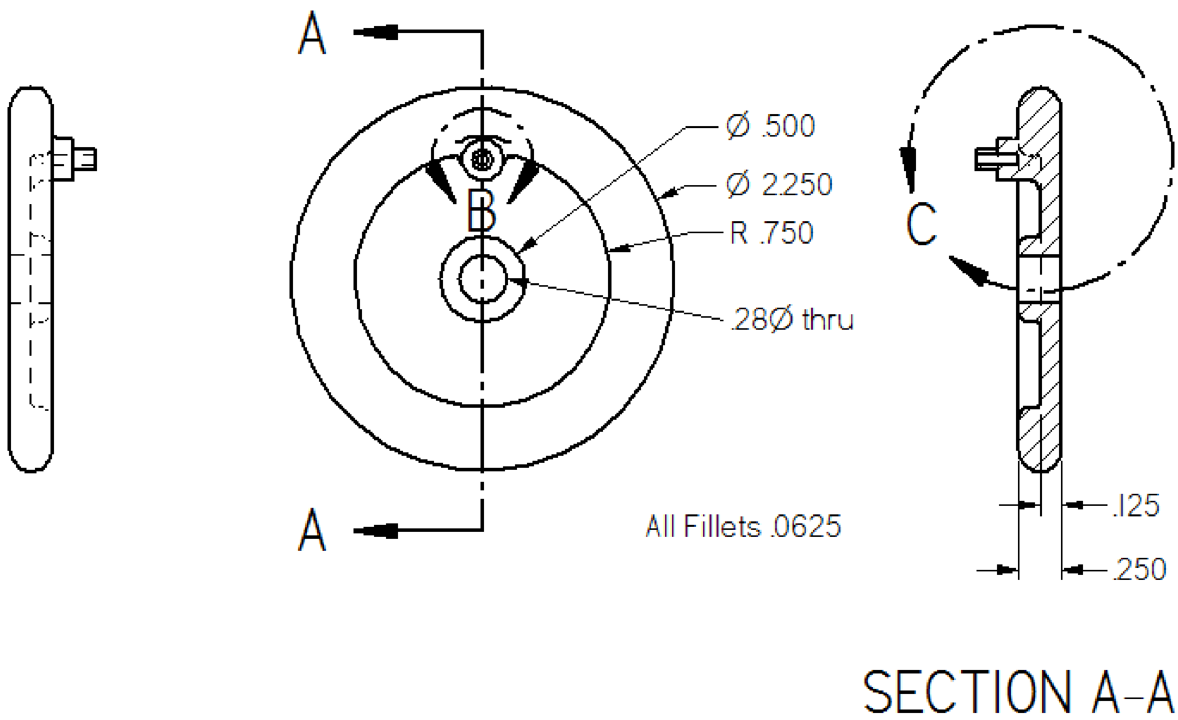
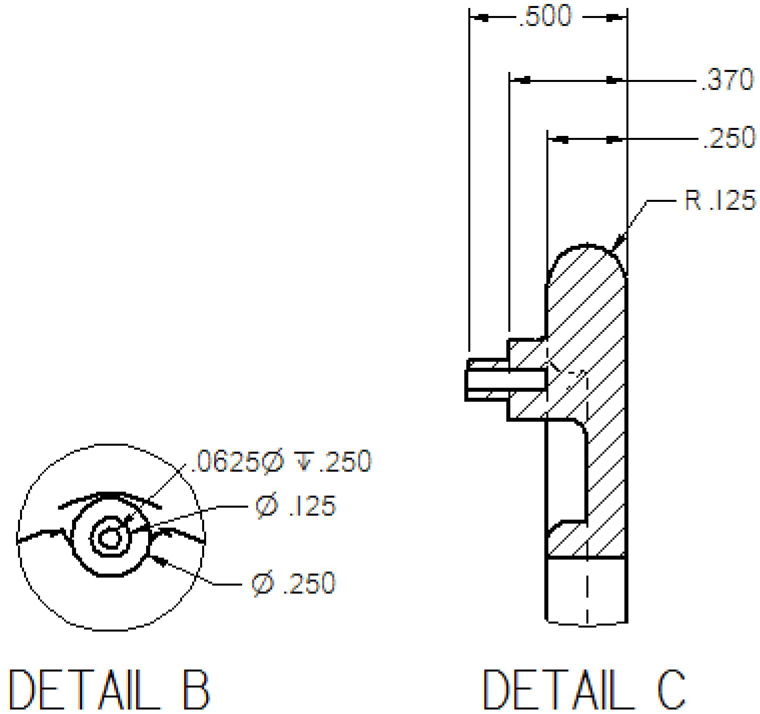
SIEMENS

Ingenuity for life

Wheel

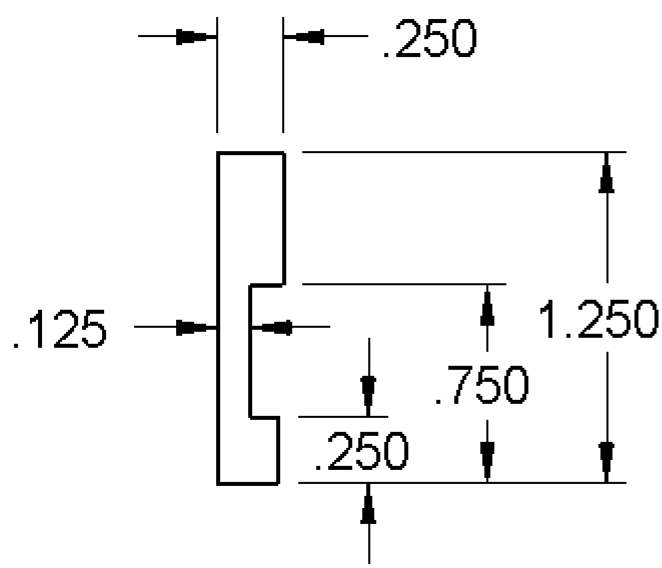
Geometric Requirements:



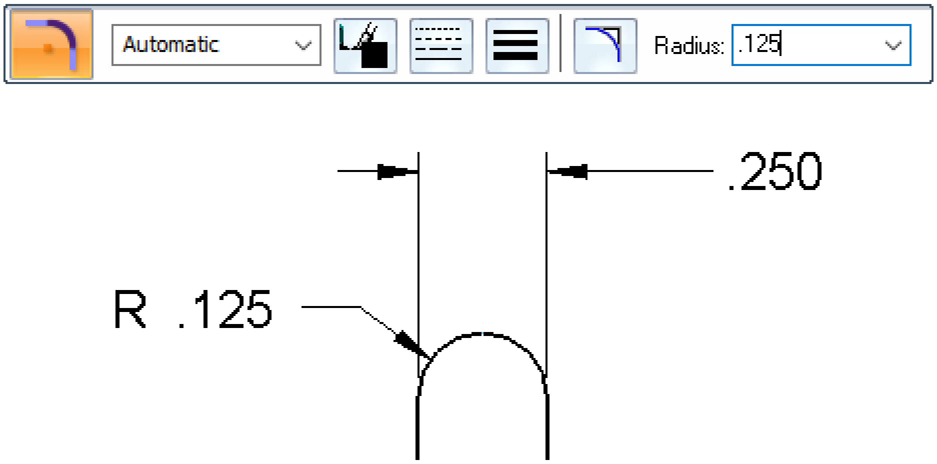


Create the sketch

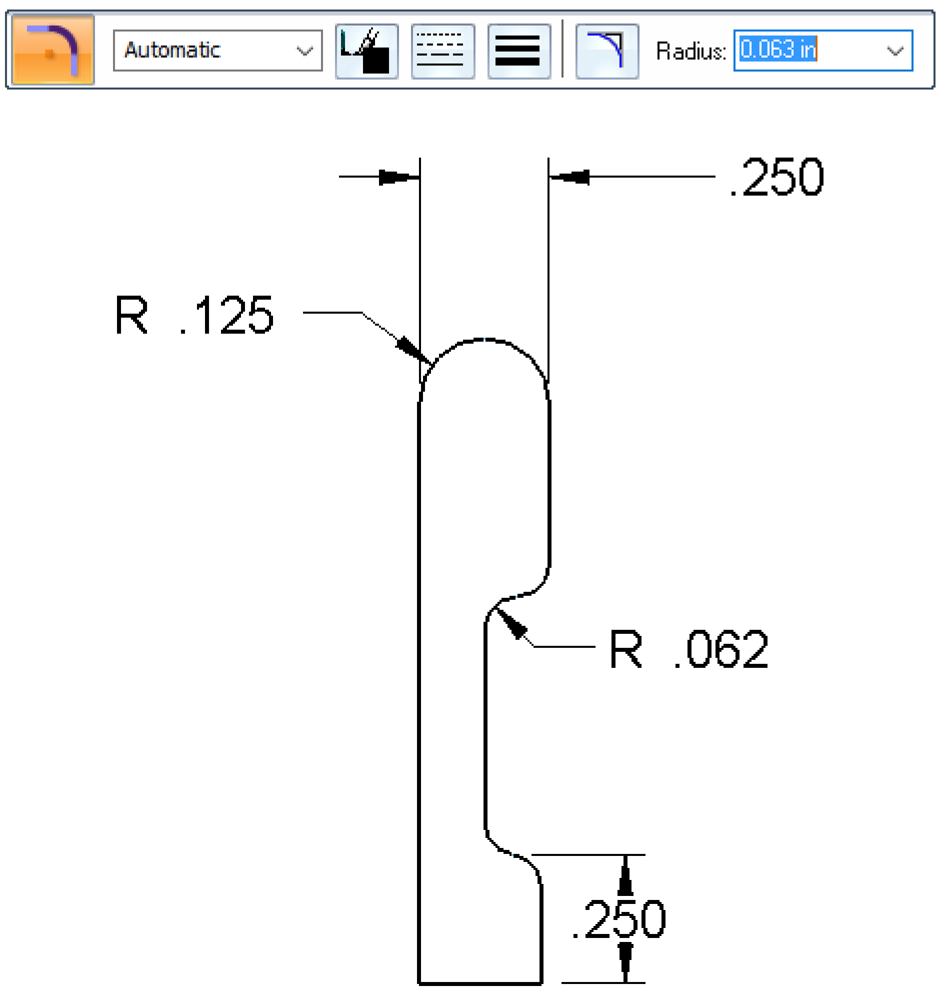
Begin with a new part file. Create a sketch similar to the one below.



Use the Fillet tool from the Draw area of the ribbon to round the top of the wheel. Use a radius of .125



Reset the radius to .0625 and round the other corners except for the bottom line of the sketch.



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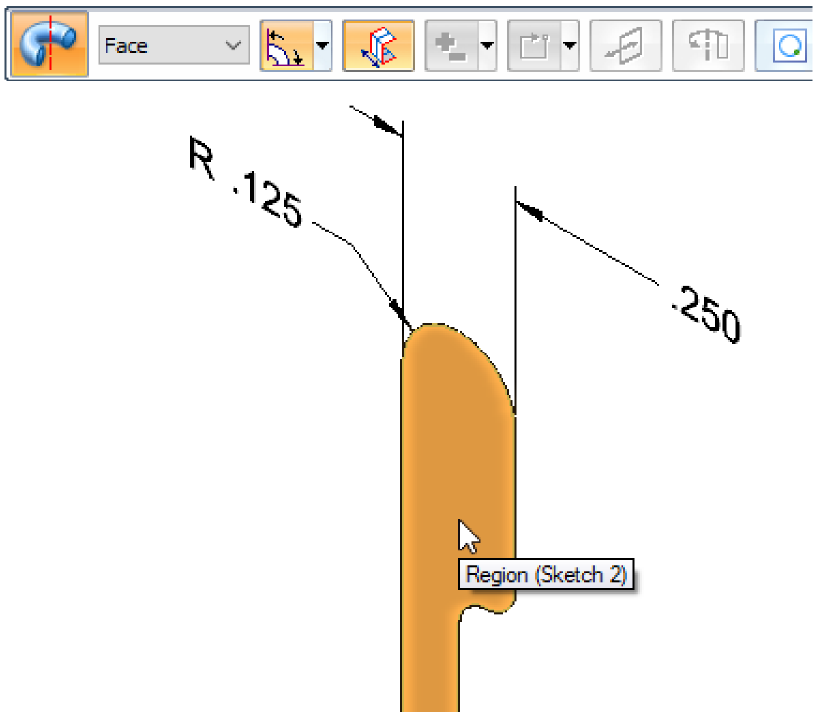
Revolve:

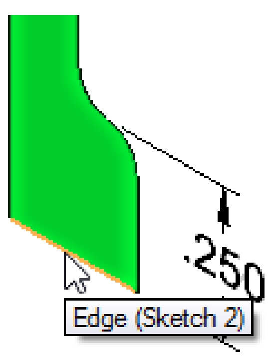
When a curve of a plane created by a collection of curves is rotated around an axis the resulting solid shape is called a revolution. Mathematicians call this a solid of revolution. CAD programs call the command Revolve. It allows for the creation of a solid shape from what is drawn by spinning the shape around an axis. For more information, select the Revolve command and press the F1 key.

Place the view into a 3D view. Select Revolve from the Solids section of the Home ribbon. Set the selection style to Face.

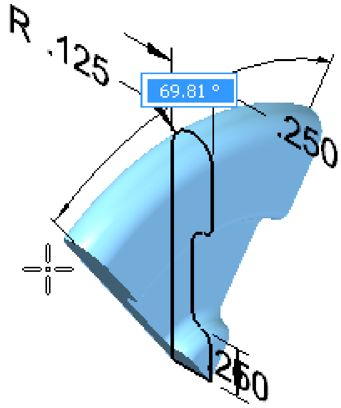


Highlight the sketch and right click to accept.

The prompt will ask for the axis of revolution. Select the very bottom line of the sketch. This should cause the shape to revolve around that line.



The shape should begin to revolve. Enter 360 in the box to create the complete wheel.



The resulting shape is the blank for the wheel.

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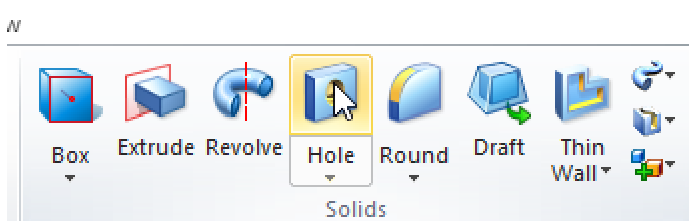
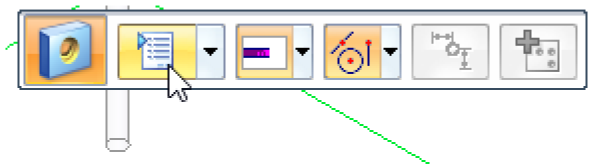
Hole:

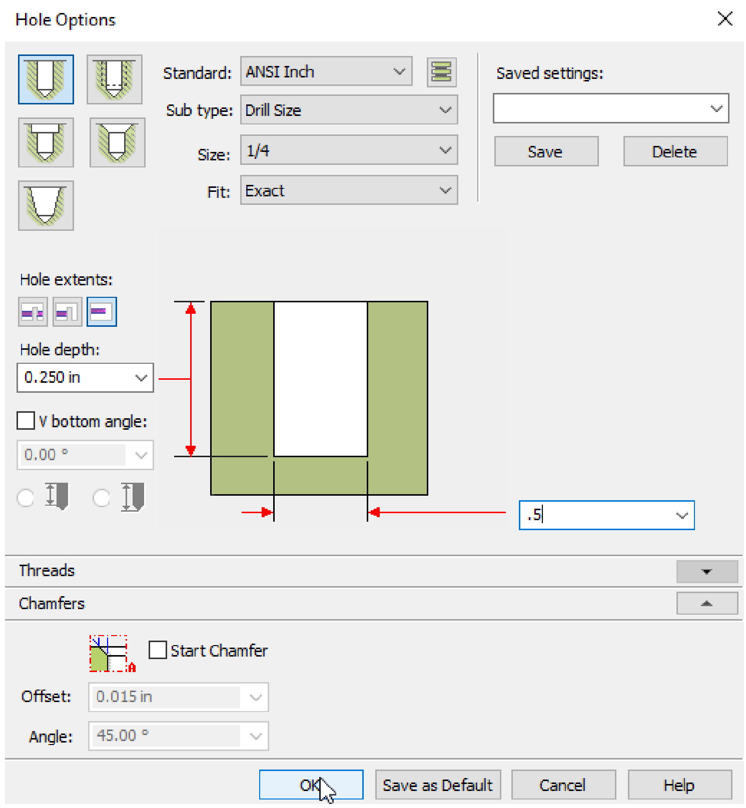
Select Hole from the Solids area of the ribbon.



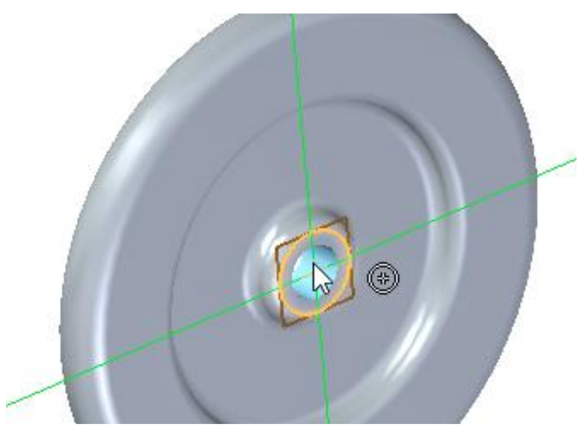
F1 will provide a lot of information about creating various types of holes.

From the Hole dialog box select the settings option.





Select the Hole command from the Solids area of the ribbon. In the Hole dialog box, set the diameter to .25 and the extents to Through all. Hover over the center of the wheel and select the F3 key to lock the plane. Look for the center relationship and place the hole in the center of the wheel.



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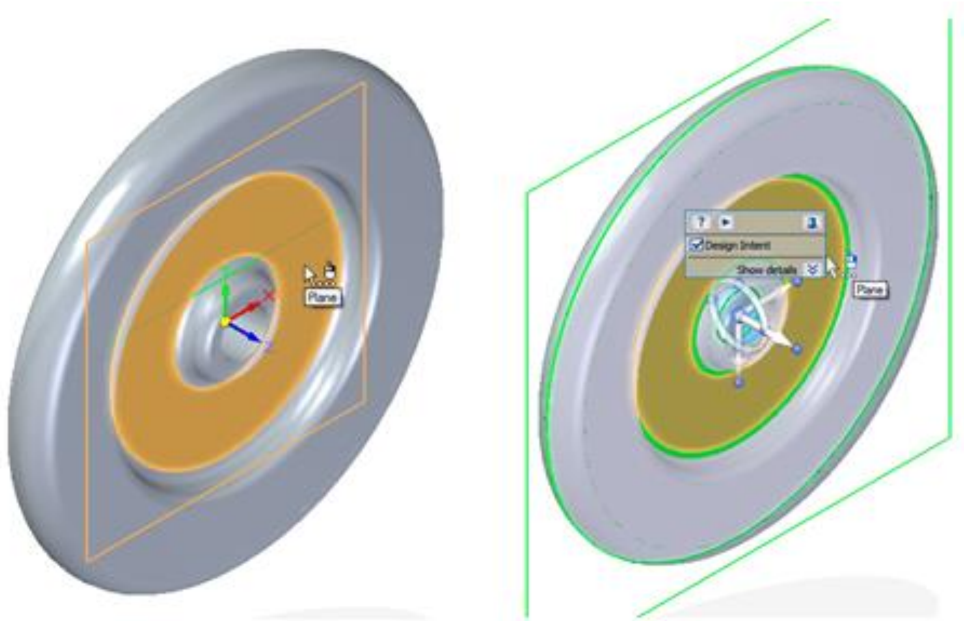
Live Section:

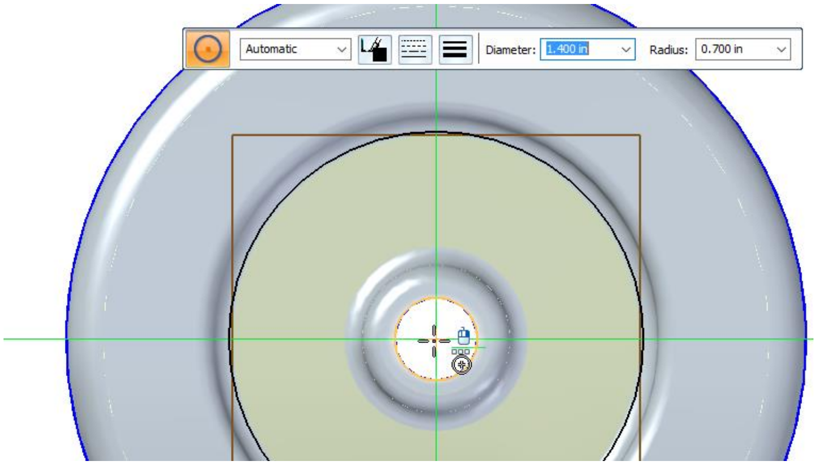
A Live Section sets a plane to work on using any reference plane or surface. The Live Section allows for work on an uneven surface. Look at the drive component of the wheel and how it is half in the wheel and half on the hub. In order to create a place to sketch use the Live Section command from the Home ribbon. For more information select F1 when you select the Live Section command from the Home ribbon.

After selecting the Live Section command, hover over the low spot on the wheel. It will be highlighted. Select that flat area and the plane will be created in the middle of the wheel.



Now select the Circle command from the Draw area of the ribbon. Hover over the plane created and select F3 to be able to easily draw on the surface.

Create a circle 1.4 in diameter from the center of the wheel.



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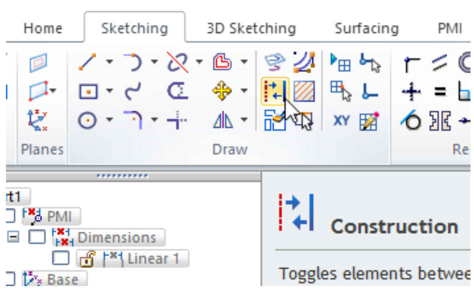
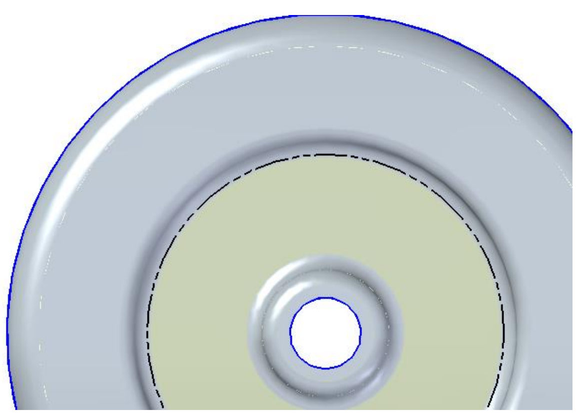
Construction Line:

A construction line is 2D geometry that allows for the placement of wanted geometry but will not be included in the creation of solid geometry. For more information select F1 when you select the command.

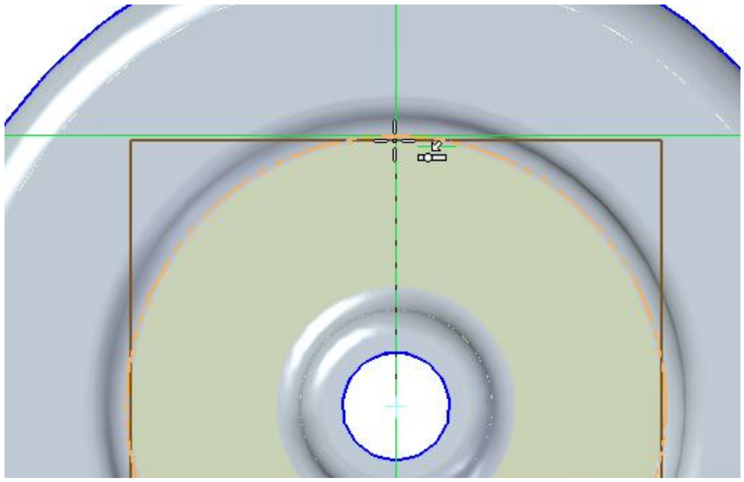
Highlight the circle you just created. Select the Toggle construction line command from the Draw area of the ribbon.



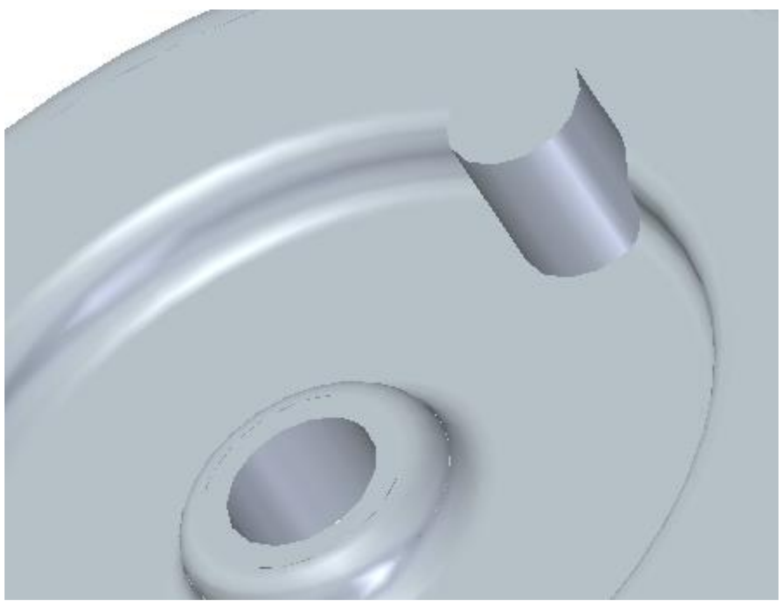
The solid 2D circle will have the appearance of a construction line - two short dashes followed by a longer dash.



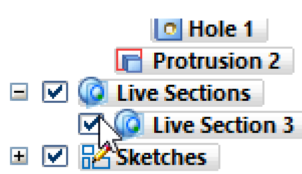
Now place a .25 diameter circle on the construction circle. Place the center so it is directly above the center of the hole in the wheel. The cursor line will show dashes and the center point will indicate the center similar to the picture below. This is placing geometric relationships on the part.



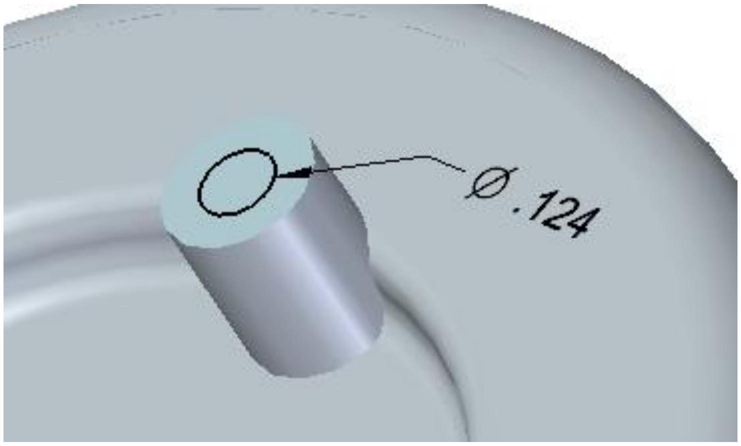
Extrude the circle. Use Chain to select the geometry and select the circle you just drew. Extrude the profile .30



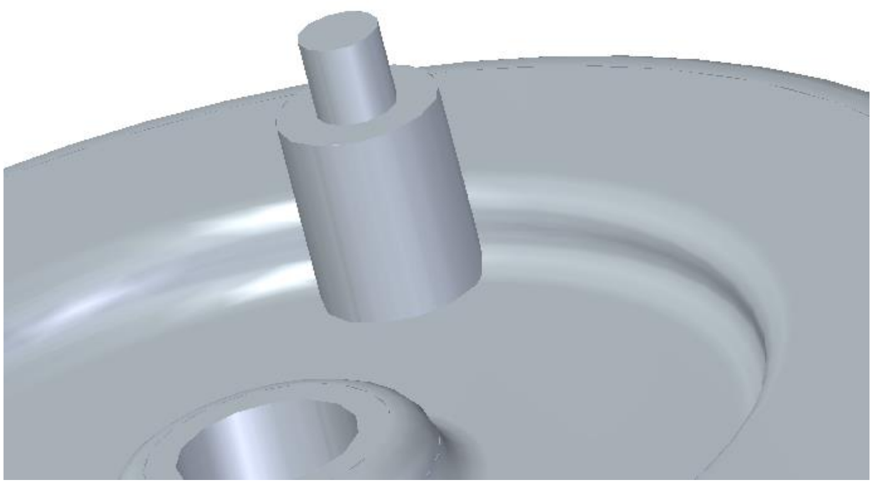
Hide the display of the Live Section by unchecking it in the synchronous tree.



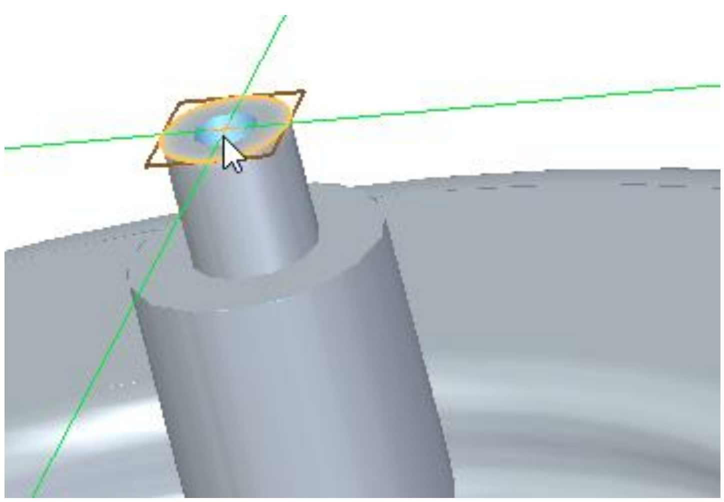
Draw a circle on top of the post you just created. Make the diameter .124



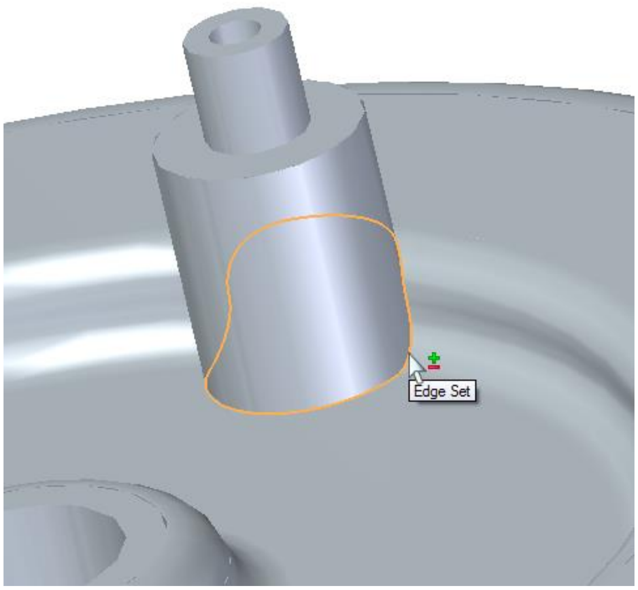
Extrude the sketch .126



Place a hole .0625 in diameter .250 deep in the center of the post.



Add fillets where the post meets the wheel. Use .0625 as the radius and chain as the selection.



This will strengthen where the post meets the wheel and remove a square corner where forces could concentrate.

Save your file.

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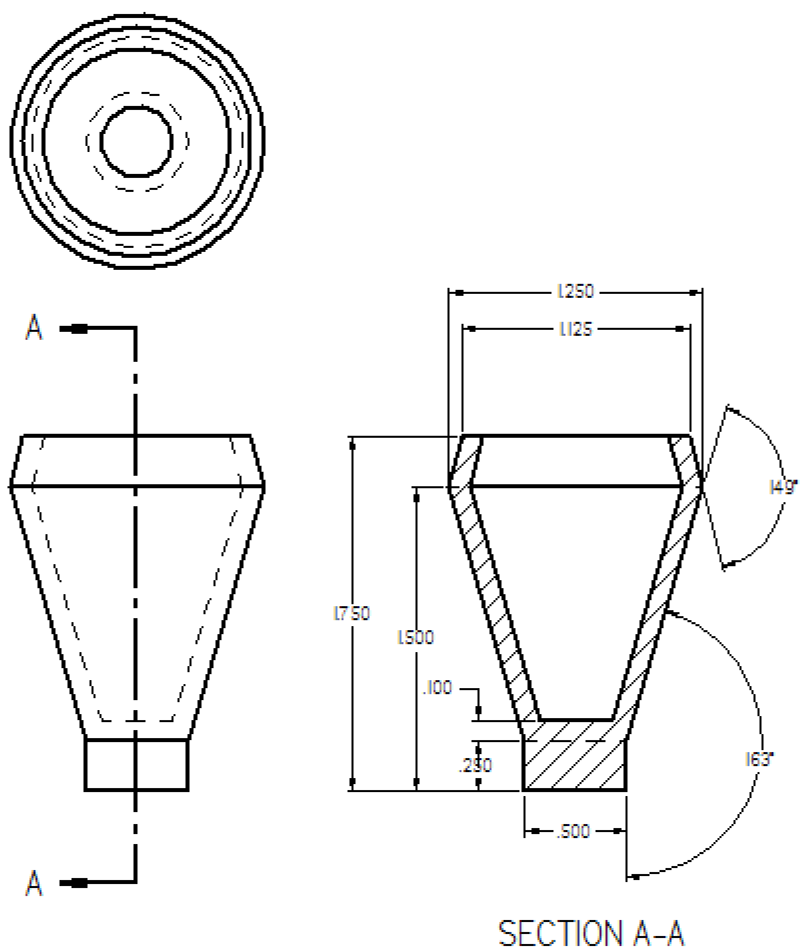
Stack

Geometric Requirements:



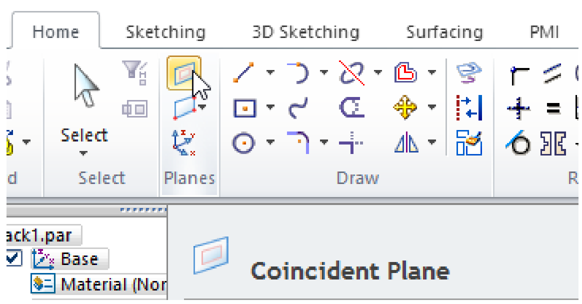
Instructions:

Lofting is the primary method for making tapered items such as wings or boat hulls. It allows for the placement of ribs, cross sections or shapes a set distance apart and connecting them with curved surfaces. In 3D modeling, planes are used to create sketches and then the computer generates the solid or surface to join them together.

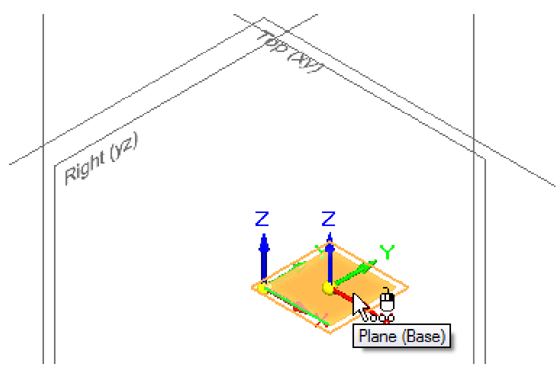
Setting Coincident Planes

The first step in creating a loft is the creation of several coincident planes at different elevations. These planes are used for the sketches and setting the alignment between the sketches. Creation of these planes must reference existing surfaces or planes. For more information about coincident planes select F1 after selecting the icon.

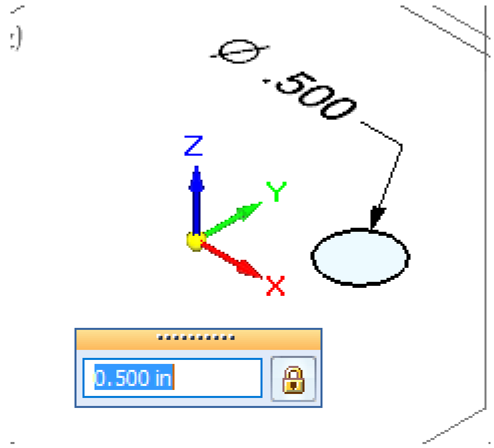
Create a new part file. Begin by selecting the Coincident Plane icon from the Planes section of the Main Ribbon.



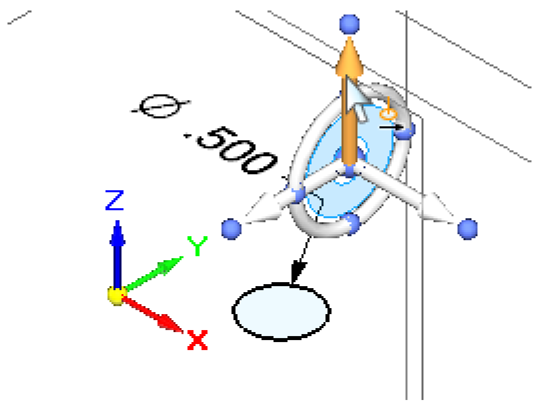
Hover over the XY or top plane until it highlights. Click on the plane.



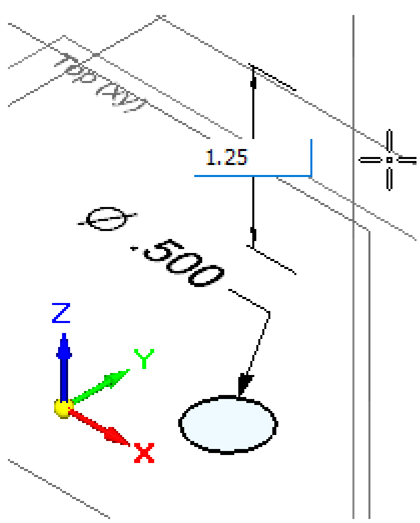
The new plane appears. Draw a circle .5 in diameter on the plane.



Select the Coincident Plane tool again. Create a second coincident plane from the first one. Select the first plane created and then select the upward arrow (Z).

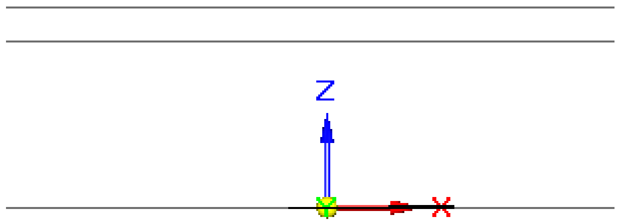


Begin to move upward and then enter 1.25 for a distance. The new plane will then appear 1.25 above the first plane.



Repeat the process so the next plane is .25 above the second plane you created.

Looking from the front you should see the three planes.



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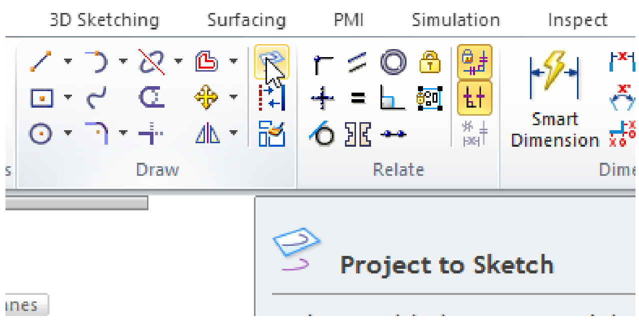
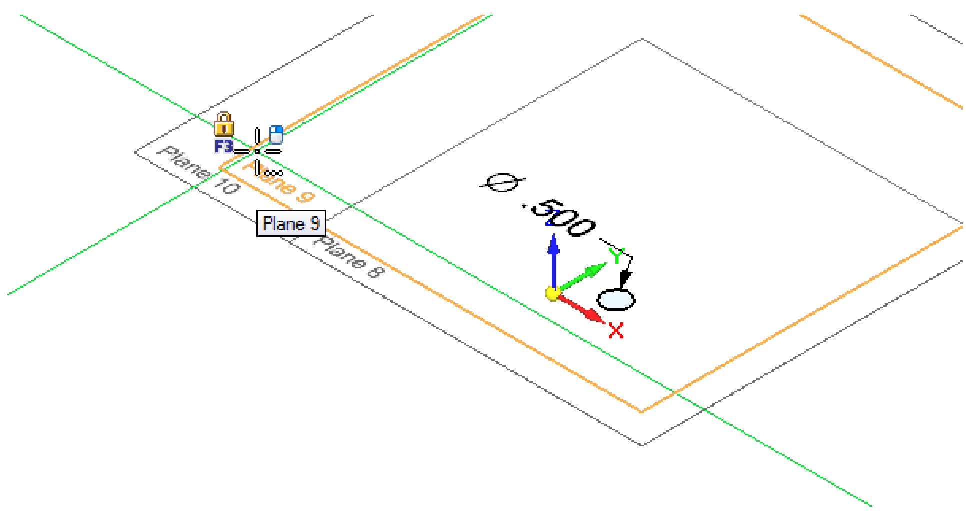
Project to Sketch

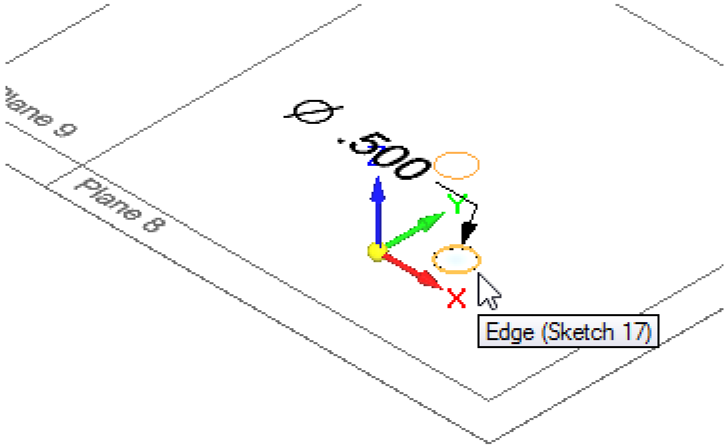
The sketches must align with the one on the plane below. Use the circle created on the first plane to position the ones on the planes above. Select the Project to Sketch icon from the draw section of the Main Ribbon. Select F1 for more information about this command.



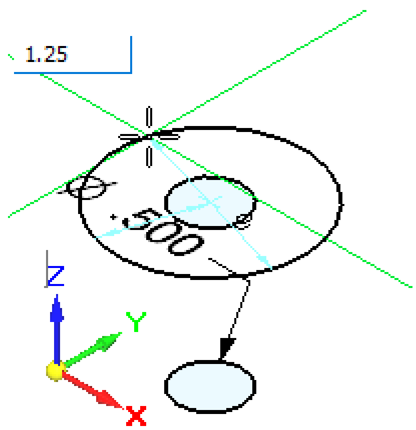
The first prompt will select the first plane. In the picture below the planes are 8, 9 and 10. Select plane 9 by clicking on the edge. This locks the sketch plane to the plane. If you see a dialog box for the options select ok.



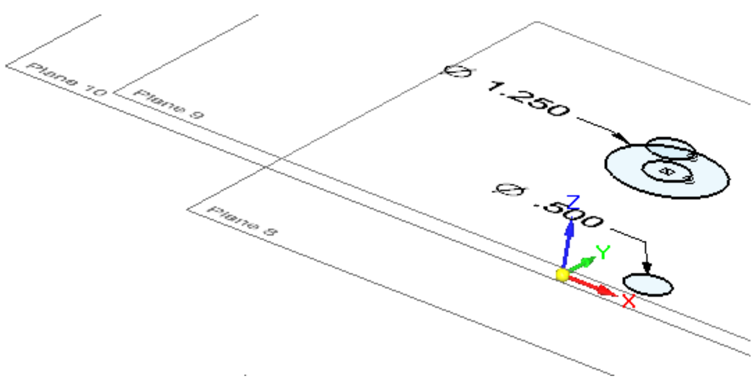
Once the Options dialog box is gone you will be prompted to select the geometry (model edge, curve or sketch element). Select the circle and it will appear on the current sketch plane.



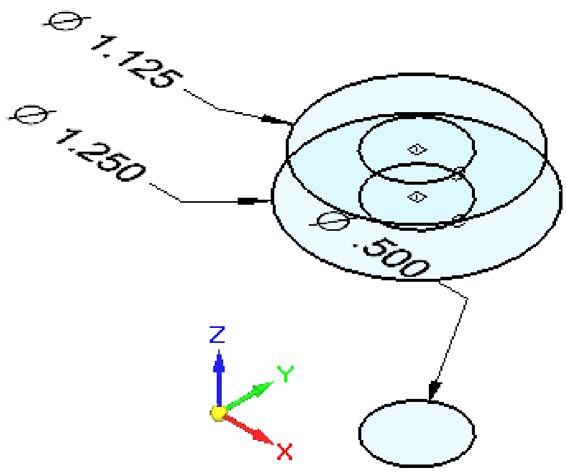
Then use the center point of that circle to create a circle 1.25 inches in diameter.



Repeat the process of Project to Plane placing a copy of the .5 circle on the top plane.



Use the top circle for the center of a sketch of a 1.125 circle.



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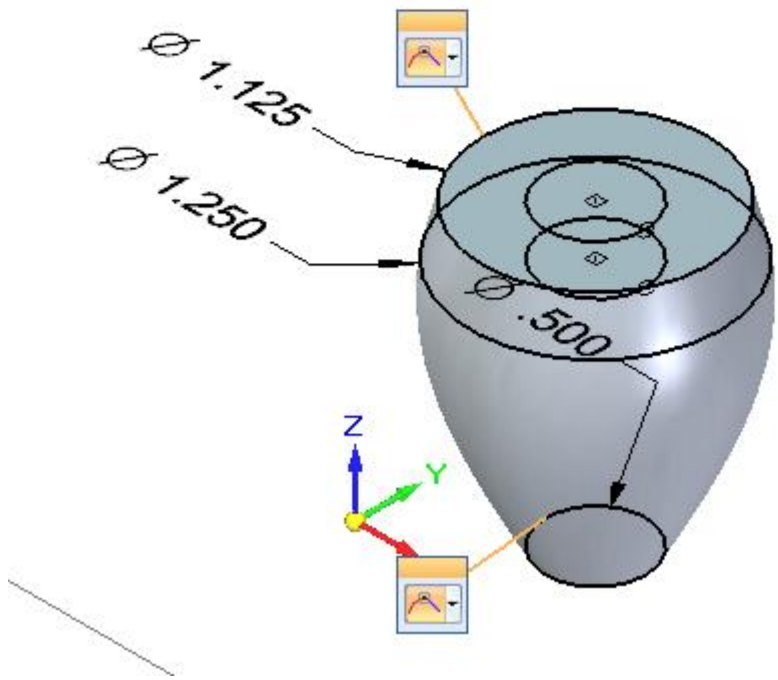
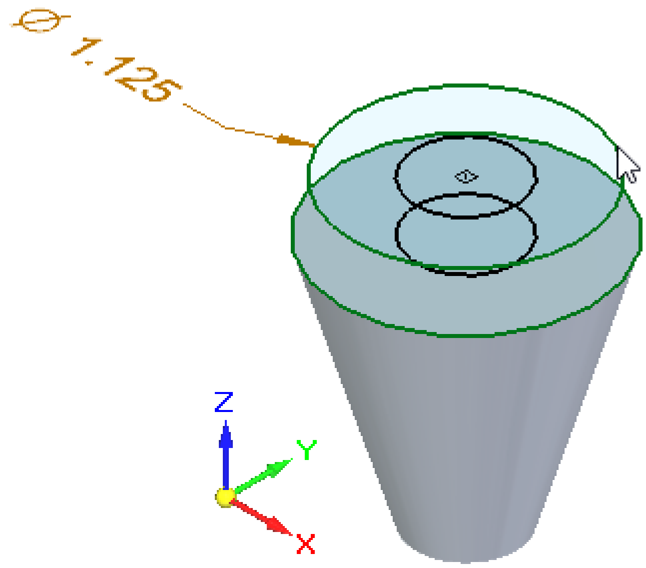
Loft:

Select Lofted Protrusion from the Solids section of the Main Ribbon. Select the original bottom circle (.5) and then the 1.25 circle and then the 1.125 circle. Right click to accept the choices. You will see a rounded shape appear. This is due to fitting the curve to pass through the center circle.

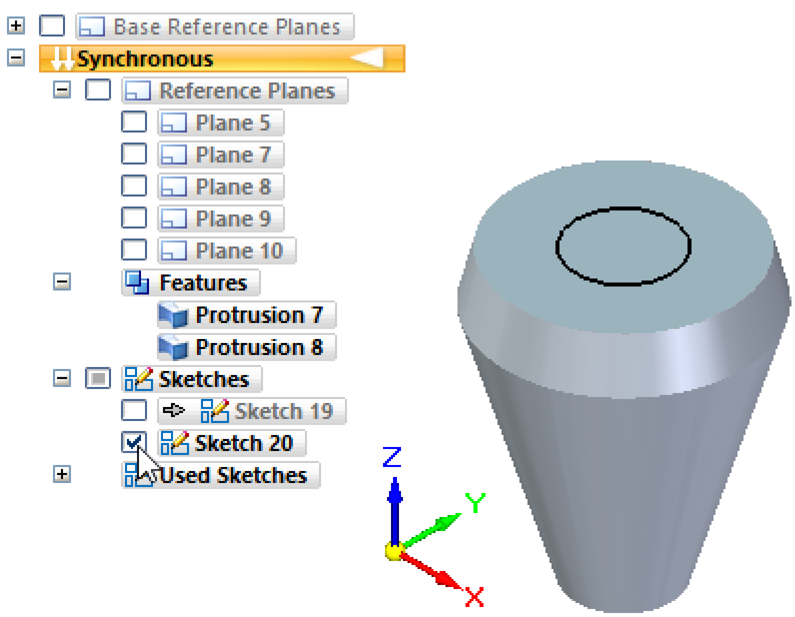


If a more angular shape is necessary utilize the (Ctrl Z) to undo this shape and then use the Loft command twice. The first loft will be from the original .5 circle to the 1.250 circle. Right click to accept and then Loft again from the top of that shape to the 1.125 circle.



Choose the desired shape.

Hide the planes and sketches left by expanding them in the tree and unchecking them.



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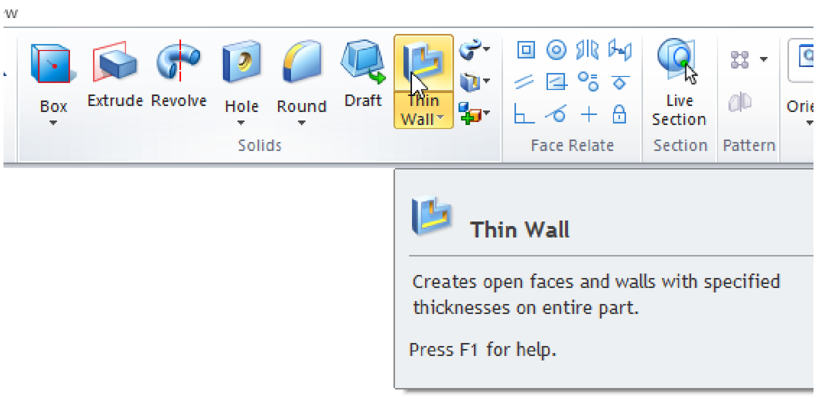
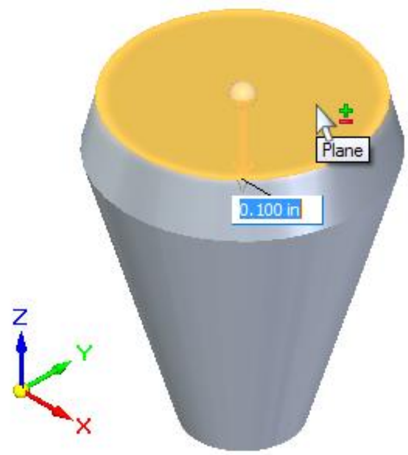
Thin Wall:

This command constructs a thin wall from a solid shape. Since the stack is to be hollow, this is an easy way to accomplish this. After you select the command you can press F1 for more information.

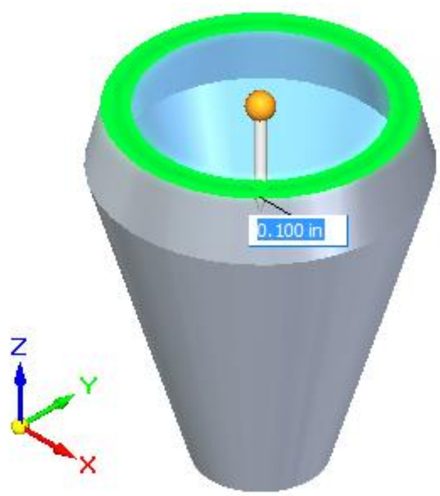
Select Thin Wall from the solid section of the toolbar.



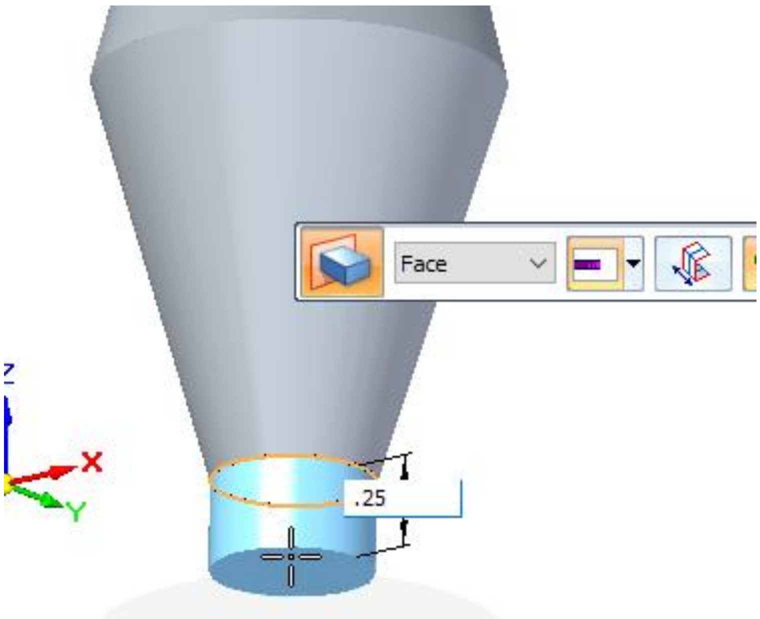
Be sure the arrow points into the stack and click on the top surface of the stack. This will be sure the top of the stack will be open. Select .100 for the thickness.



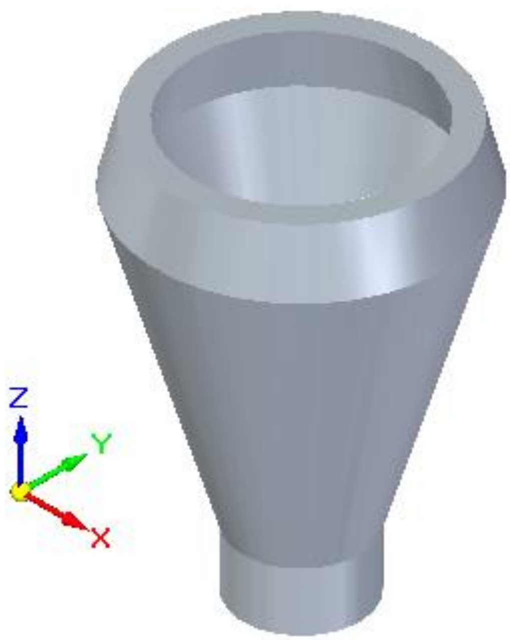
The top of the stack will disappear and the thickness of the walls will appear. Select enter to accept this.



Now rotate the stack to see the bottom of the stack. Select extrude from the solids section of the ribbon and then highlight the bottom of the stack. Extrude downward .25 so this can then be inserted into the train body later.



Save your part.



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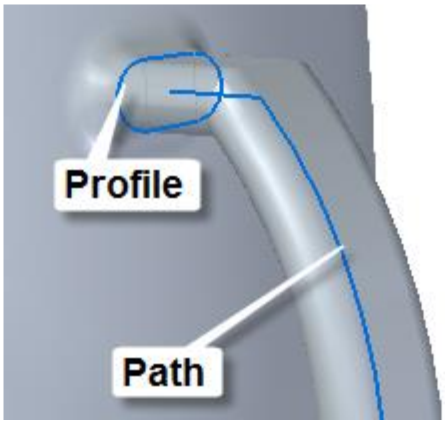
Sweep

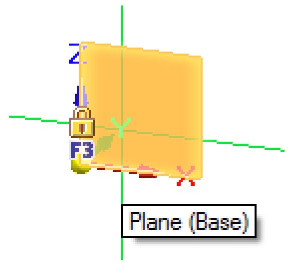
The Sweep command is a tool used to take a profile and move it along an irregular path. An extrusion moves in a straight line. The handle on the mug below was created with a sweep.

A sweep requires a profile and a path. The profile is the shape or cross section, the path is a series of lines that controls the shape.

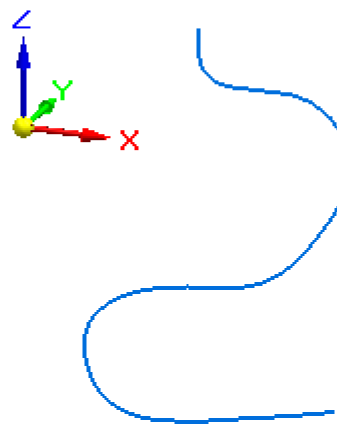


Begin a new part.

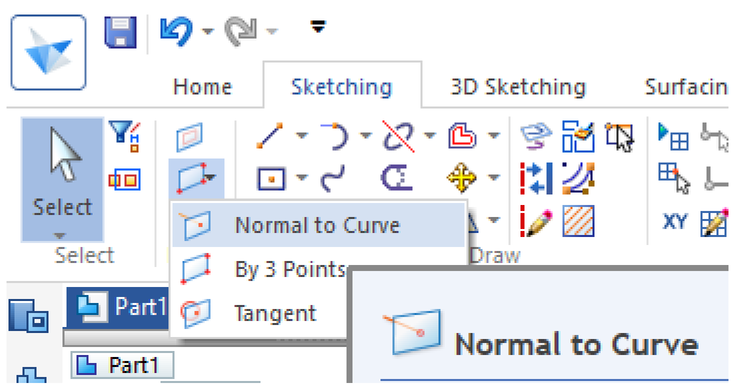
Select a Plane to draw the path upon.



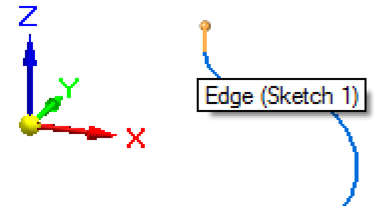
Use a combination of line types to define the path. If the turns are too tight or would cause the shape to intersect itself and an error message will appear when you go to sweep the shape.



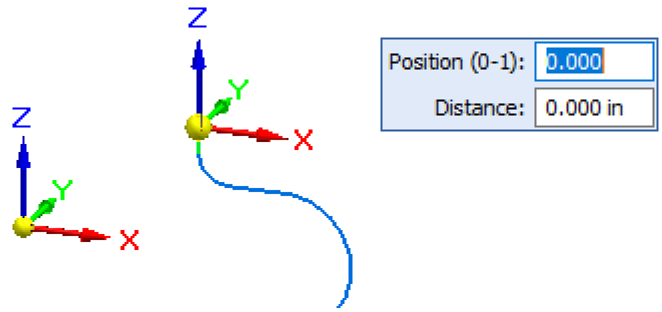
Use the ESC key to end the line command. Once the path is done you need to create a sketch that will sweep along the path. The sketch will work best if it is normal to the path. From the Planes section of the sketching tool ribbon select the option for plane Normal to a Curve.



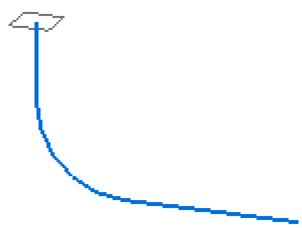
Select the very end of the path line.



Set the position to 0.0 and the distance to 0 in.

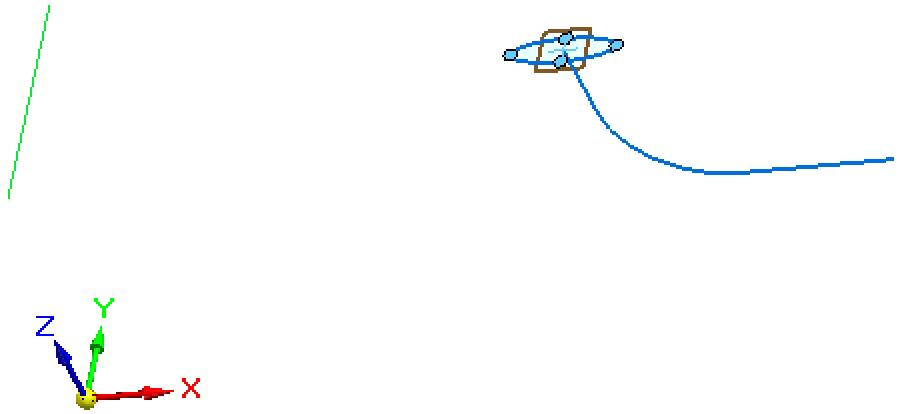


A plane will be created on the very end of the path line.

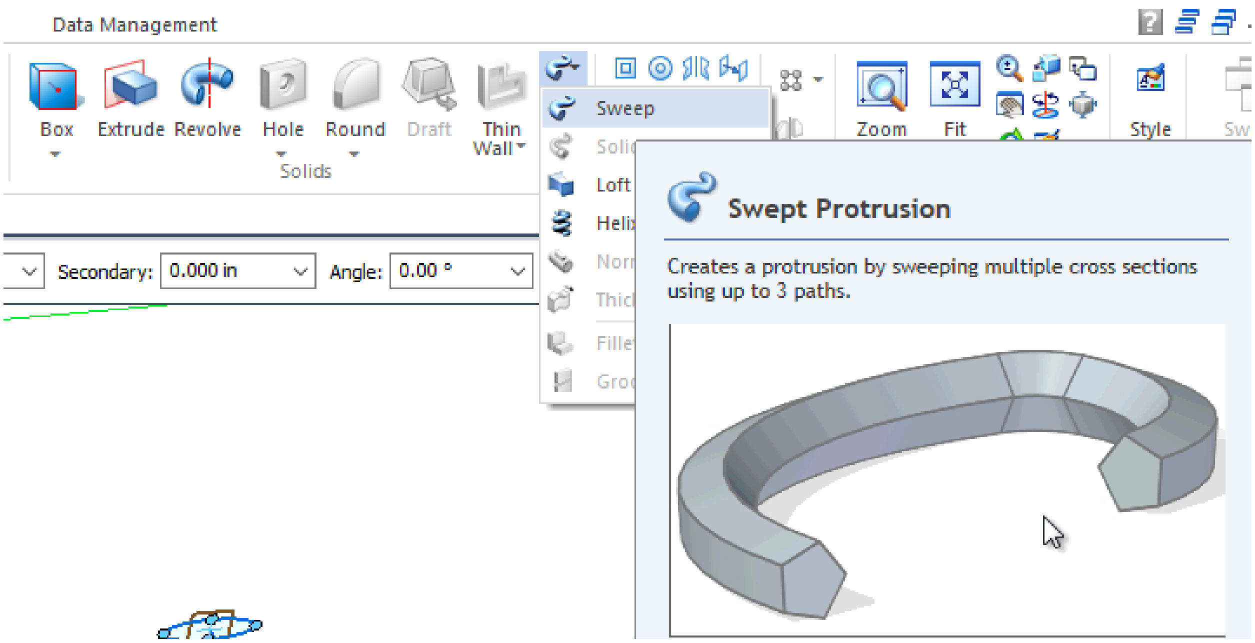


Draw the shape desired for the sweep on the plane at the end of the path.

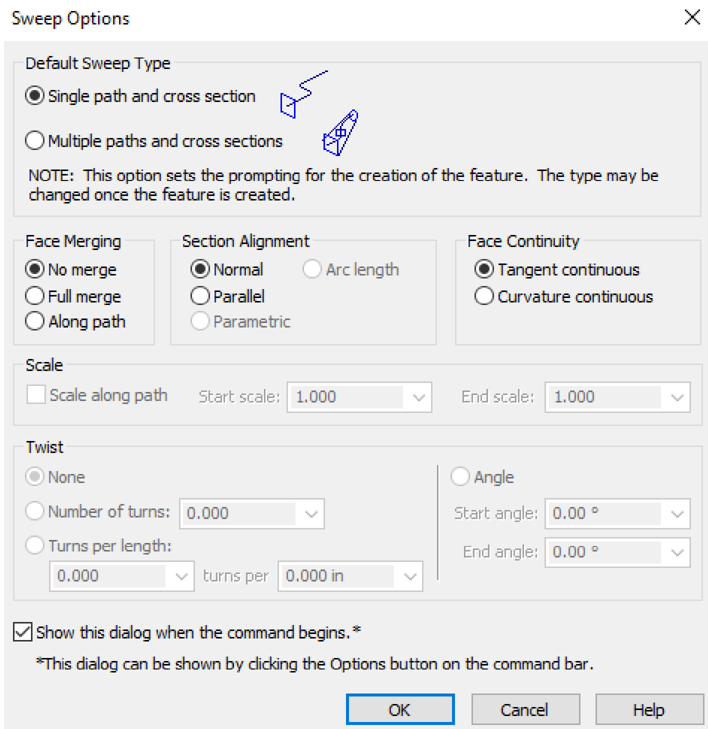
In this example, an ellipse is being created with the center directly on the end of the path. The sketch does not actually have to touch the path but it is easier for beginners if it does.



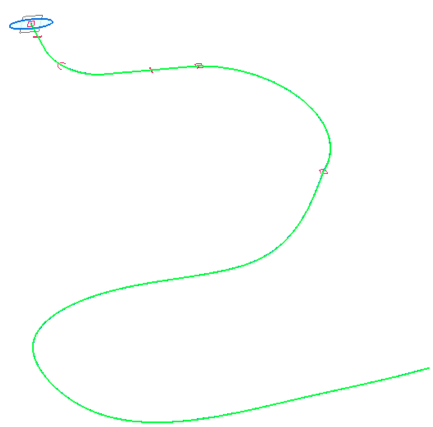
Select Sweep from the Solids Menu of the Home ribbon.



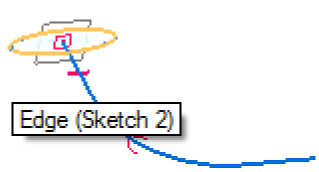
This will bring up the Sweep options dialog box. In this case select a Single path and cross section.



Select OK. In the Sweep dialog toolbar select Chain and then select the path desired.

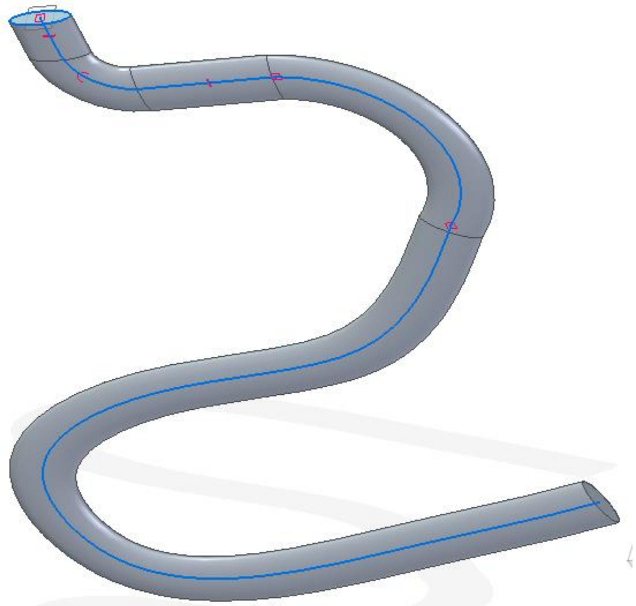


Right click to end the selection of the path. Select the face or sketch from the prompt that makes up the profile or cross-section.



Select your profile.

Assuming there were no errors in the path or profile the sweep will be created.



Save your part.

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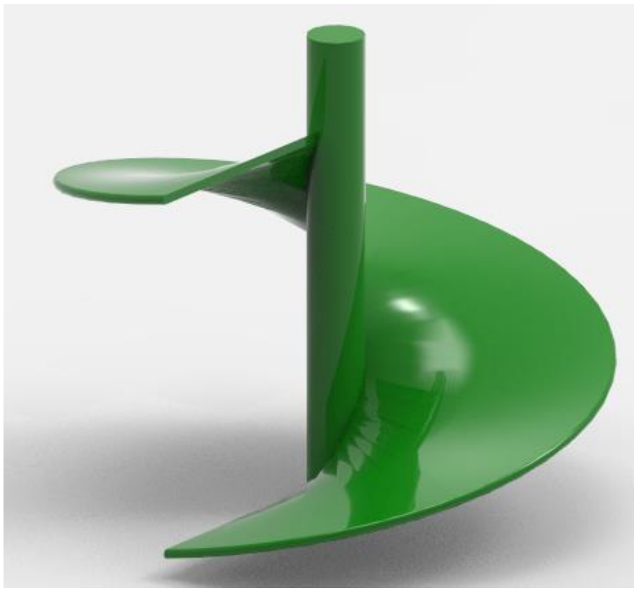
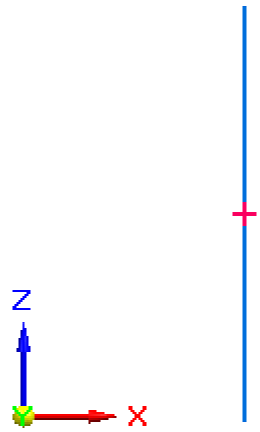
Helix

A helix is a three dimensional curve. There are lots of uses from springs to stairs to screw threads. The image below was the beginning of a slide.

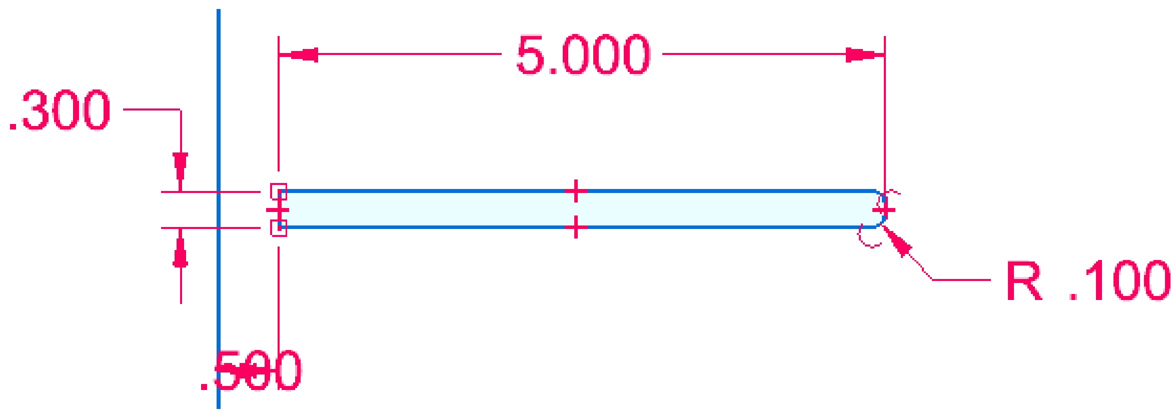


A helix needs two things. It needs a profile and an axis that the profile rotates around. The pitch is the measure of the distance between rotations.

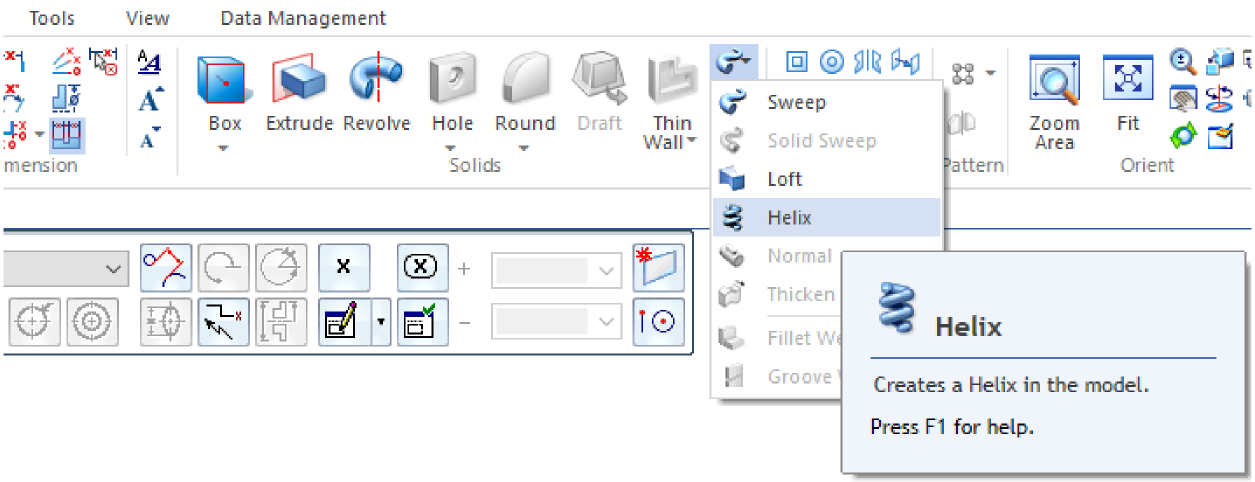
Begin by drawing a vertical line. In this example the line was 10 inches long.



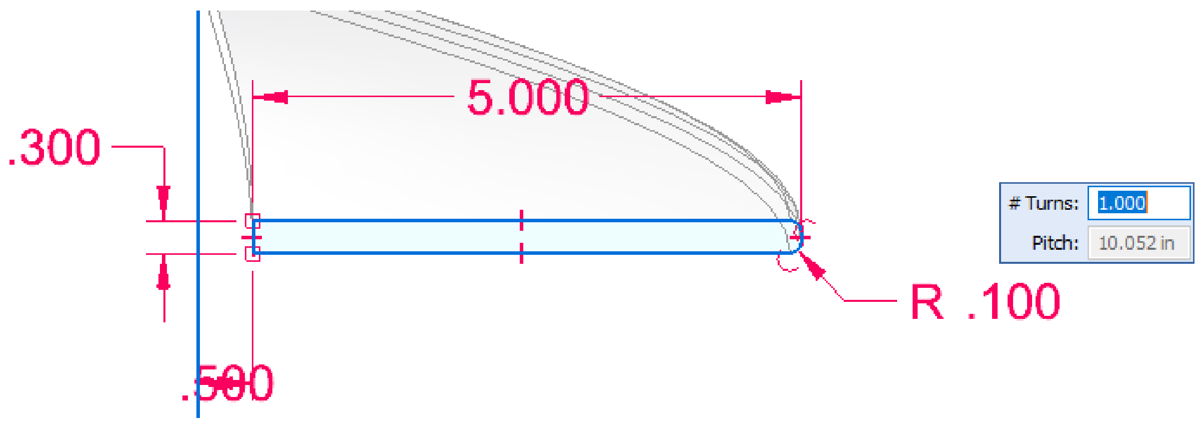
Next a shape was drawn.



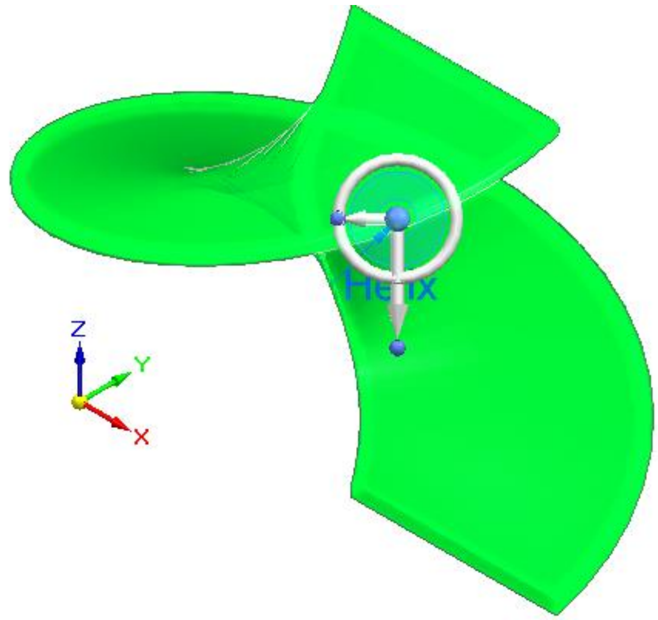
Once the shape is completed select the Helix command from the Solids section of the Home ribbon.



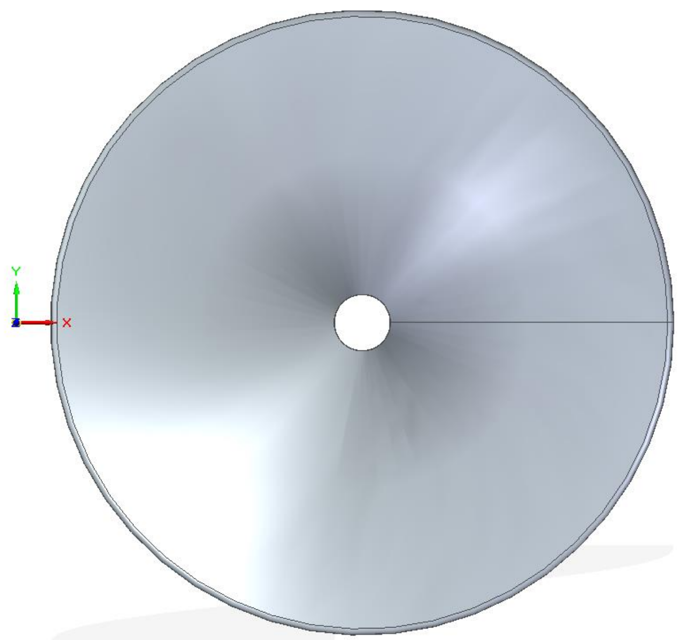
Select the profile or cross section drawn and then the vertical line. Right click to accept. A prompt for the number of turns will appear. In this example 1 was used.



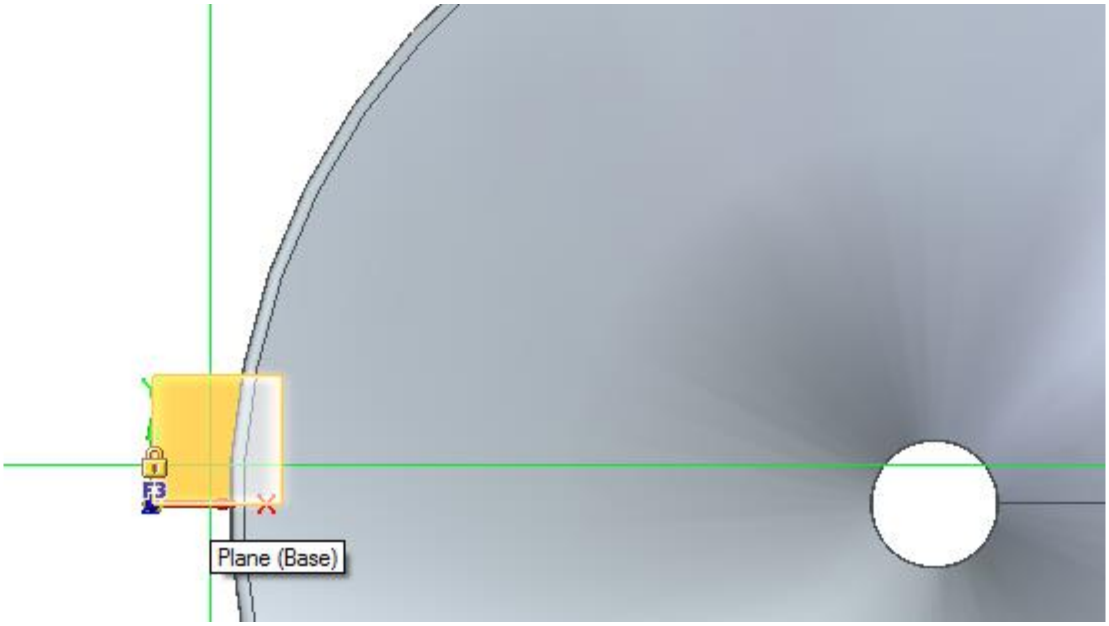
Right click again to accept. The helix appears.



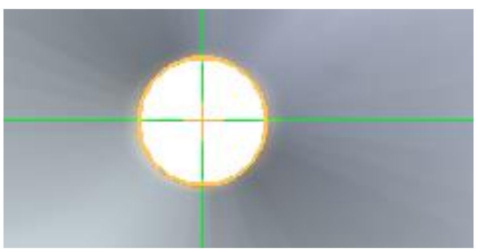
Place your part in the top view.

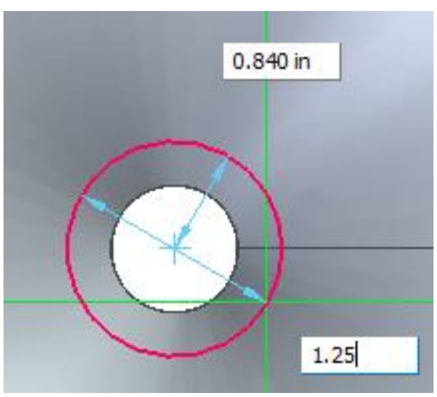


It is time to add the shaft for the center. Select the circle command. Lock the plane to the XY plane.

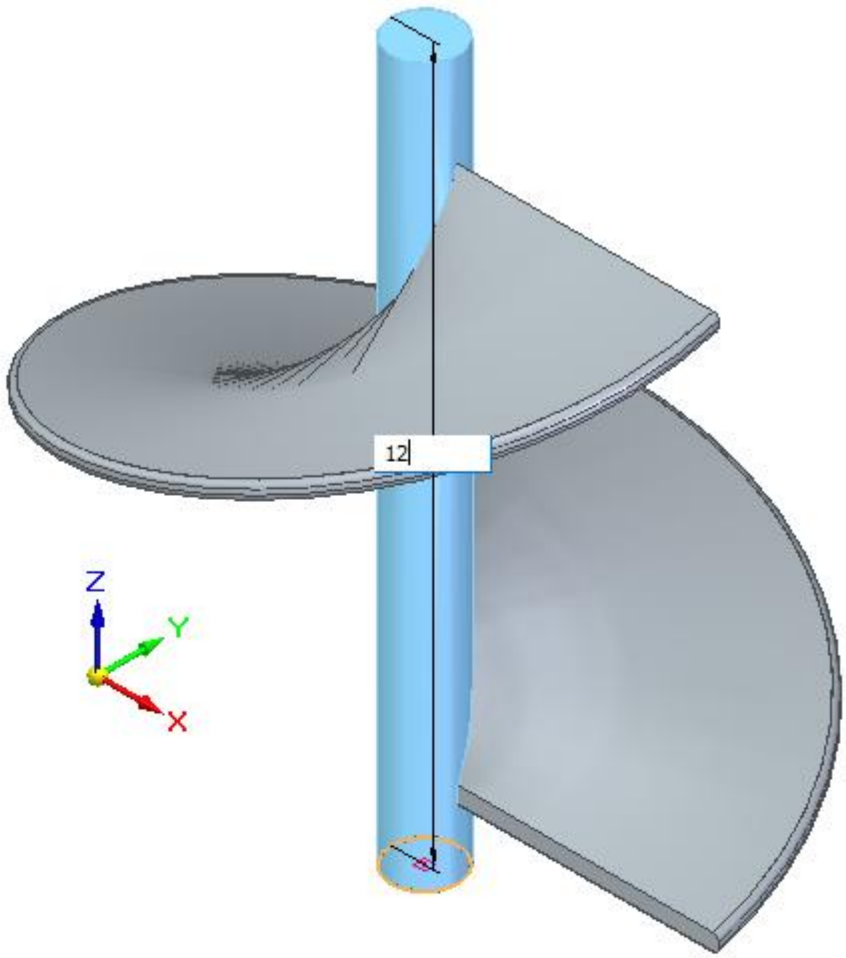


Use the center of the helix to locate the circle. Dimension the circle to slightly larger than the opening of the helix.





Return to the isometric view. Extrude the circle. In this example 12 inches was used.



Save your part.

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Creating Drawing Views

Drawing views are a two dimensional representation of a 3D part. Designers use these views to communicate the shape, size, and finish of a part and how the parts are assembled. The drawings apply international standards that determine how to display information in the proper format. Like an engineering notebook the engineering drawings are legal instruments containing all the available information about a design. It is important to know how to create detailed drawings. Drawings, along with 3D solid models, communicate exactly the designer's intent for the part. Dimension and tolerance describe the exact shape and size of a part to fit with the other components in a product.

There are a wide variety of drawings. Each allows the viewer to see information undistorted in two dimensions. "Working drawings" is the name of the collection of drawings for a product. Working drawings typically contain a collection of different drawings. Drawing creation can be researched in various help menus and reference texts. For more information about drawings you can research:

- Multiview drawings
    - Orthographic
    - Auxiliary
    - Section views
- Annotation
    - Dimensions
    - Tolerance
    - Class of fits
    - Notes
    - Material
    - Finish marks
    - Weldment symbols
- Assembly drawings
    - Part identification balloons
    - Bill of materials
    - Exploded assembly drawings

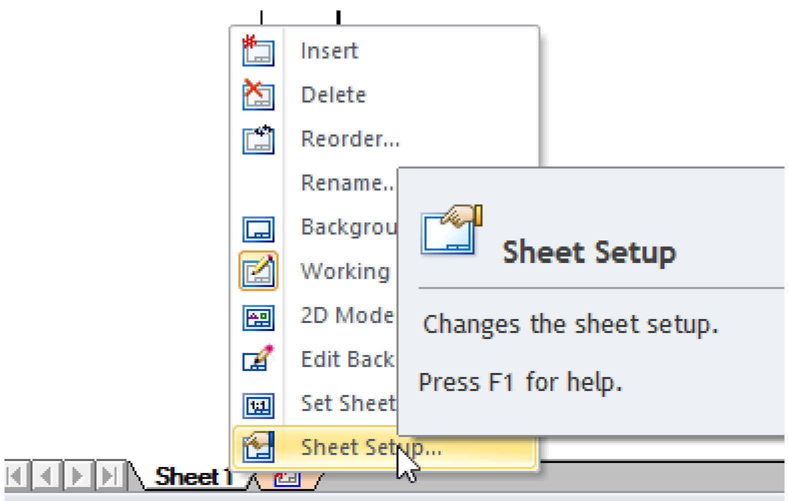
CAD systems have evolved to create lines automatically and allow for the solid model to communicate with the drawing views. In the tutorial that follows we will explore many features of drawing views. There will be faster methods of doing this work and good designers educate themselves on the standards to make communication the central goal. Before beginning this tutorial, create the 3D models of the individual parts.

Setting up the Sheet

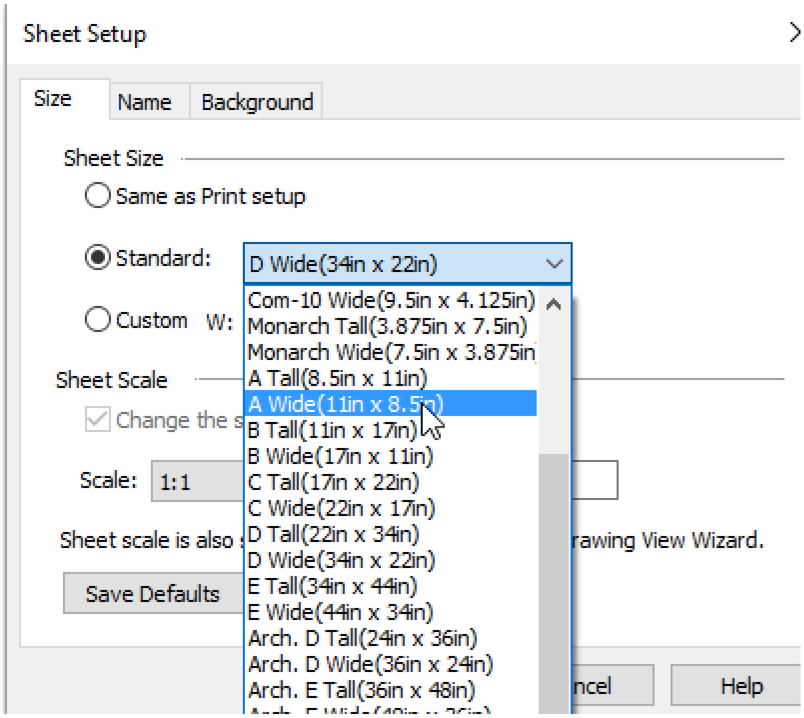
"Drawing sheets" contain information about a part or assembly. Standards define the size and shape of the sheets to allow the viewer of the working drawings to find information quickly. Companies customize sheets and create templates to include information specific to their industry. There is a border on the sheet which limits the formal drawing area. Sometimes there is a location grid included in the border. This is important on large sheets so information can be located quickly. There is also a title block. This block contains information such as the author of the drawing, date, company name, revisions, people that have checked the drawings and other standardized information. Individual companies customize this so it always contains the similar information in the same location on every drawing.

Begin a new Draft document.

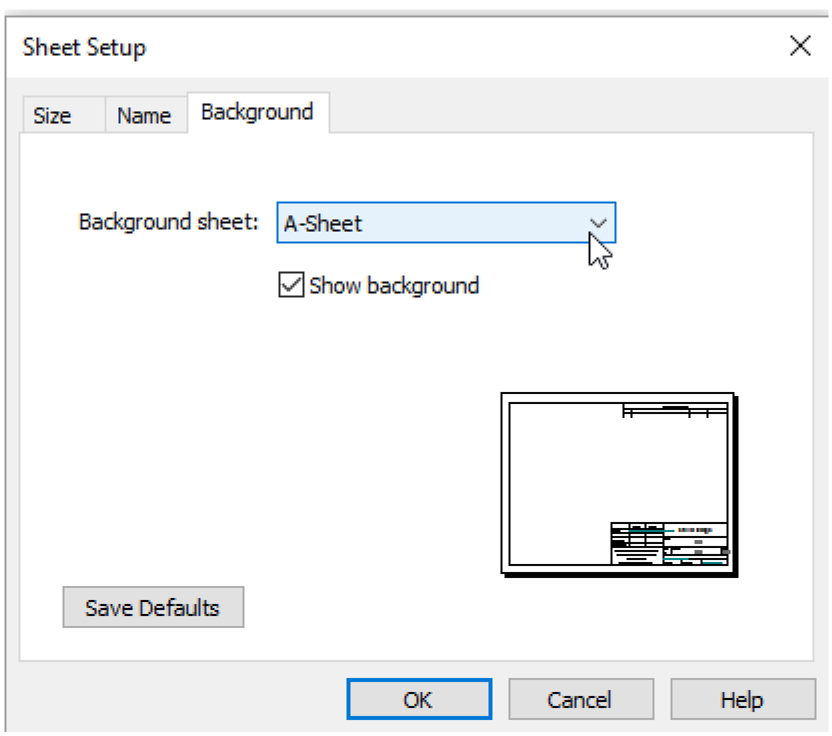
You will see the title block and border. The default setting is for a D sized sheet. This size is too big to print unless a large plotter is available. Most small printers will handle A sized paper. To adjust the paper size, edit the properties of the sheet. Right click on Sheet 1 at the bottom of the screen. Select Sheet Setup from the options.



Begin with the Size tab. Look through the options selecting "A Wide".



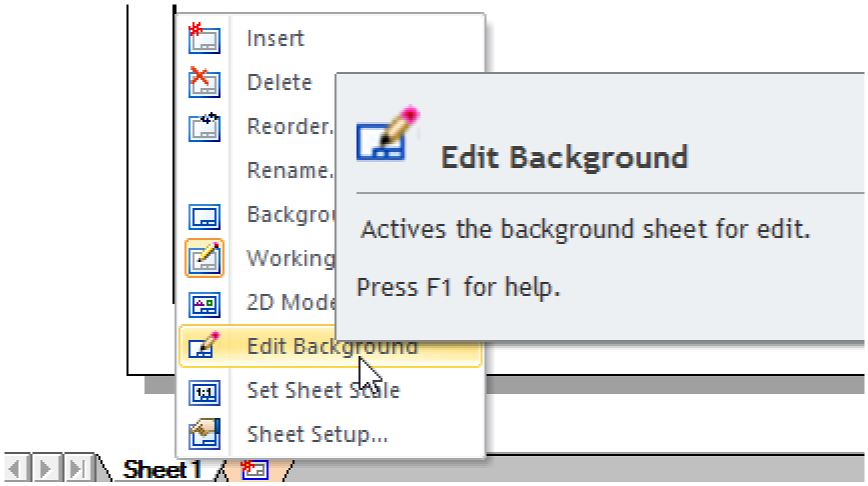
Go to the background tab. Change the background sheet to A-Sheet.



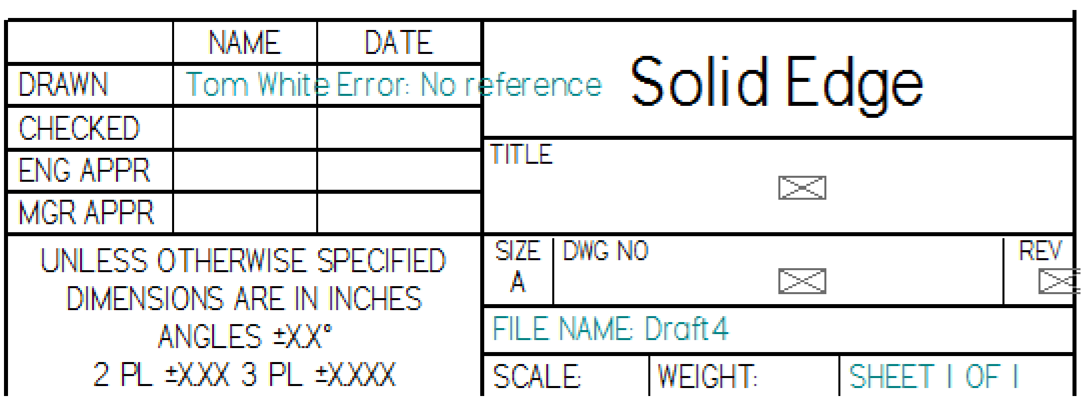
Click on the Save Defaults. Then click OK. This will apply the settings to all the sheets in the working drawing set.

The sheet and background should now appear for an A sized paper. The title block isn't designed for a school. We can edit the background to personalize the sheet.

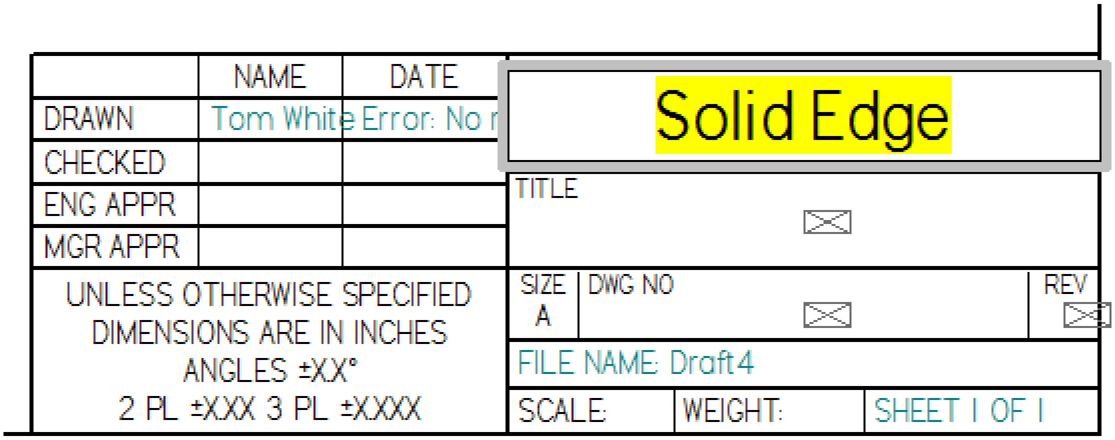
Right click on the sheet 1 again and select Edit Background from the options.



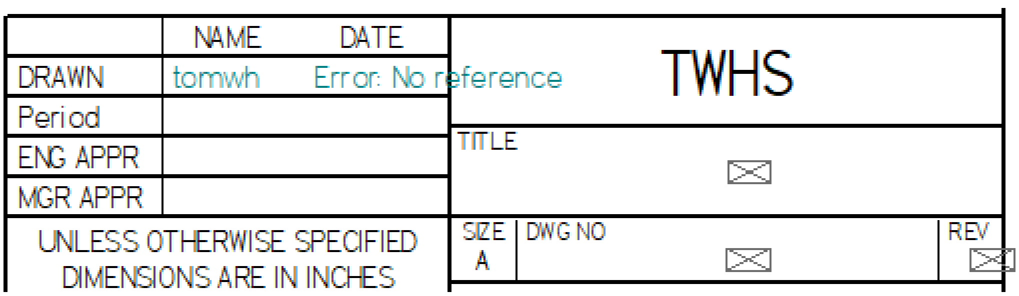
This brings up the background for the A-sized sheet. If you look at the title block you see the name is crowded. It is really set up for initials not a name. We will edit the block to personalize the sheet for use.



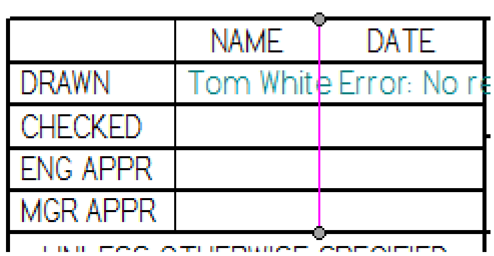
Where it says "Solid Edge", highlight by swiping across the text.



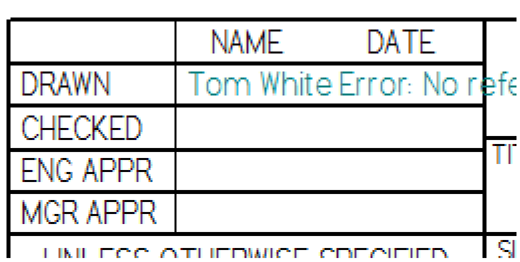
Change the text so your school name is listed.



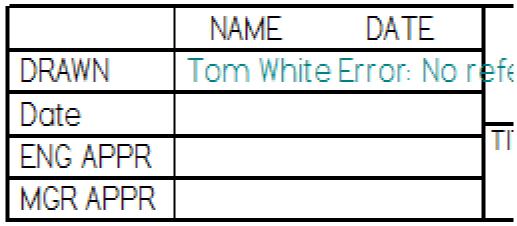
To provide more room for your information delete the line between name and date. Click on the line to highlight the line.



Select your delete key to remove the line.

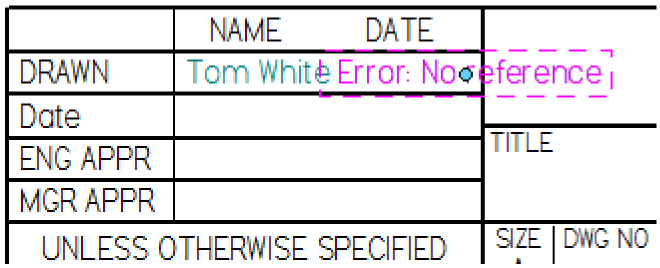


Now change the "Checked" label to the word "Date" by highlighting and replacing it.

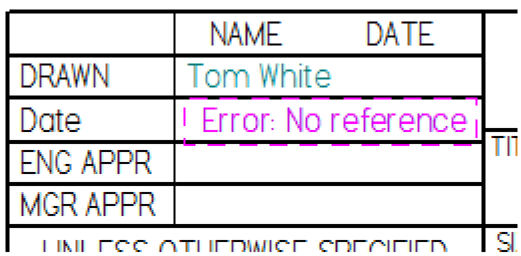


Now we have a place to put the automatic date. Left click where it says Error: No Reference.

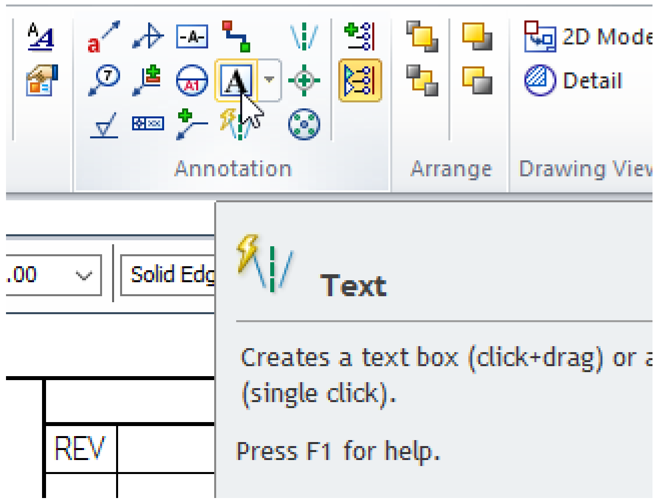
It will highlight and a blue dot will appear in the middle.



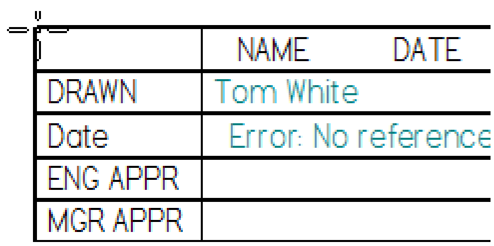
Left click, someplace in the box and drag the text so the blue dot is in the center of the block next to the word Date. Remember Ctrl Z will undo the last action if necessary.



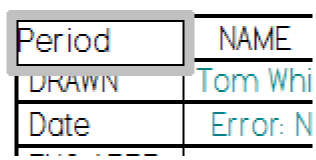
From the Sketching ribbon select the icon for text



Click the top left hand box of the title block and drag to the opposite corner to place a label.

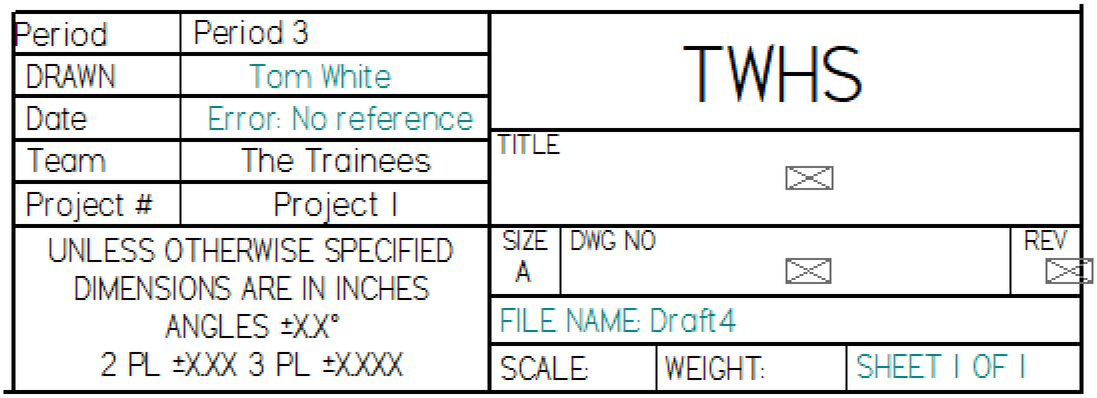


Type the label “Period” in the box.



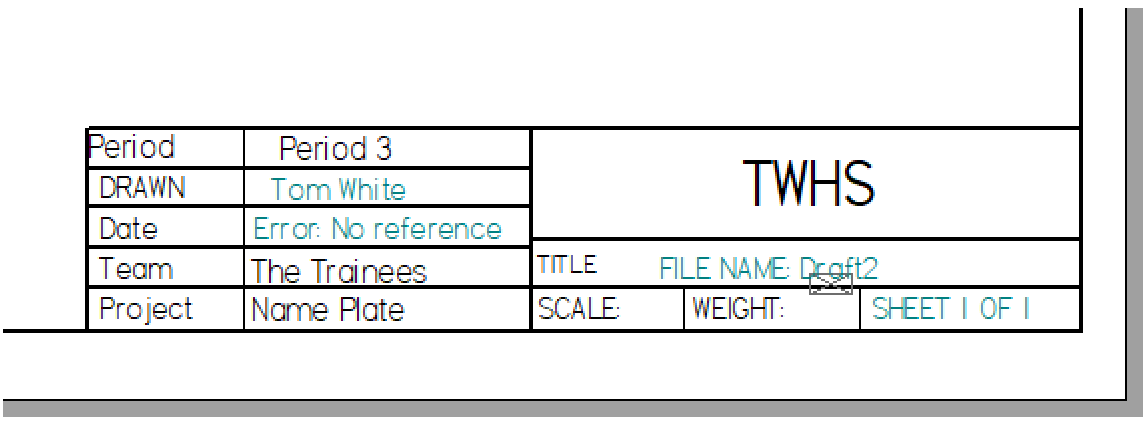
Now delete the text next to period and place your period number in the space.

Add your team name and other information to personalize the sheet.

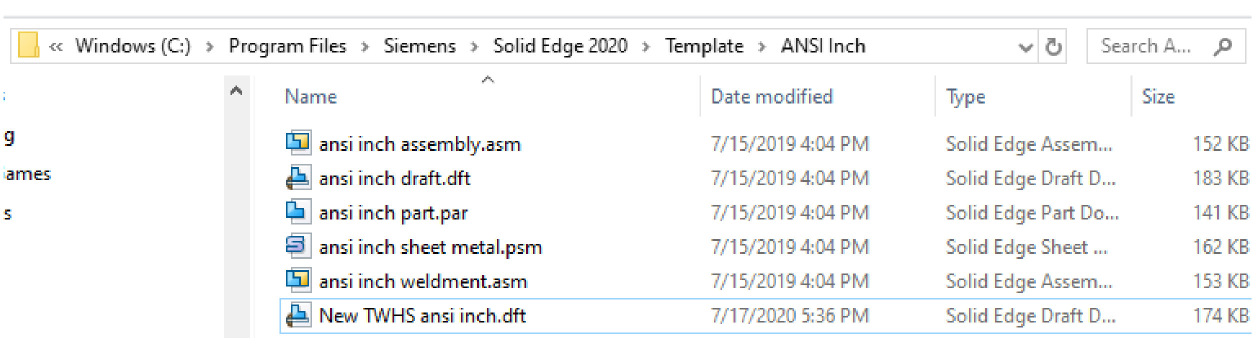


Delete lines and unused spaces to provide more space to place drawing views.

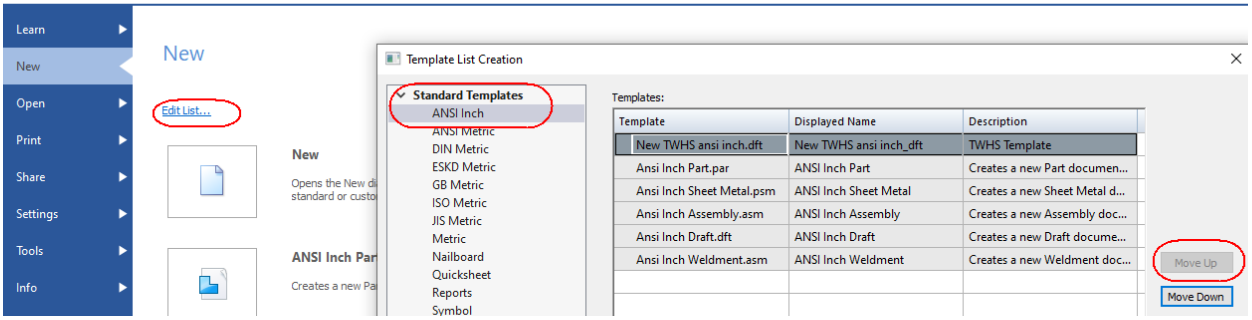
When satisfied with your title block, right click on Sheet 1 and select Background. This will turn off the background sheets and your title block will show. As you add sheets to the set of working drawings you can select the sheet setup and select the A background and all the data appears as edited. When you save your Draft with a name you will see the date and name appear on the sheet. New sheets will update with a new sheet number.



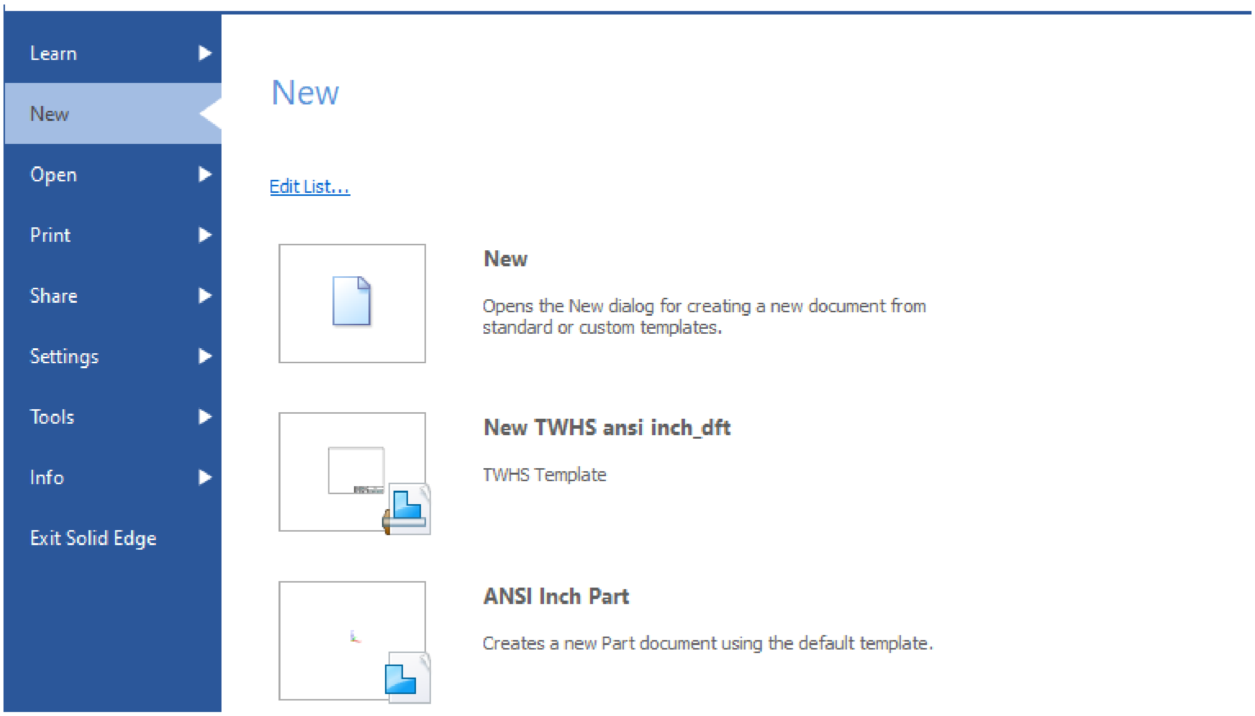
To use this as a template for your students save the blank draft file with a unique name to the template folder for the standard you are using. In this case the location is C:\Program Files\Siemens\Solid Edge 2020\Template\ANSI Inch.



Select New from the Application button menu. Click on the Edit list button. Select the template folder you saved the template to. Use the move up button to move it to the top of the list or where in the list you want it. Click OK



Then when you select New you will see the file you created and named.



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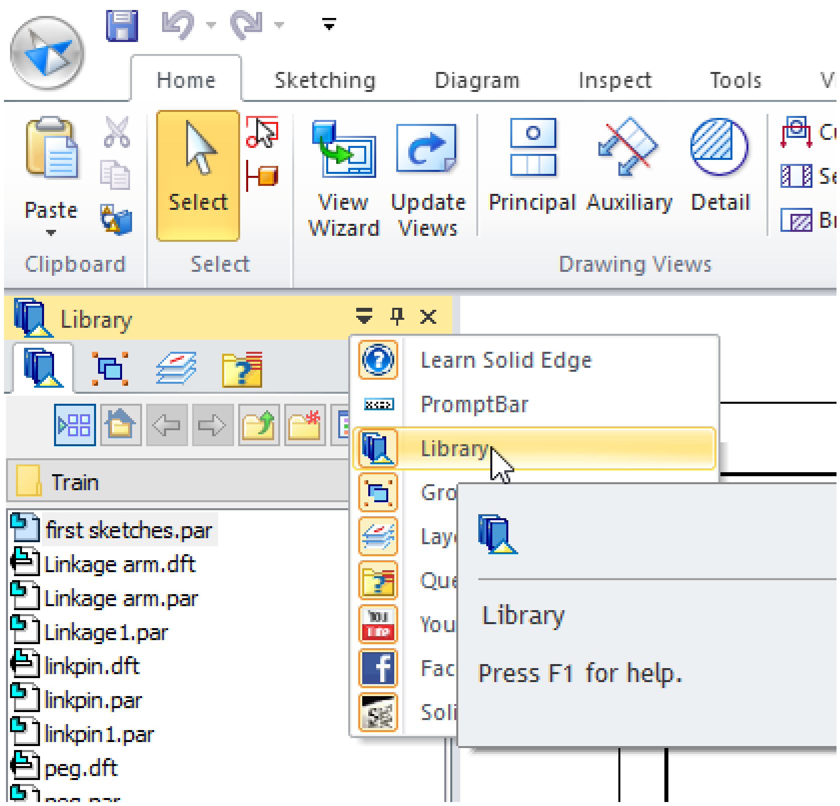
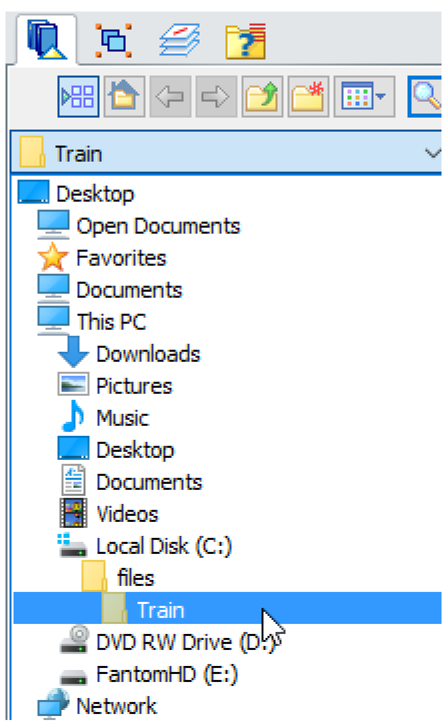
Basic Views

Once you have the correct title block and information, the process of creating drawing views can begin.

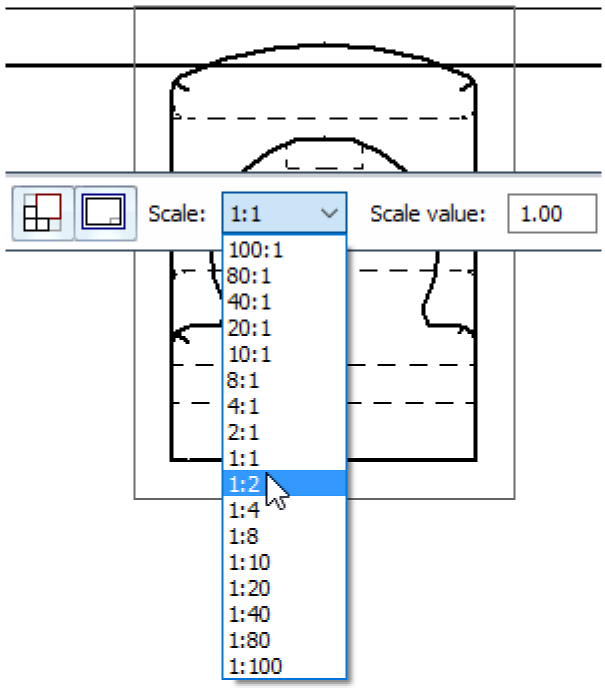
To begin creating views access the Library.



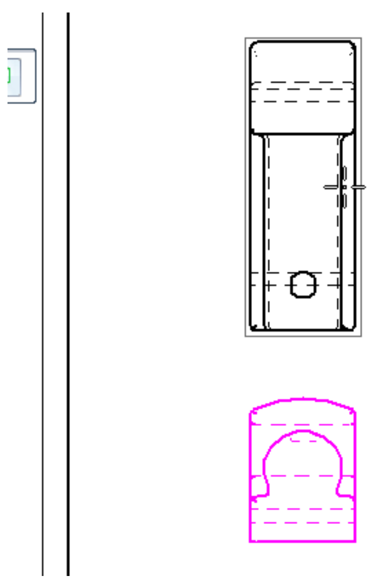
Navigate to where your parts are stored.



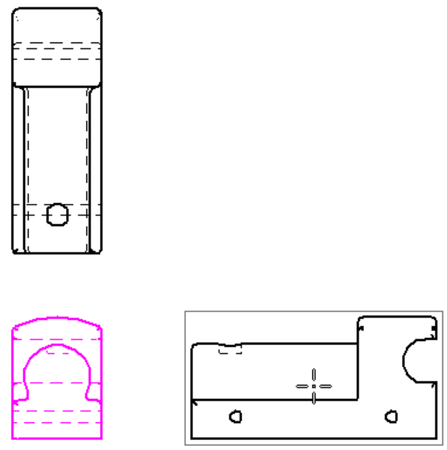
Once in your directory you will see the saved parts. Left click on the train body and drag it out to your sheet. Depending on the size of the parts you have drawn you might have problems fitting them on the paper. Use the scale setting to adjust the size of the view.



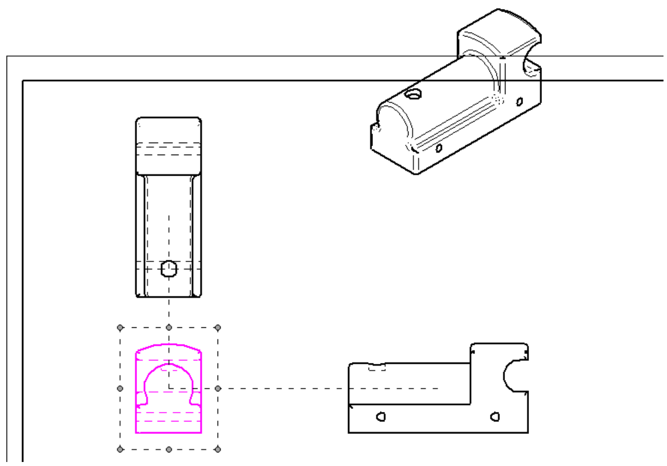
For this one use a scale of 1:2. Once the ratio is selected the drawing will shrink. Move it to the lower left hand section of your drawing sheet and left click to place it. Slide the mouse above the view you just placed and left click again to place the top view.



Now move to the right of the original view and click to place the side view.

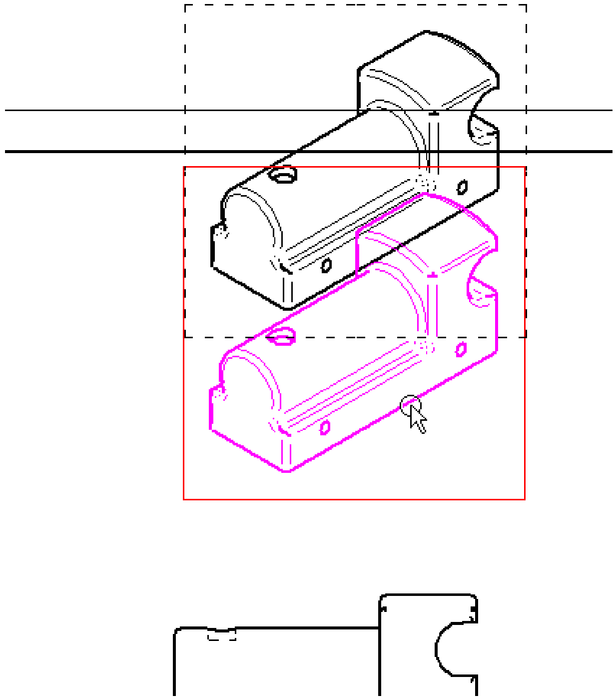


Move the mouse to a diagonal from the original view and this will create the isometric view of the train body.

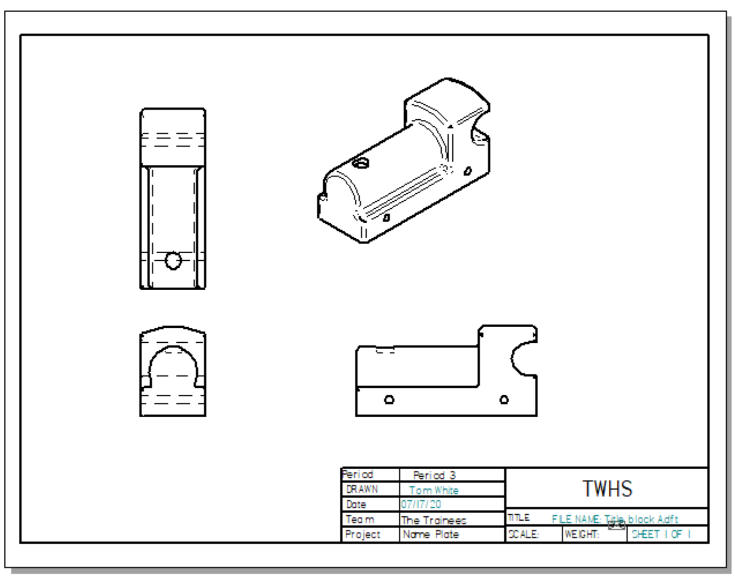


Hit the Esc key to exit the command.

Don’t worry about the actual positioning at this point. Once the views are placed you can then move the views as desired to make room for dimensions or fitting them inside the borders. To move a view, click on a line of the view. It will highlight and you will be able to drag it to the position you wish.



Let go of the mouse button and the view will be in a new position. Practice moving views.



Save your file.

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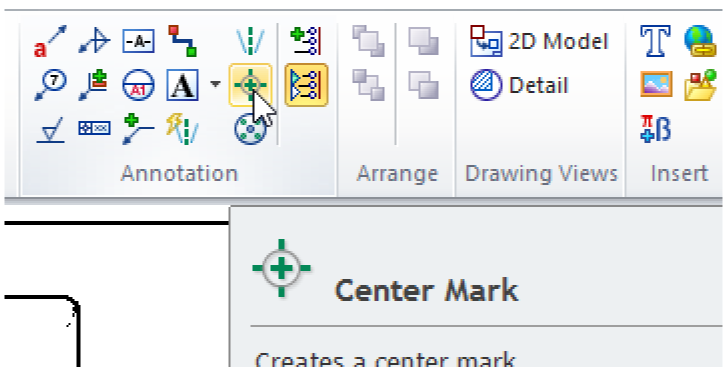
Adding Dimensions and Annotations

Dimensioning a view shows size, location, and the orientation of the various elements in the drawings. Annotations are text and graphics that give information about the design. More information about dimensioning and annotation standards can be found in reference texts and help menus. Search for dimensioning overview. It is the combination of the dimensions and annotations that provides the reader the completed design intent.

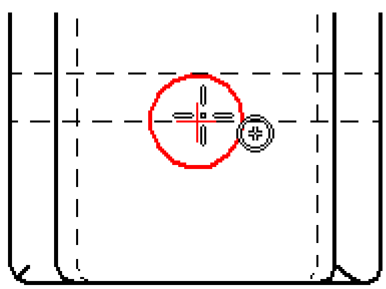
Dimensions and annotations should appear in the views that best show the intent of the designer. In the train body there are several circular features. To dimension circular features, use centerlines so the reader knows the distance to the centers.

This example has magnified the dimensions to be easier to read.

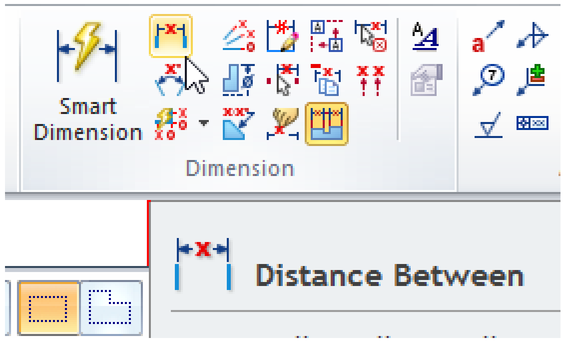
The top view contains a hole where the stack will fit. Begin the dimensioning by adding a center mark. Select the center mark from the annotation section of the ribbon.



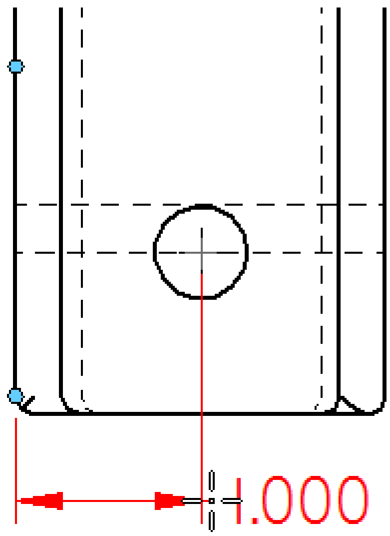
Slide the mouse over the hole and select the center of the hole.



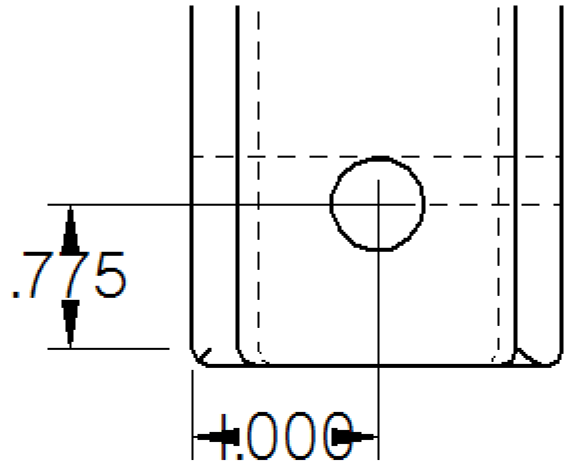
The center is now defined. Measure from the edge to find the exact placement. Use the Distance Between option to place the dimension.



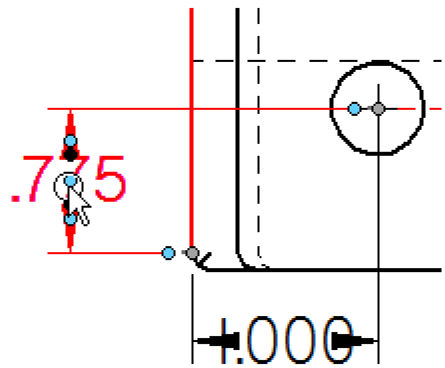
Select the edge of the train and the center mark of the hole. Slide below the top view to position the dimension. Hit the esc key to exit the command.



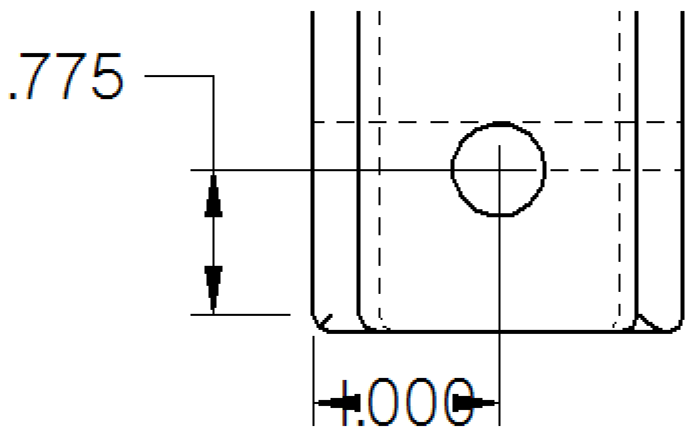
Select the same two places only slide to the side and the distance to the center from the front of the train will appear.



While the dimensions are correct they are difficult to read. Hit the esc key to exit the dimension command. Click on one of the dimensions to see the grips. Grab the blue grip in the middle of the dimension.

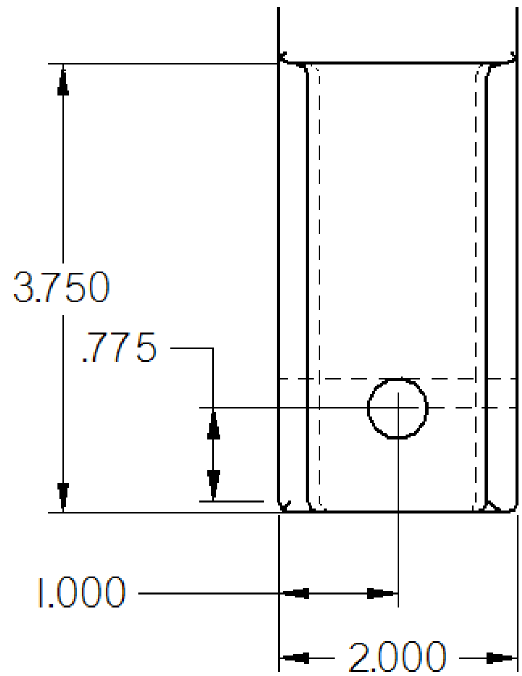


Move your mouse up above the extension lines to move the dimension outside of the lines.

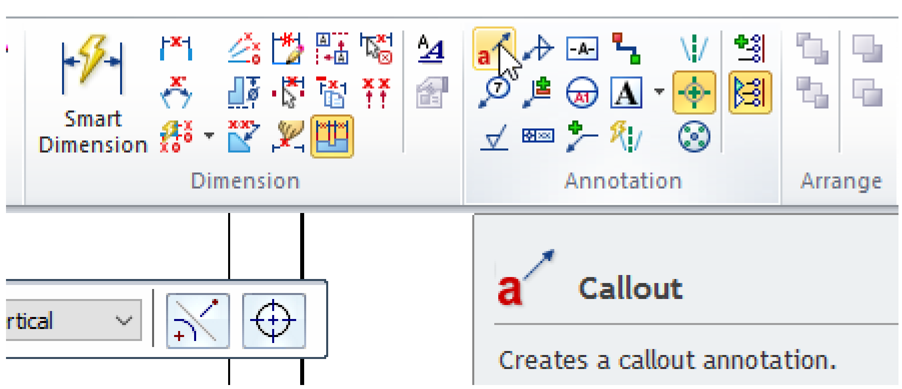


Repeat the process so the other dimension is readable.

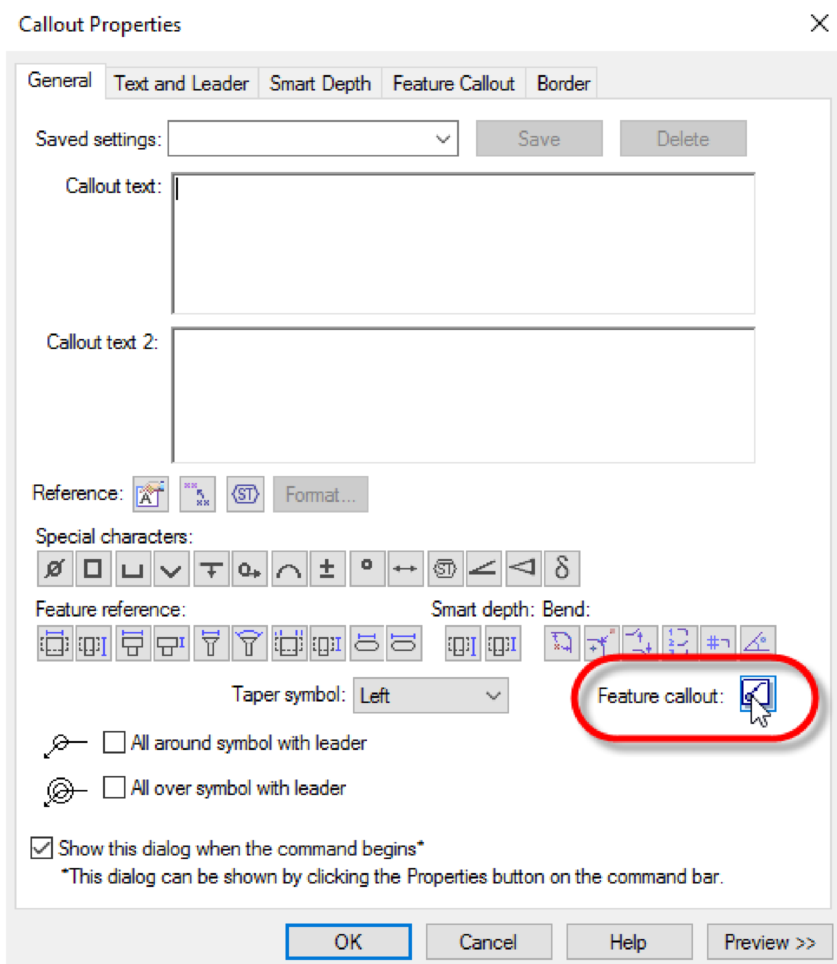
Add dimensions to match the picture below.



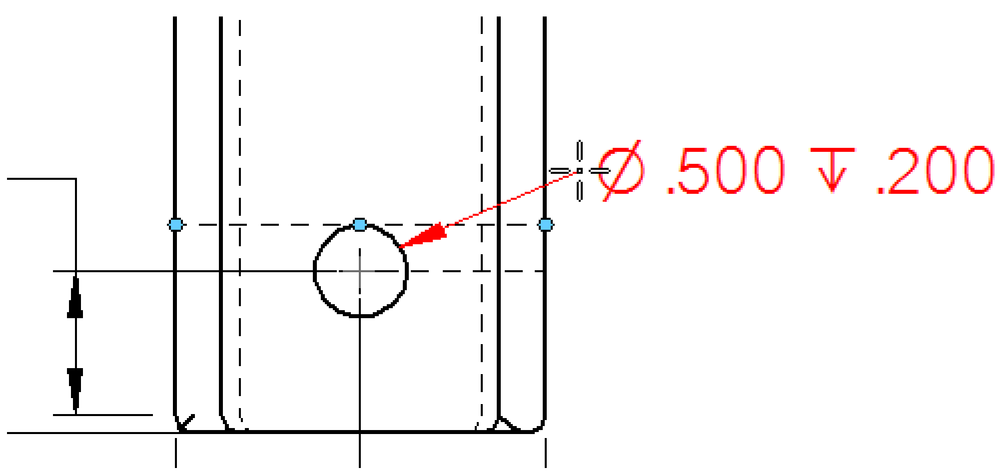
Add a note to let the viewer know the size of the hole. Use a callout to add clarity about a feature, calling the reader’s attention to a specific location. Select callout from the annotation section of the ribbon. For more information hit the F1 key.



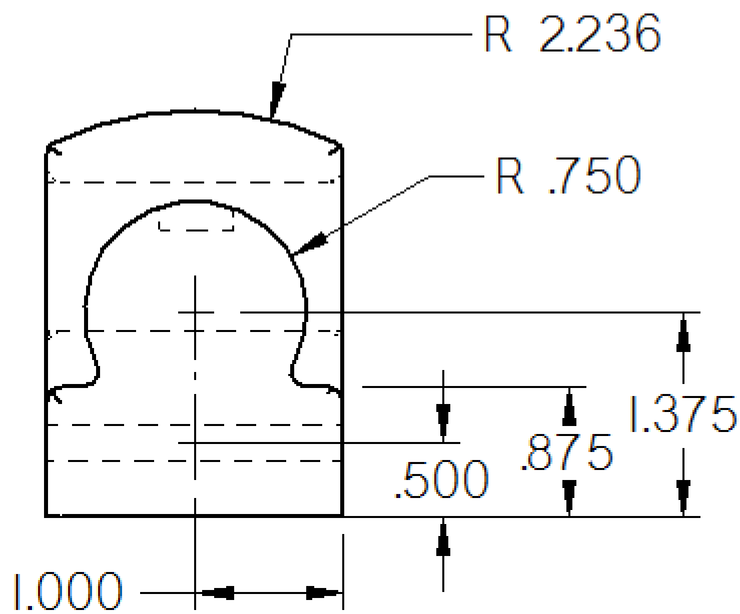
In the Callout properties dialog box, erase the current callout text. Then click on the feature Callout button.



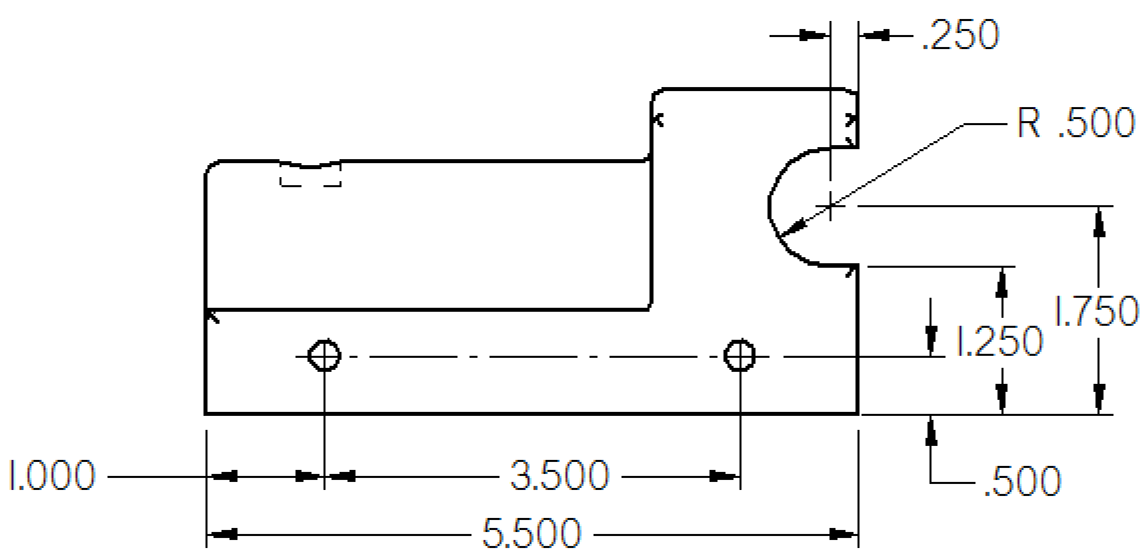
Select OK and then click on the circle representing the stack hole. Move off the hole and click to place the hole note. This lets the reader know the hole is .500 in diameter and .200 deep.



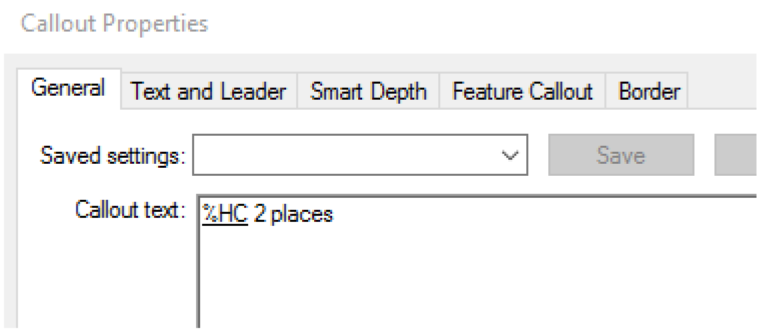
Add center lines and marks to the front view to communicate the centers of the important arcs. Dimension the front view to resemble the picture below. Notice how the dimensions are organized so the reader can quickly find the desired dimension.



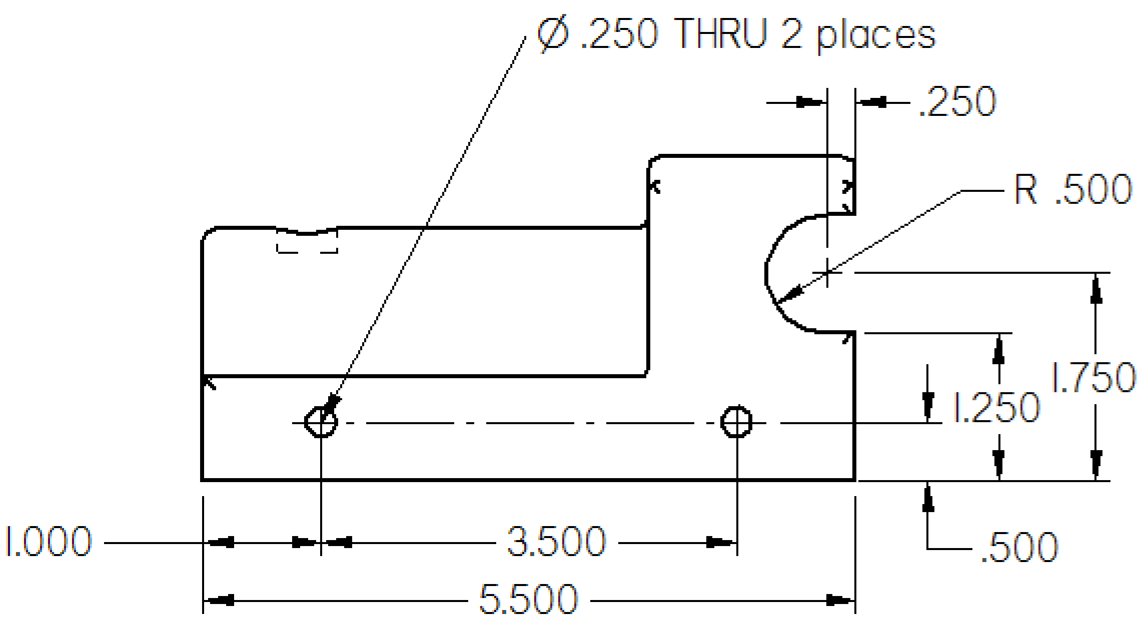
Add center marks to the side view and add dimensions.



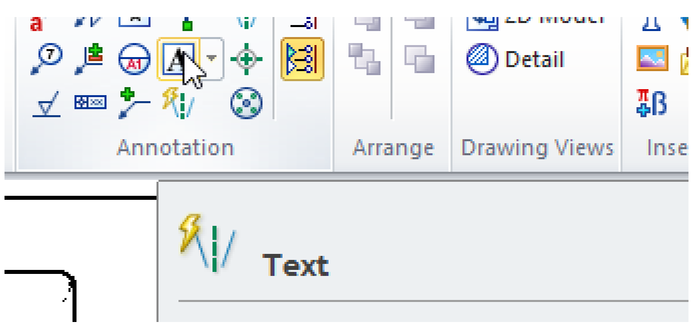
Add a callout to dimension the holes. Since the holes are the same we can use one callout for them. Select the Callout command. This time click on the Feature Callout button and then type in “2 places” after the command in the callout text.



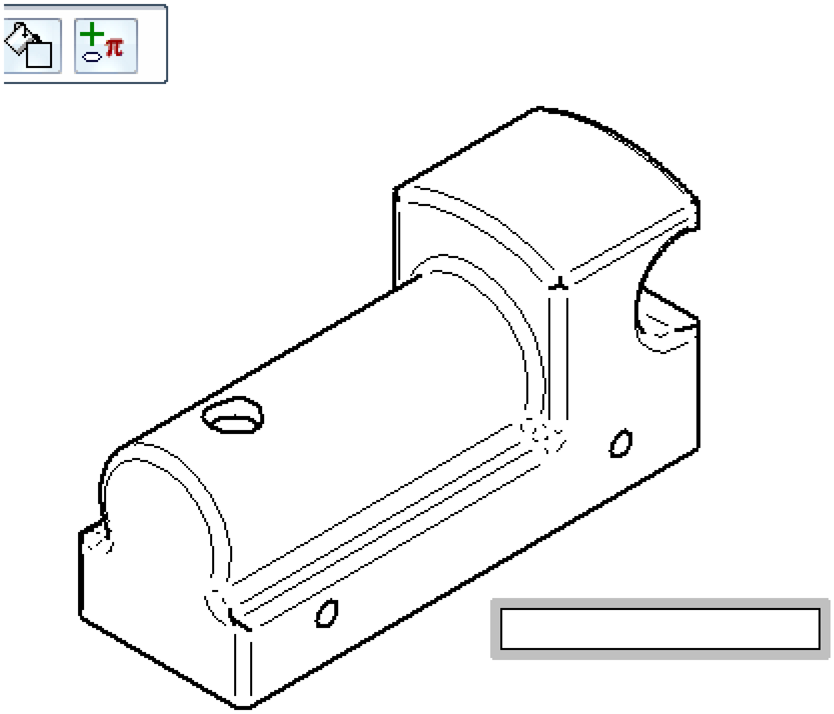
Select OK and highlight one of the holes to place the note.



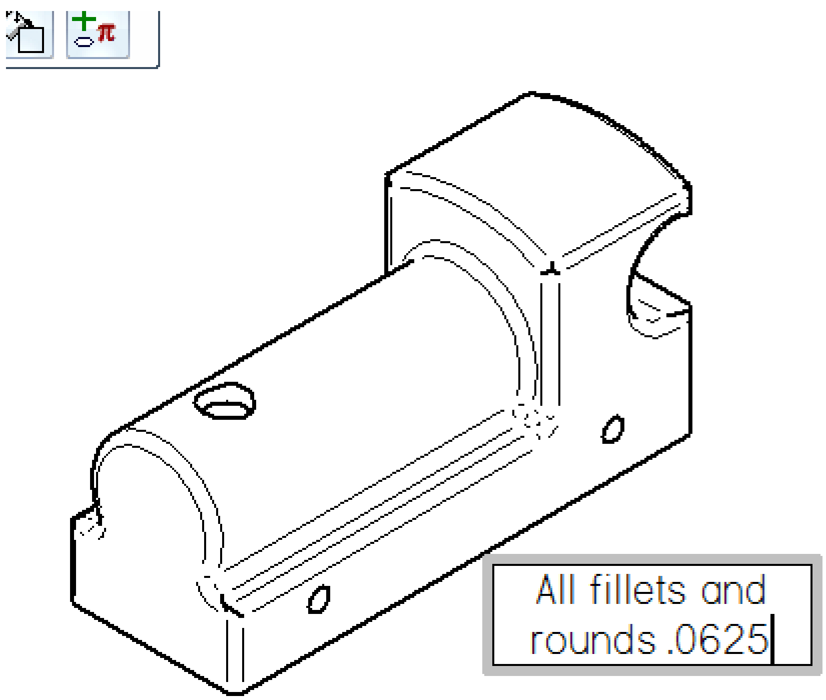
To complete the annotations add a note about the fillets and rounds on the train body. A note that is general about views can be placed where it will be seen. Select the Note icon from the Annotation section of the ribbon.



Drag a rectangle on the screen where the note will be located.



When the dialog box opens, type the following into the box.



Save your file

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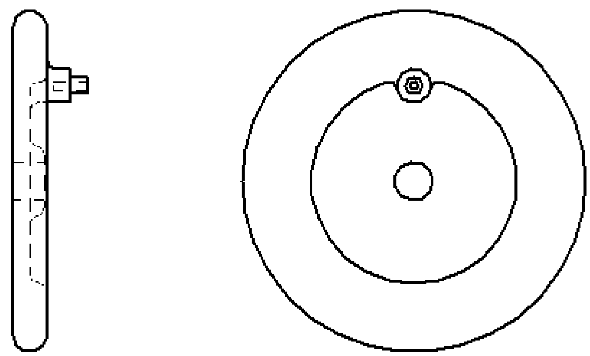
Section Views

Occasionally, normal views of a part do not show hidden detail. Additional views are needed when detail is obscured by the part itself. A “section” view is what would be seen if the part was sawed horizontally through a part and looked at the cut edge. Designers use a line called a cutting plane defining where the cut is and the arrows at the end indicate the orientation.

Begin a new drawing sheet in the working drawings.

Drag the wheel from the Library onto the work area. Use a scale of 1:1 placing a front view and right side view.



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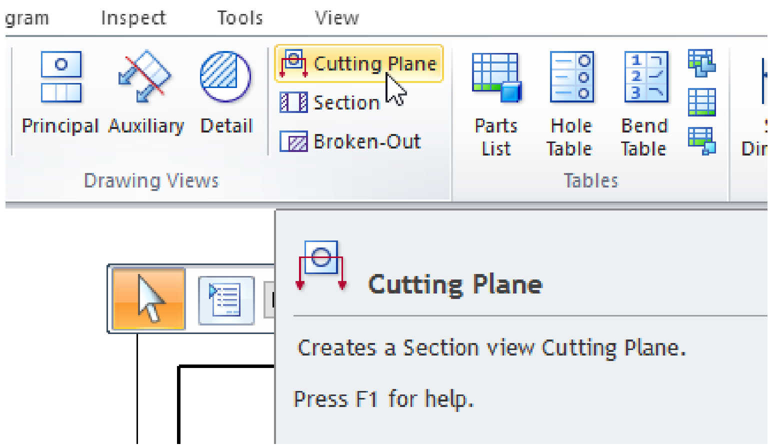
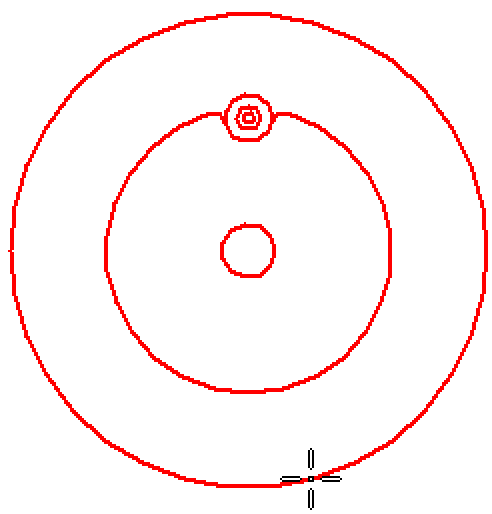
Cutting Plane

To create a section view, create a cutting plane. A cutting plane is an imaginary plane used to show where a part will be split for a section view. The simplest is a single line through an object. If there are multiple things to show that are not in a line the section plane can be created to pass through several points as long as the lines touch each other and don’t form a closed region or loop. Check a reference text for section views and cutting planes. Use the F1 key for help during the command.

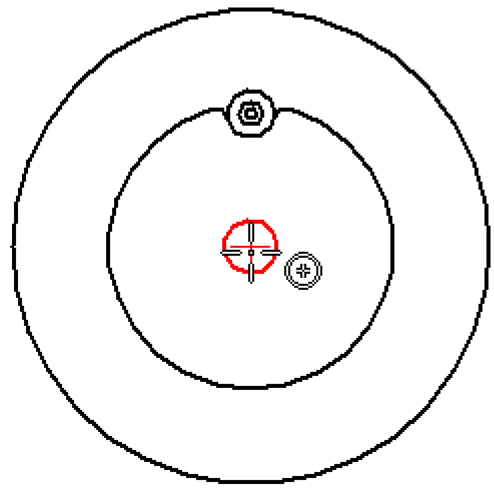
Select the Cutting Plane tool from the Drawing Views section of the Main ribbon.



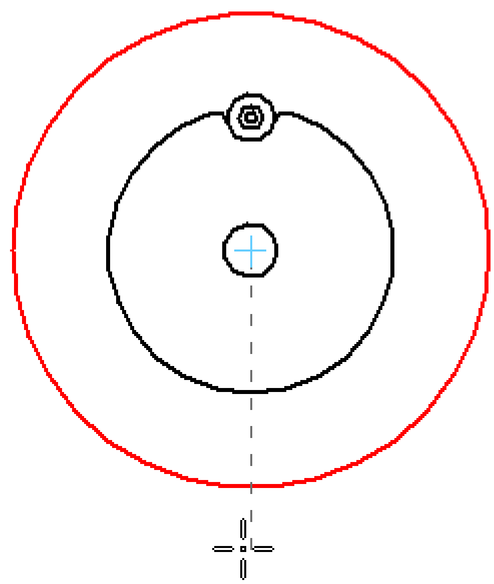
Click on the view that shows the circular nature of the wheel.



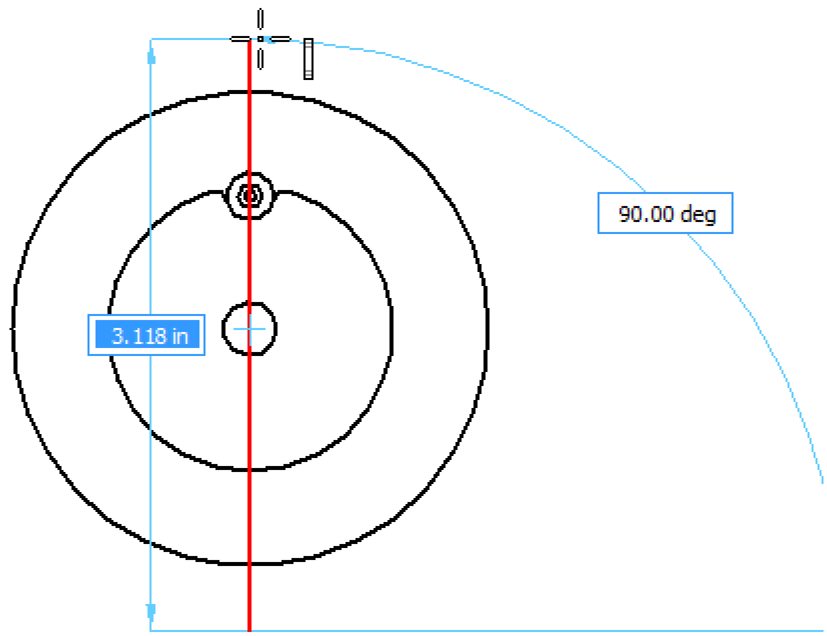
The screen will change and prompt for the first point. We want a line right through the center of the wheel through the cylinder for the linkage rod. Hover over the center of the wheel until you see the center mark appear.



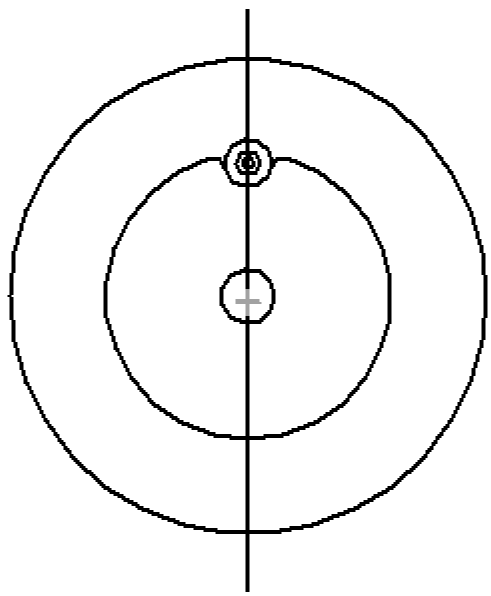
Do not click here but move the mouse straight down. You will see the intelligence of the program figuring out you want a line through the center.



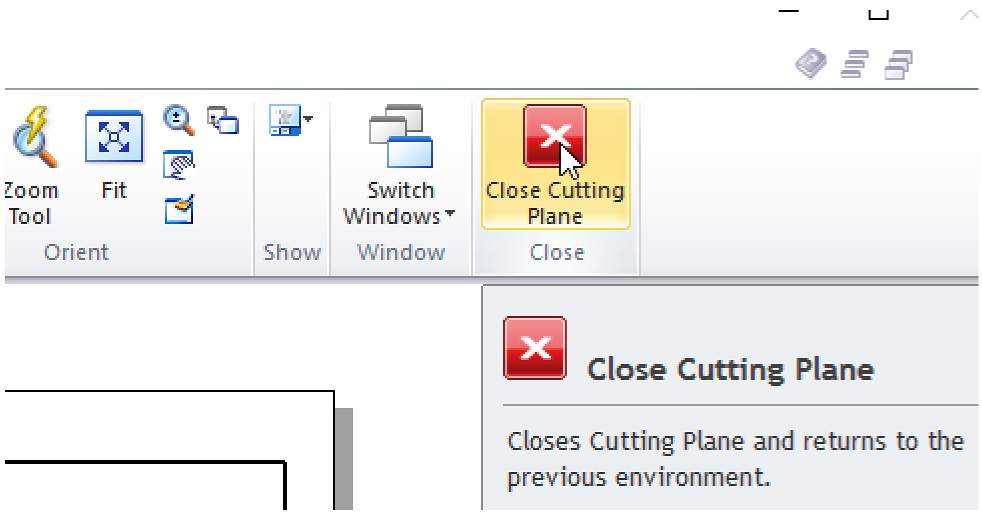
Click below the wheel. Then move your mouse straight up past the top of the wheel to click again. This will create a line through the center of the wheel.



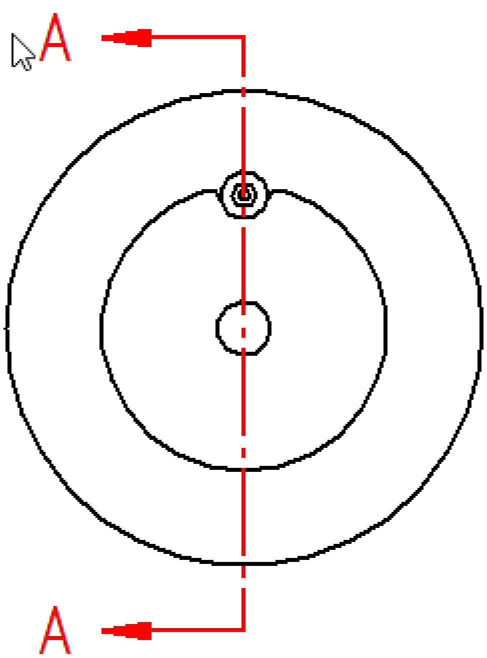
Hit the esc key to indicate you are finished. The line drawn will appear.



From the ribbon select the Close Cutting Plane icon.



A prompt will appear to select the side view desired. Move your mouse toward the left side of the screen and click. You will see two arrowheads appear with a letter next to each. The first section is labeled A-A. The second is B-B etc.



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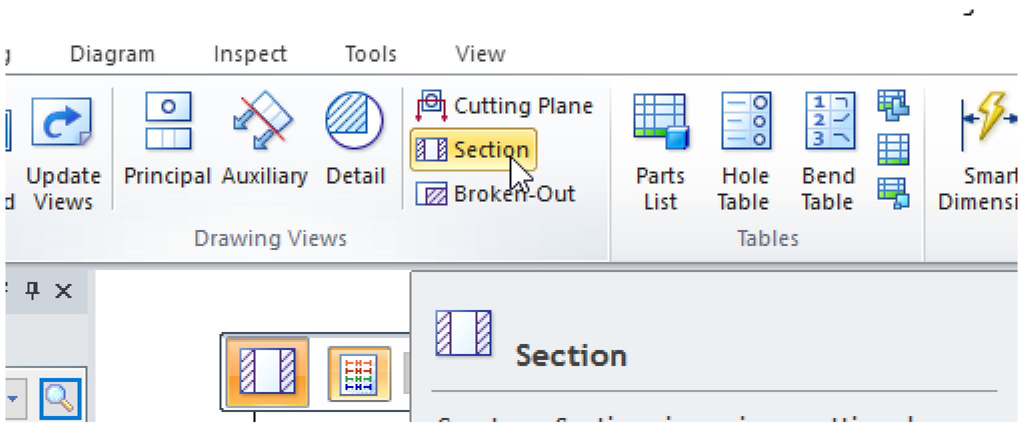
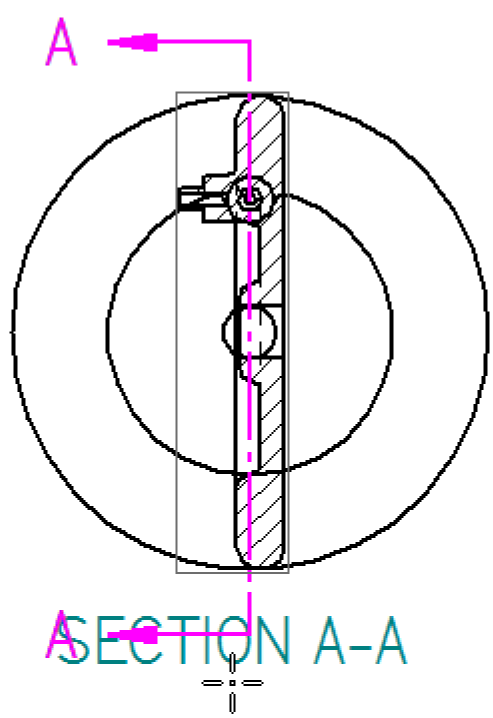
Full Section

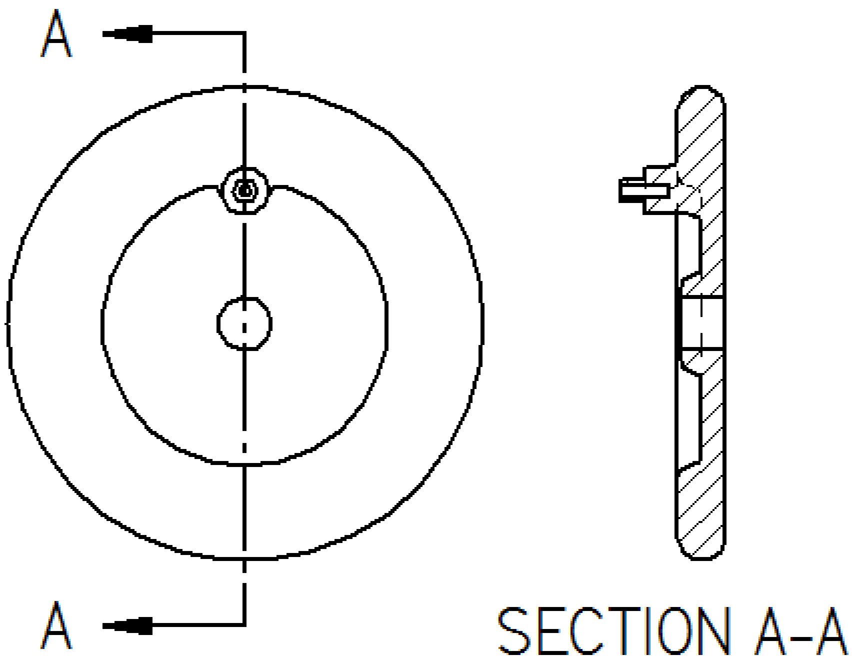
Splitting an object in half to see the internal structure is called a Full section. Now that the cutting plane is in place, create the section view. Select Section from the Drawing Views section of the ribbon.



Select a cutting plane line at the prompt. Click on the one just created.

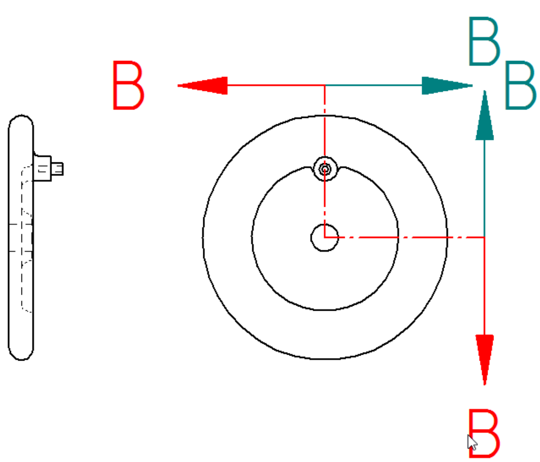


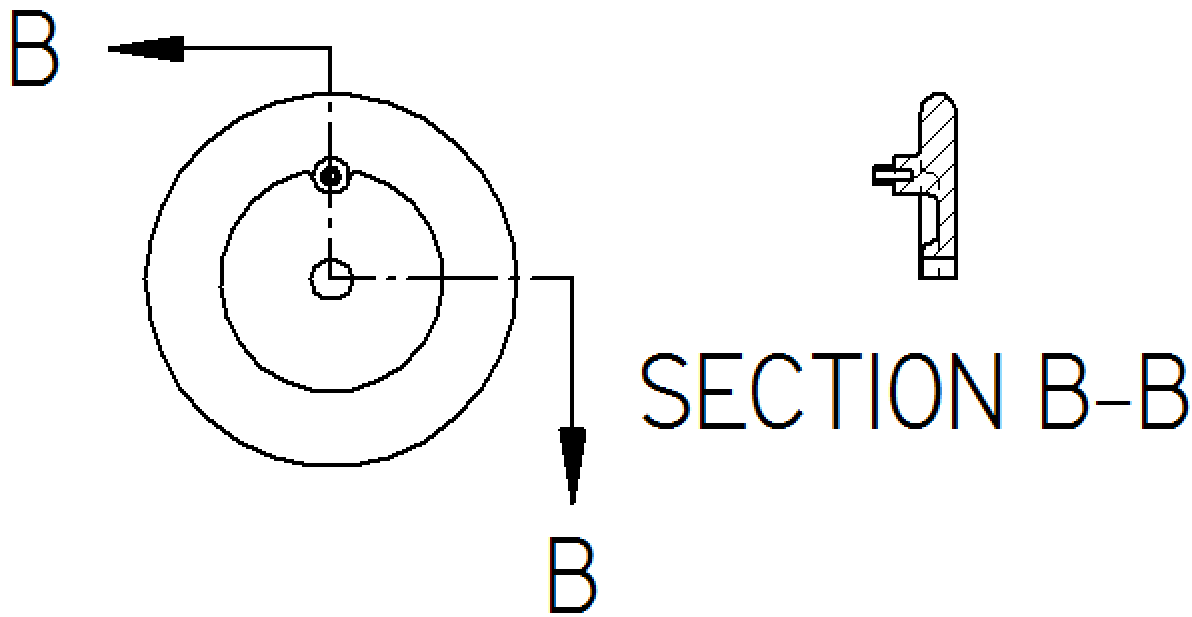
You will see the section view created and labeled Section A-A. Slide to the right and place the section to the right of the wheel.



If you didn’t want to section the entire wheel you could create a half section by using a different cutting plane line.

In this case the cutting plane is set to look down and to the left.





Notice how this section is different from the Full section.

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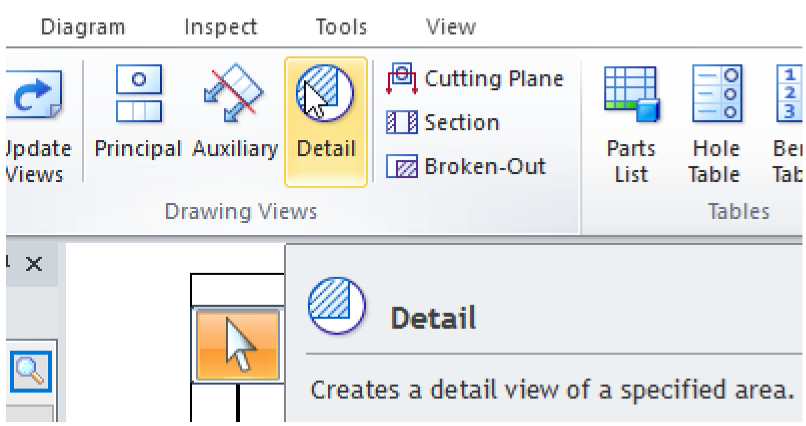
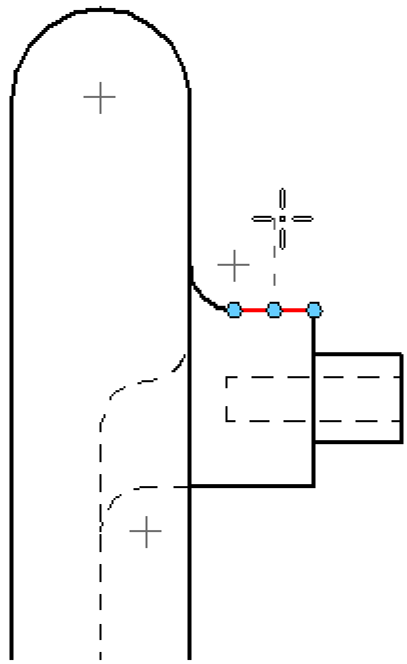
Detail Views

Detail views are utilized to show detail and dimensions on small areas. We change the scale making them larger so dimensions and annotations can be added without crowding the view.

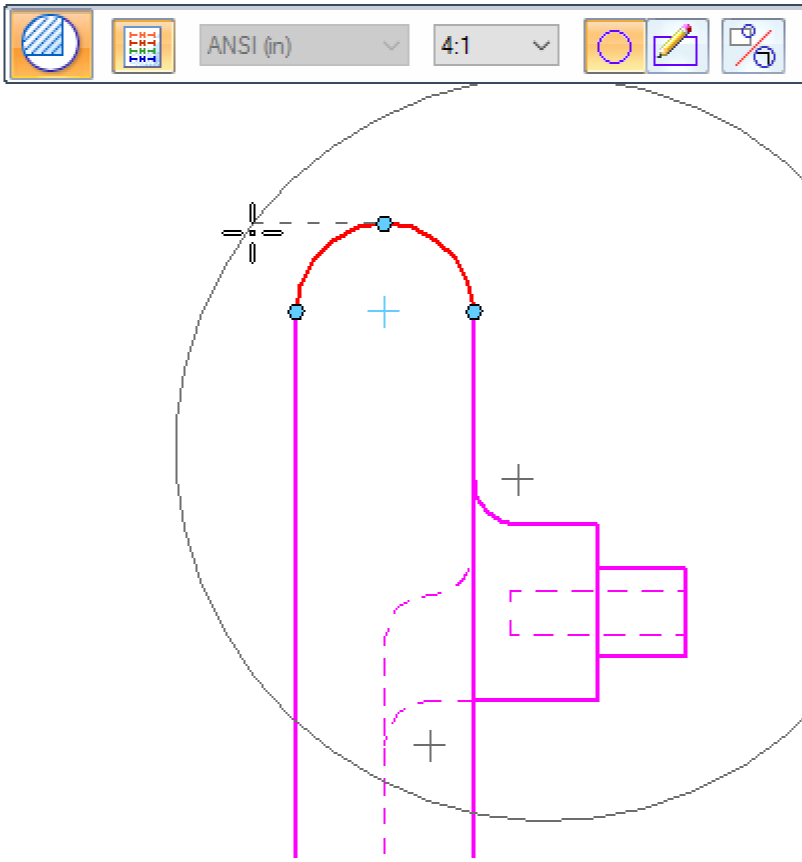
Select the Detail icon from the drawing views section of the ribbon.



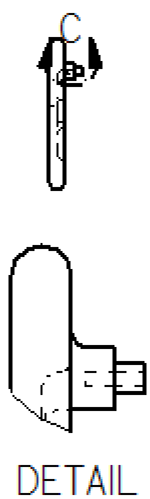
The prompt will ask for the center of the circle that will define the area of detail.

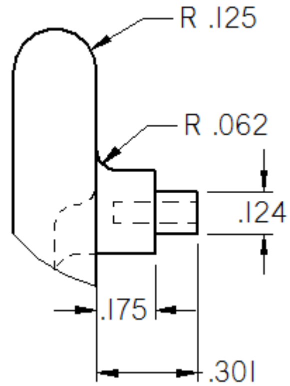


In this example, a point is selected that will allow the drawing of a circle around the top of the wheel and also the raised cylinder for the linkage rod.



From the dialog box, set the amount of magnification wanted on the detail view. 2:1 or 4:1 will provide a detail that can be dimensioned without crowding.





DETAIL C

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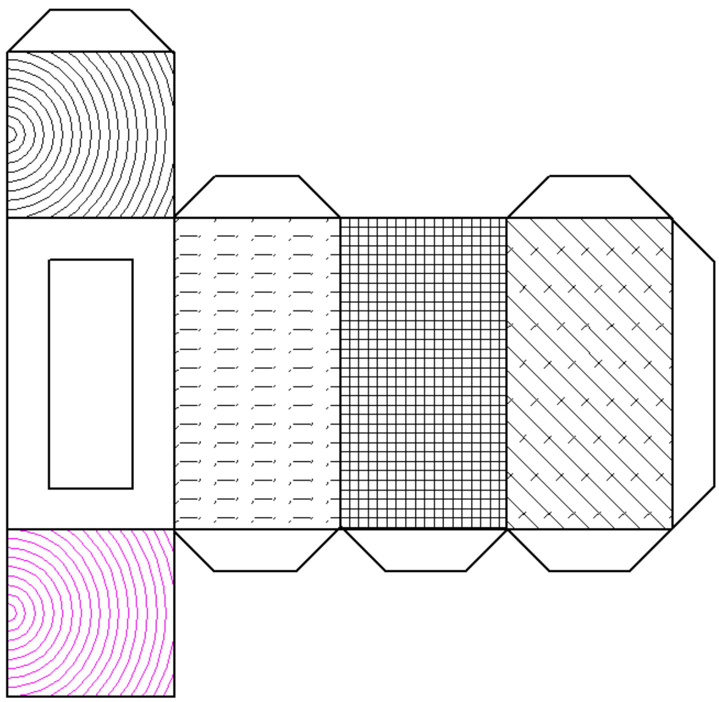
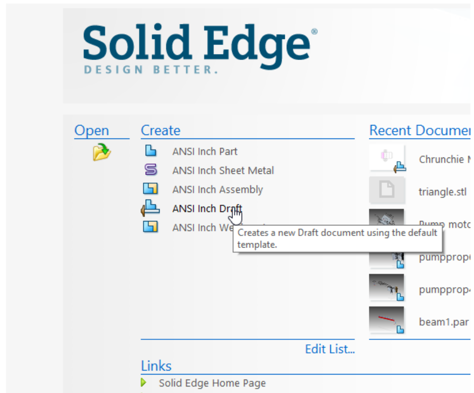
Drawing Nets

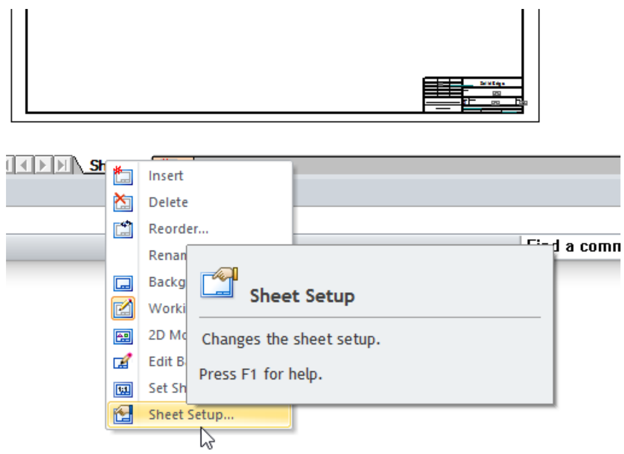
A net is a 2-dimensional pattern which, when folded, creates a 3-dimensional solid object. Industries making objects from flat stock such as sheet metal for containers are known as flat patterns. This exercise will help you create the flat pattern necessary for a shape and add the flaps or tabs necessary to fasten it together.



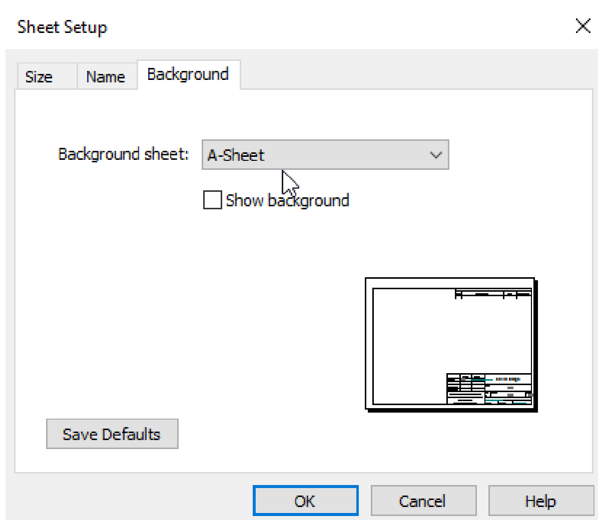
Open Solid Edge. Since we are not only interested in a 2-D shape but also the lines for the folds we will be using a draft template which allows for these functions.



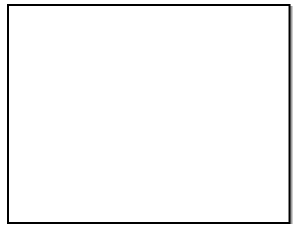
When the template opens you will see a sheet along with border and label. Since we don’t want this you will right click on the Sheet tab at the bottom of the window and select Sheet Setup from the options.

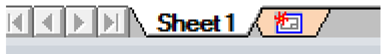


Select the Background tab and select the A-sheet from the Background sheet options. Uncheck the show background check box. Select the OK button at the bottom of the window.

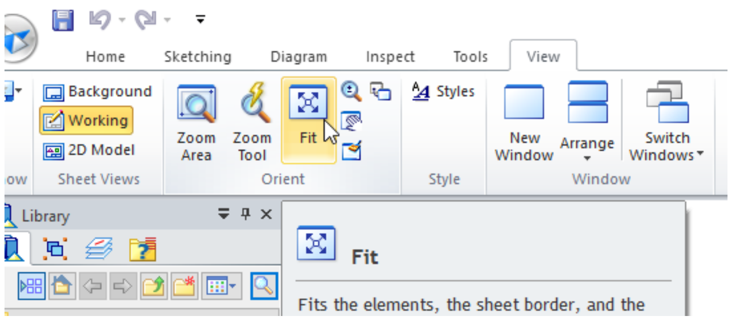


The sheet will resize to be that of an 8 ½ x 11 sheet of paper.

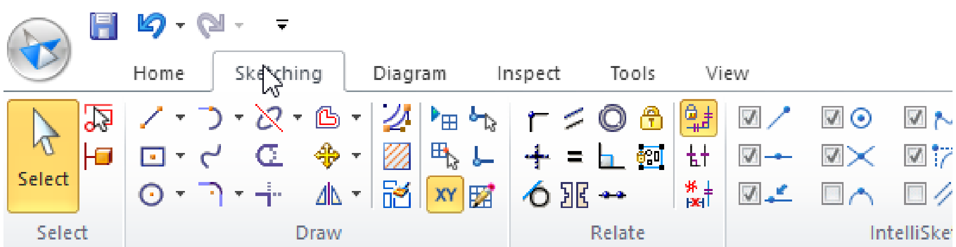




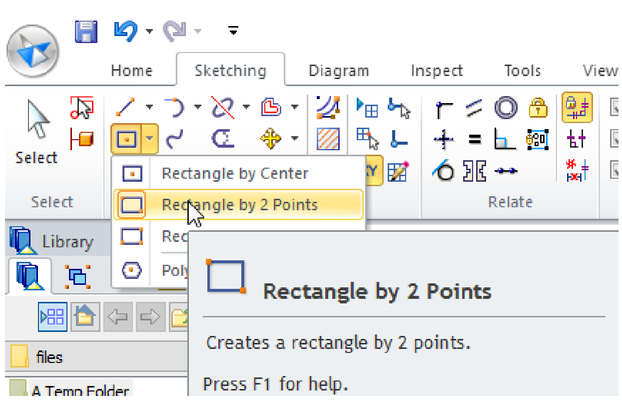
Expand the image so it fills the screen. From the View tab of the main ribbon select the option for Fit.



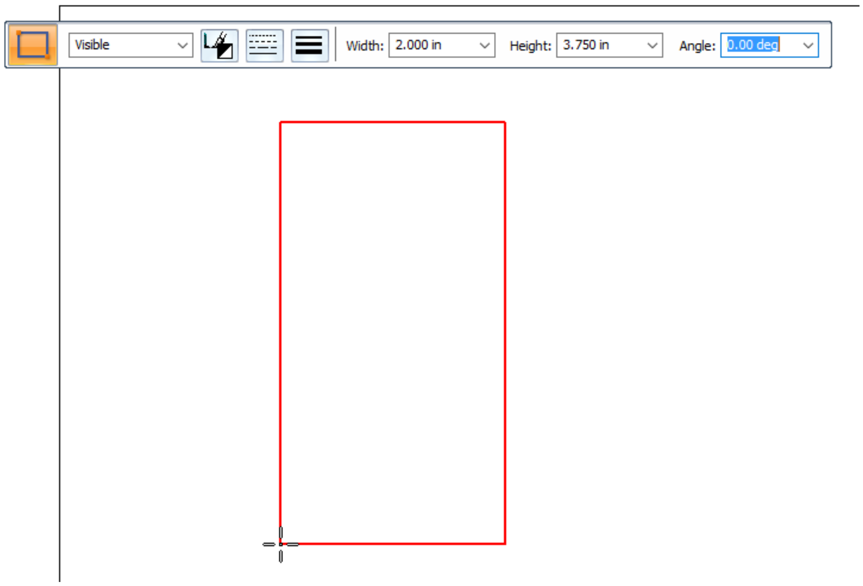
Select Sketching tab of the Main ribbon. This will bring up your drawing tools.



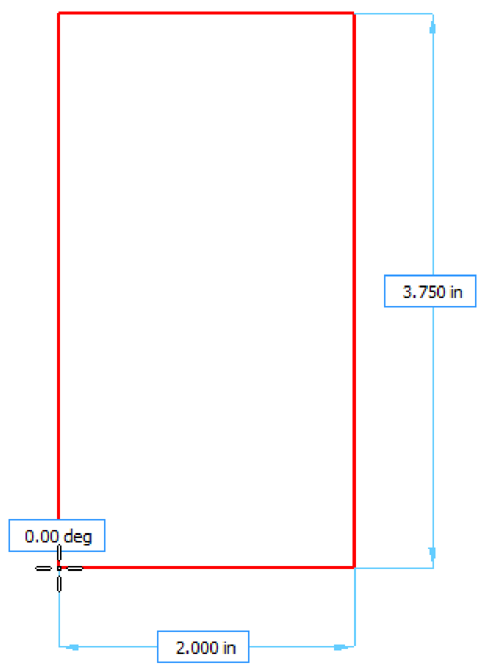
Select the option to create a Rectangle by 2 points.



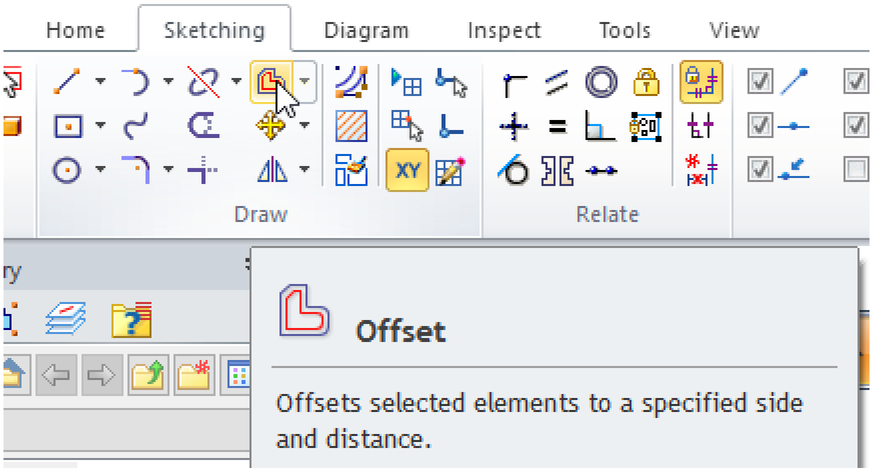
In the rectangle dialog box you can enter in the precise size or you can just draw and dimension the rectangle later. Use 2 inches for the width and 3.75 for the height.



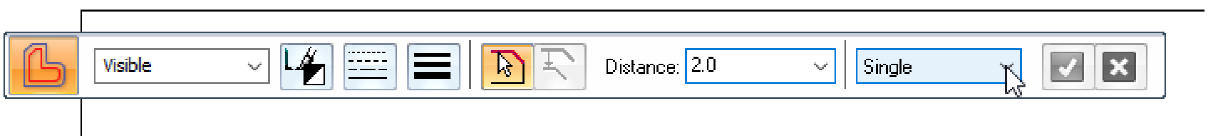
This will provide the basic shape to begin.



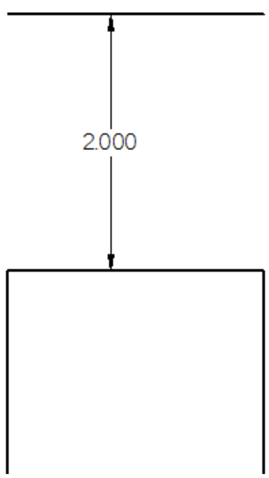
Now select the Offset tool from the Draw section of the Sketching tools.



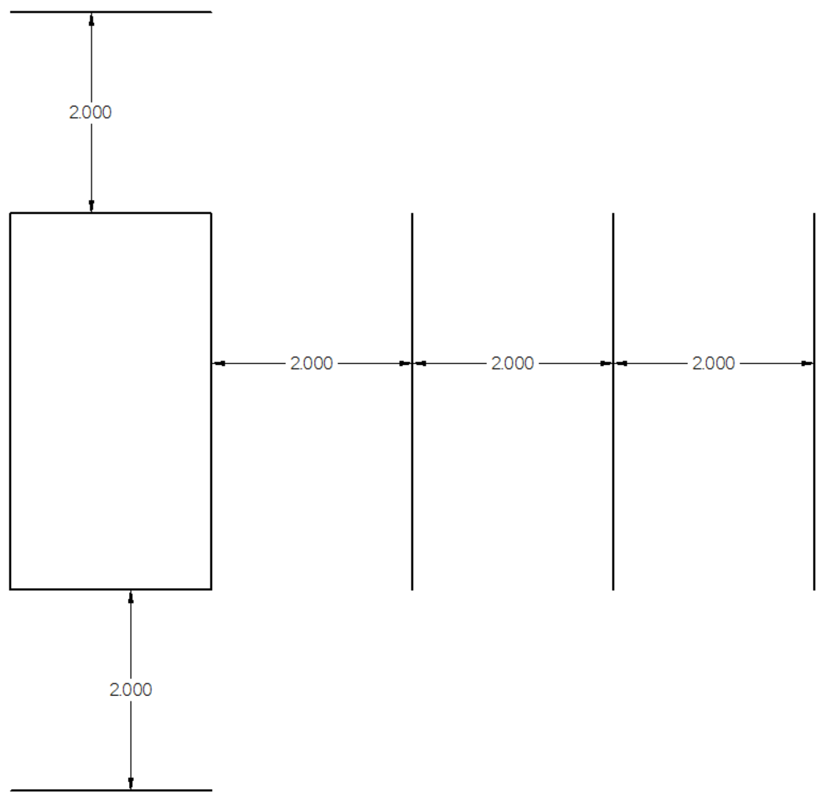
In the dialog box select 2.0 for a Distance and Single as the selection method.



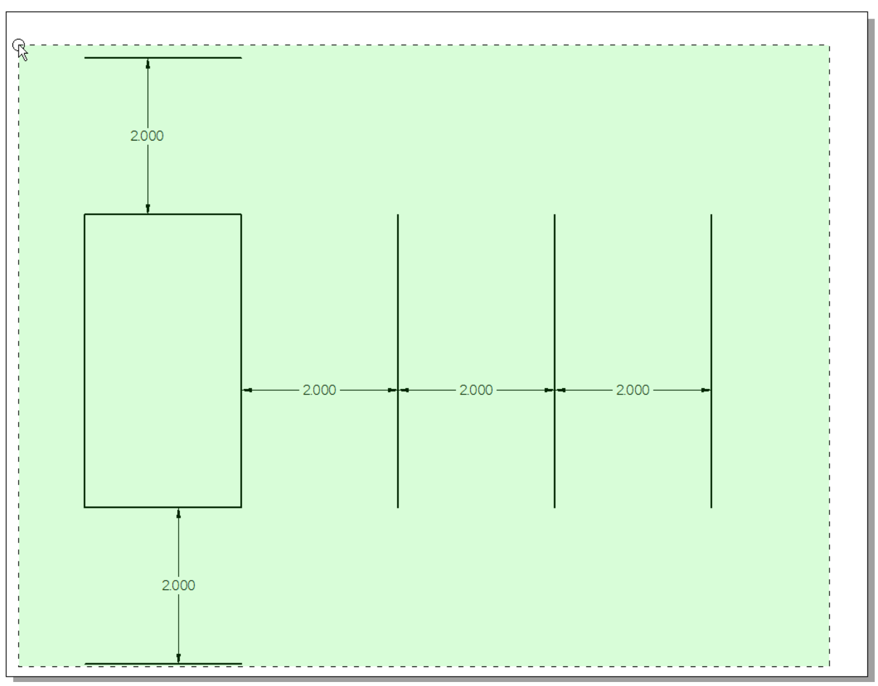
Highlight the top line of the rectangle and right click to finish your selection. Move your mouse above the rectangle. You will see a red arrow pointing up. Left click on your screen and hit the esc key. You should see a line that is 2.000 inches away from the rectangle.



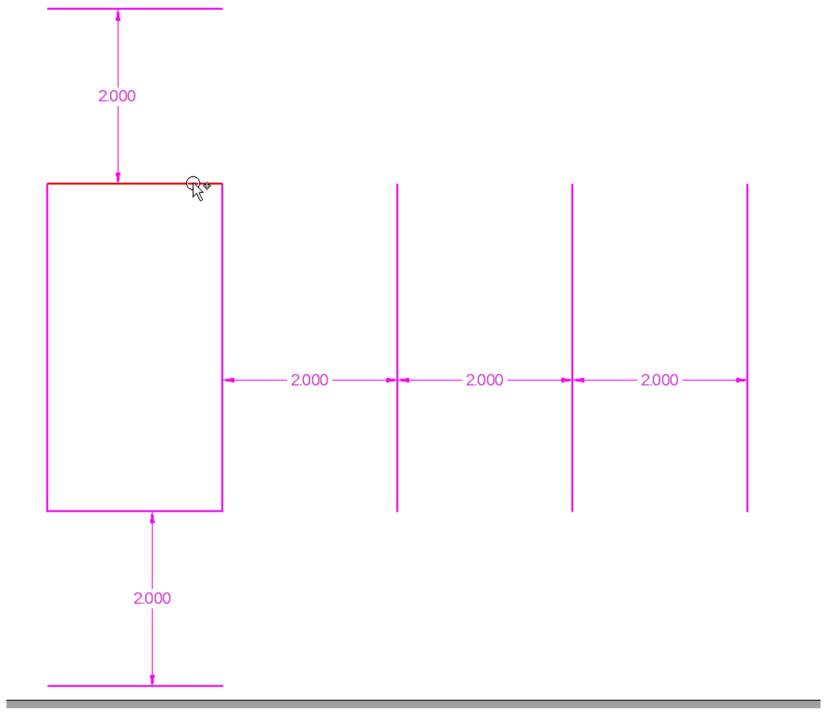
Follow the same pattern to select lines and create the lines in the picture below.



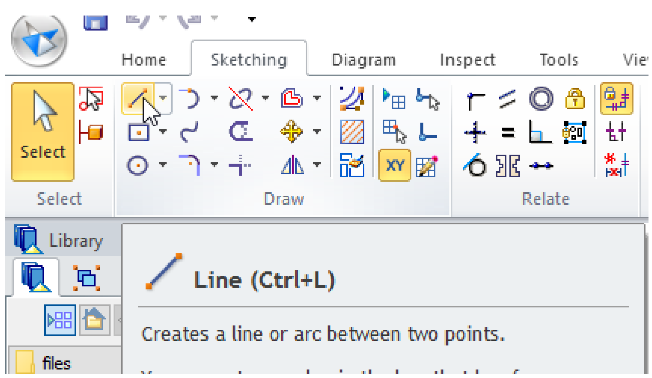
If the lines are off the border of the page you can select all the lines by dragging a box around them all.



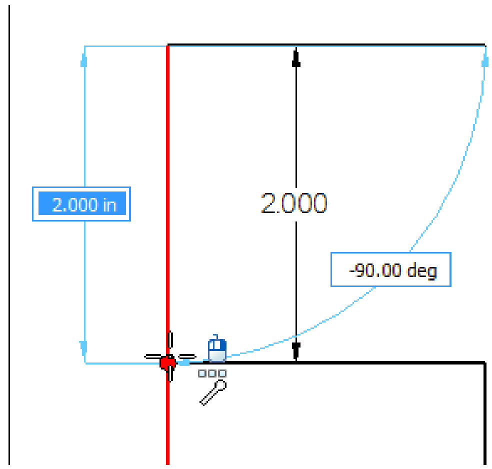
This will highlight all the lines. Once the lines are highlighted you can then move them as a group where you want by selecting a line and dragging it into position.



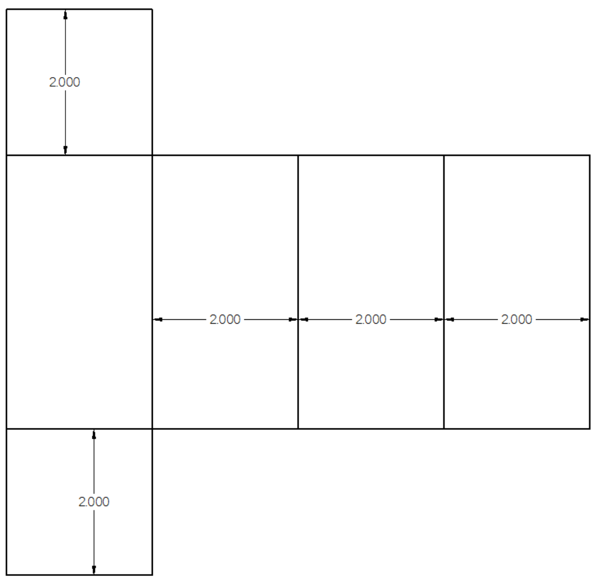
Select the Line command from the Draw section of the ribbon.



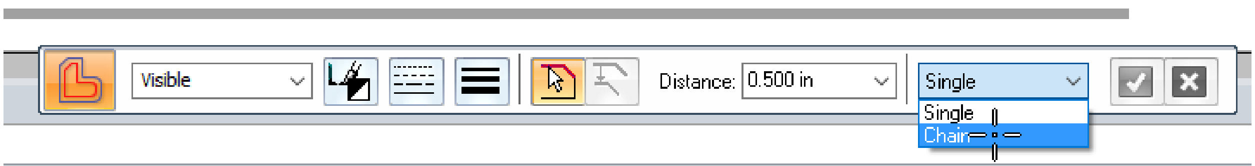
Connect the rectangle to the top line by adding a line. Right click to accept the placement.



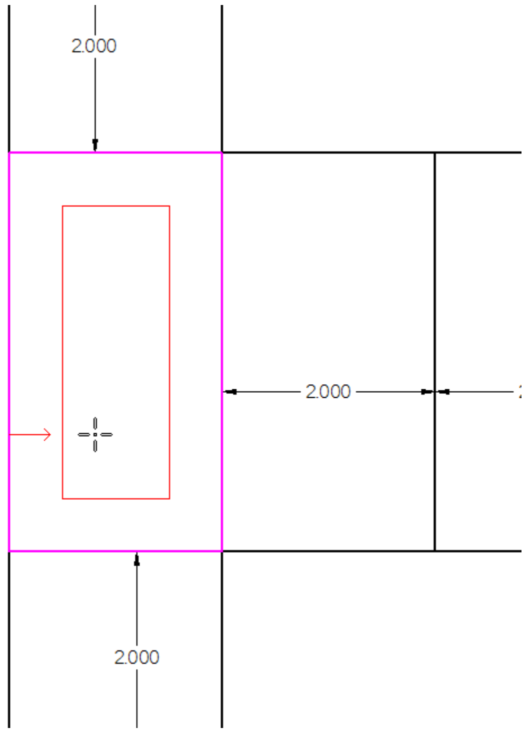
Continue adding lines until your sketch looks like the basic net below.



Now use the Offset command to create the window. In the dialog box select Chain from the options and set the distance to .5.



Select the sides of the original rectangle and then right click. Move your curser inside the rectangle and a new rectangle will appear.

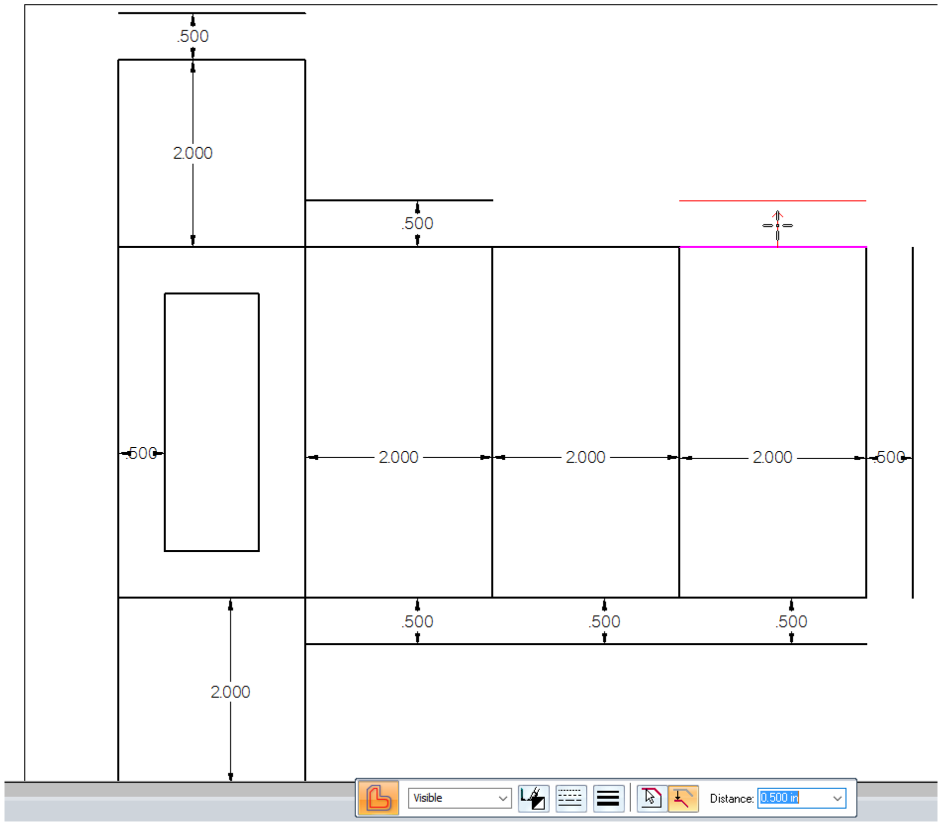


Adding Glue Tabs and Flaps

When creating a flat pattern that will be folded into a product, tabs and flaps are added. Flaps are moveable and are short components used to keep product inside a box. Glue tabs are virtually the same except they are designed to have adhesive applied in order to maintain the shape. Frequently the flaps are also given slots or other mechanical shapes for connecting parts together quickly.

Select the Offset command. Change the distance to .5 and set the option to select a single line.

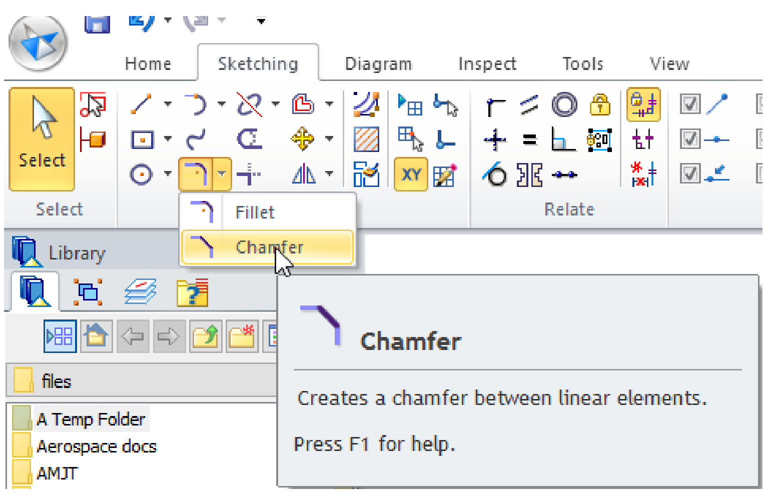
Add offset lines so your drawing looks like the one below.



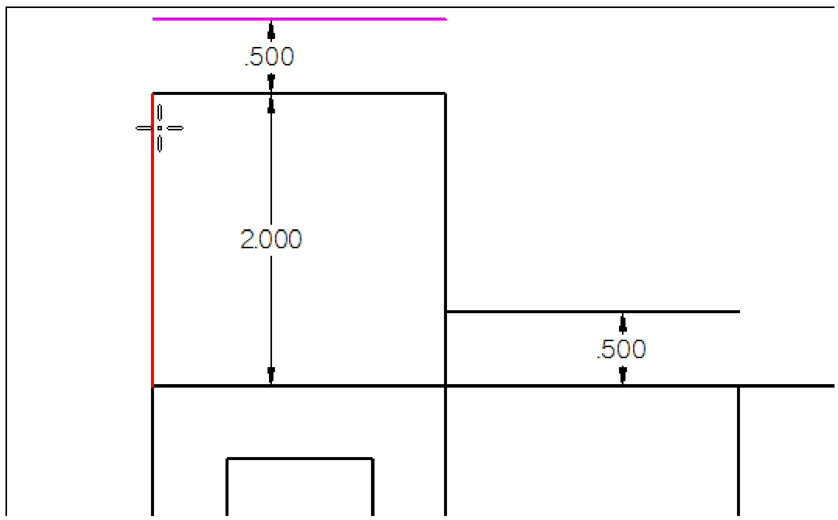
Adding Chamfers

A chamfer is the process we use for easing square corners. It generally creates a symmetrical angle. In this case the chamfer is used to allow the paper pattern to fold without creating areas that will interfere with the folding process.

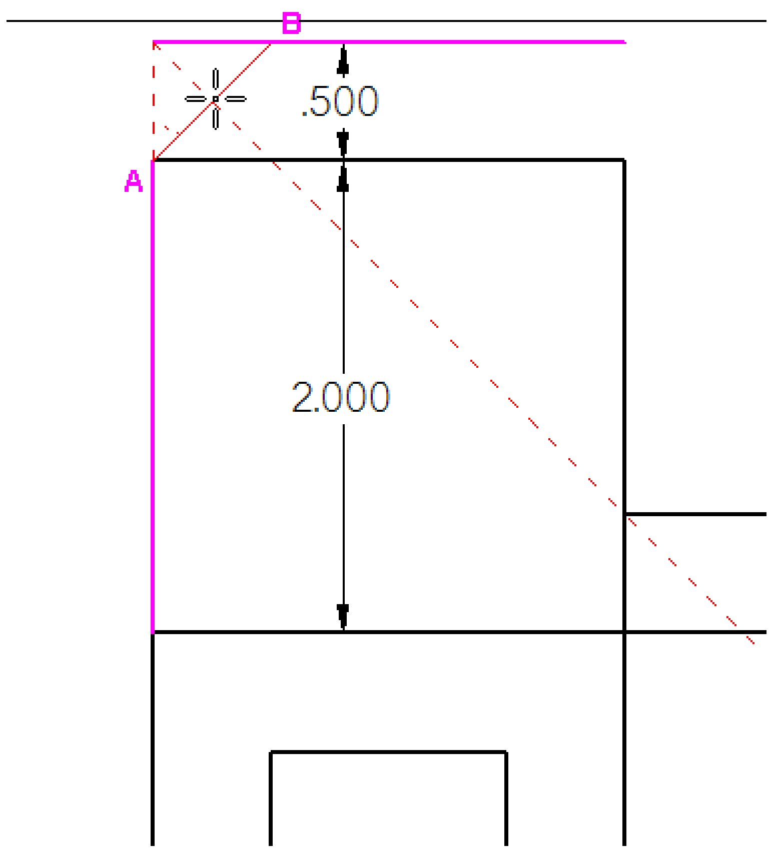
From the Draw section of the Sketching ribbon use the pull down menu to select Chamfer.



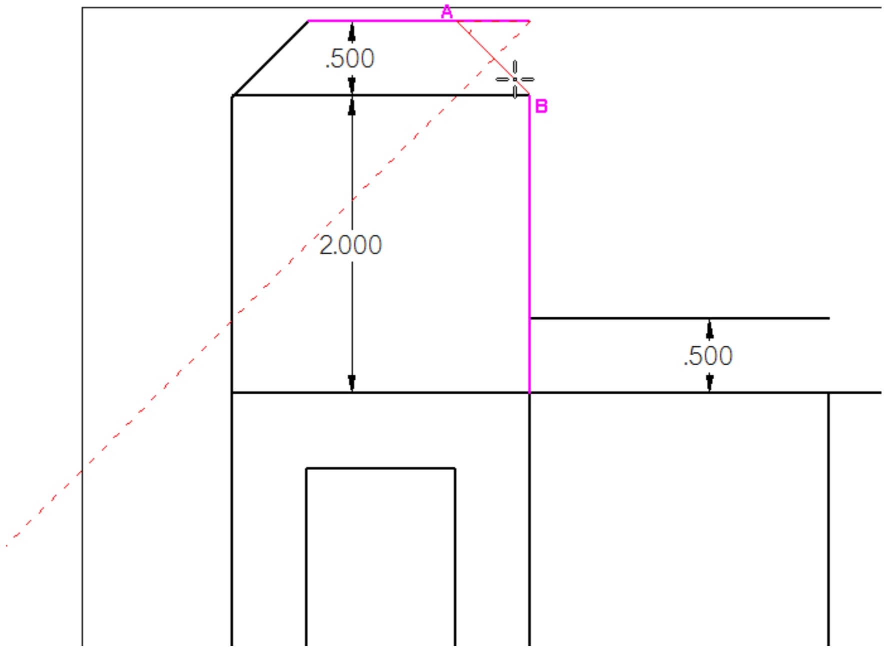
In this case we can identify how we want the chamfer to appear by selecting the edges we wish to join. Select the line above the top square. Then select the vertical line of the square similar to the picture below.



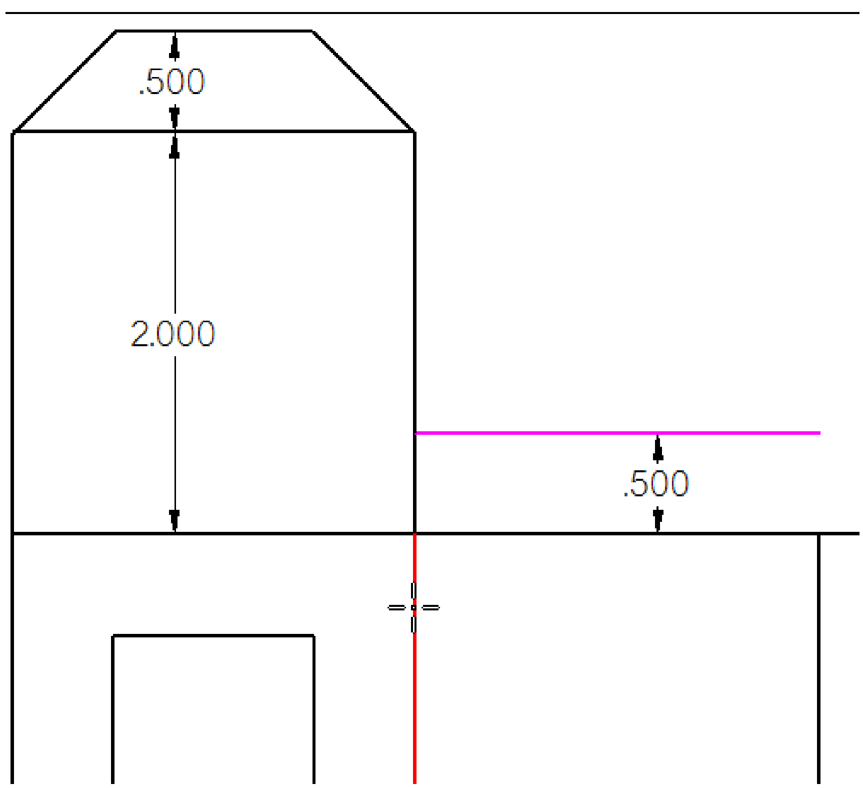
You then see the image of the chamfer. In this case the point A is placed on the corner of the top square. Left click when the chamfer is in position.



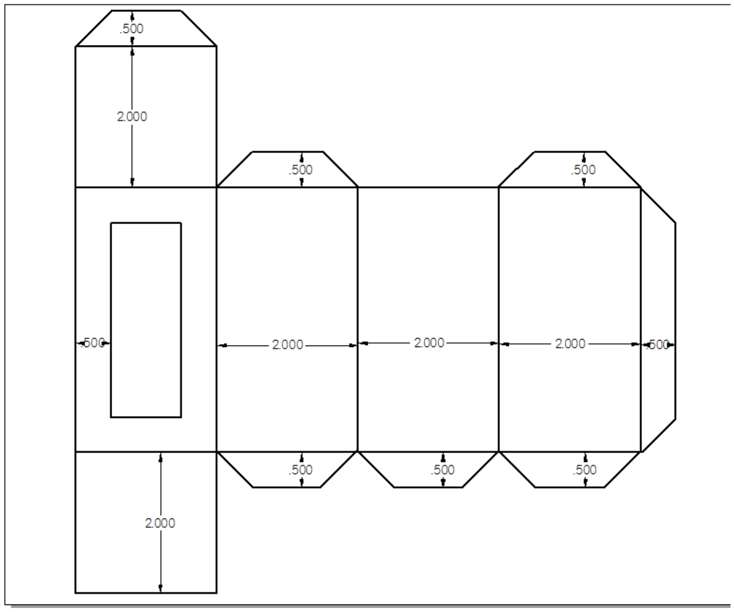
This places the chamfer. Repeat the process on the other side of the top of the box.



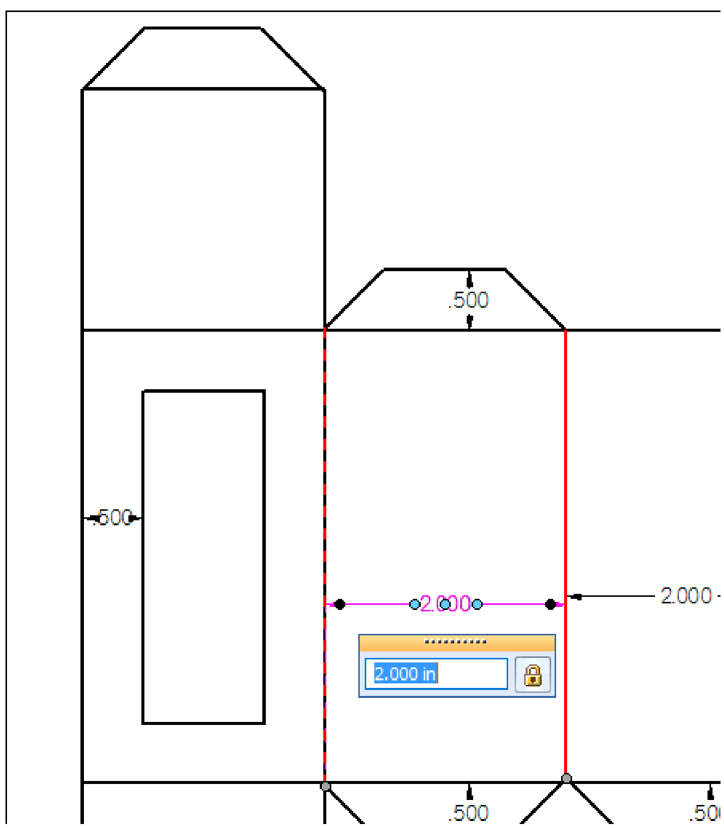
Where the tab line intersects with the shape you select the lines in the areas you wish to keep. See the picture below.



Continue working around the pattern until all the flaps and tabs have chamfers.



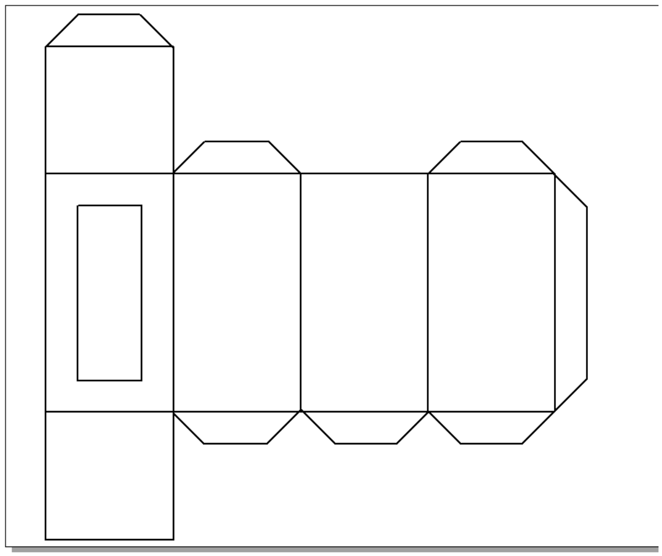
Since everything is now the correct size you should remove the dimensions from the drawing so they will not show in the final printing of the pattern. Highlight the dimensions and use the delete key to remove them.



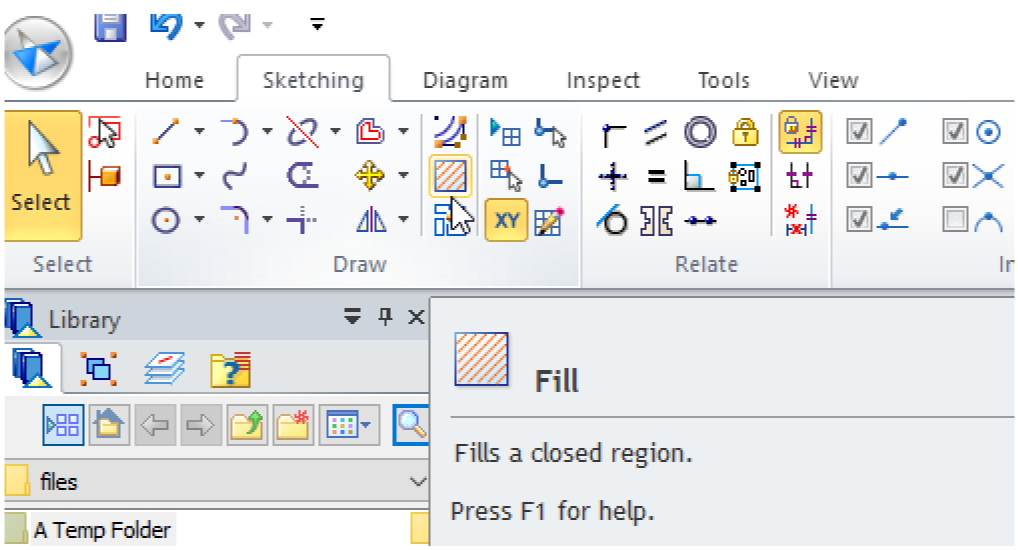
Adding Fill Patterns

Fill patterns denote materials or surfaces in 2D drawings. We also use them to denote appearances or for emphasis in certain areas.

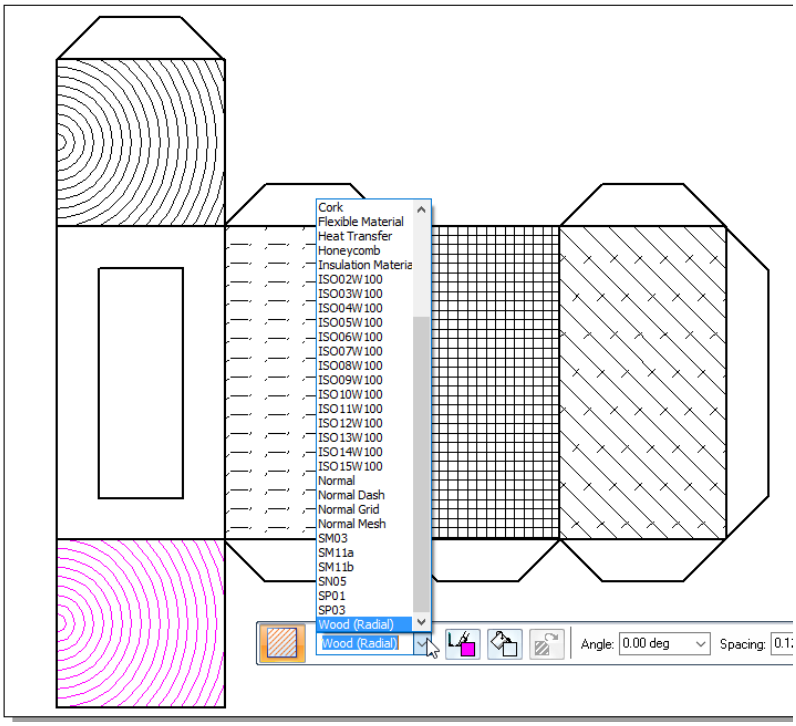
Your drawing of the pattern without dimensions should now look similar to the one below.



From the Draw section of the Sketching ribbon select the Fill command.



From the tool bar you can select from a variety of patterns and colors. Use these to create a visual image on the outside of your pattern.



Print your pattern and cut along the outside lines. Fold the pattern into a box. Following similar steps you can create virtually any shape you desire.

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SIEMENS

Ingenuity for life

Tennis Ball Container

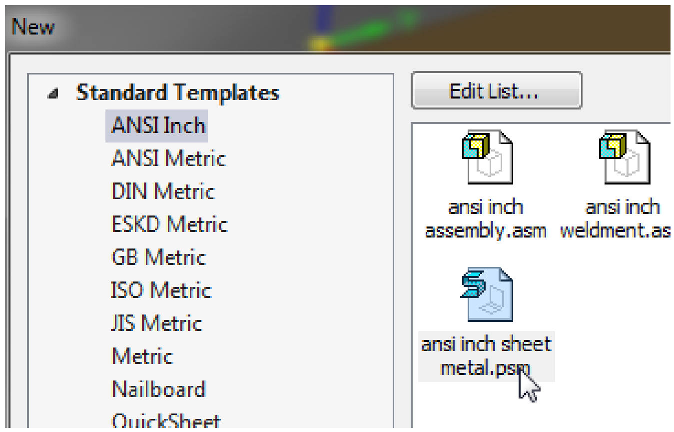
Introduction

There are numerous ways to approach modeling this box. Here is one way to approach the process. It is important to remember, there are always different approaches. Some will take more time and some might be faster, but there is no one correct way.

The first step in designing a container for a tennis ball is the decision about the size of the container. According to the International Tennis Federation, the official ball diameter is 6.54-6.86 cm. (This is between 2.57 and 2.70 inches.) The container will be designed to accommodate any officially sized tennis ball. The next step is to determine the material to be used for construction of the container. With these two steps completed, the process can begin.

Creating designs made by folding flat stock is a challenging process. Whatever material selected for the container will stretch resulting from the shaping and folding process. It is impossible to create a truly 90 degree angle bend. Design programs can compensate for how the material will behave if material properties are established in advance.

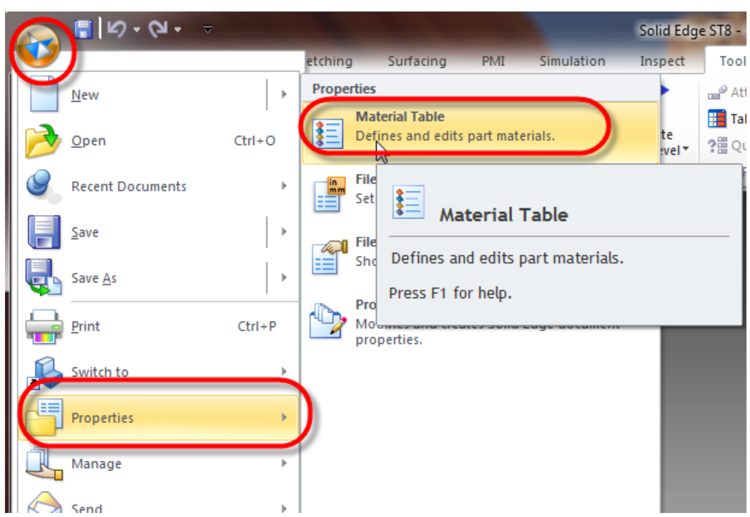
Begin a new sheet metal file by selecting the icon for ANSI Inch sheet metal from the options in Solid Edge. Select OK to open the file.



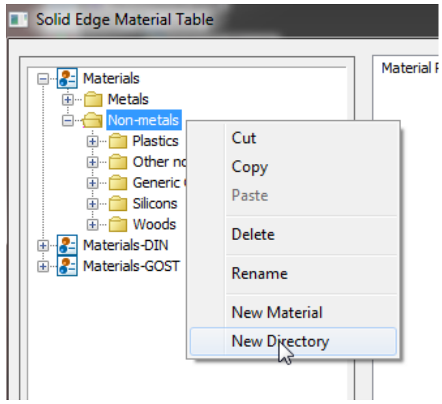
Save the file in your folder with a recognizable name. In this example, the file is called TBcontainer. Check the top of the Solid Edge window to be sure your name is there.

Creating a Material

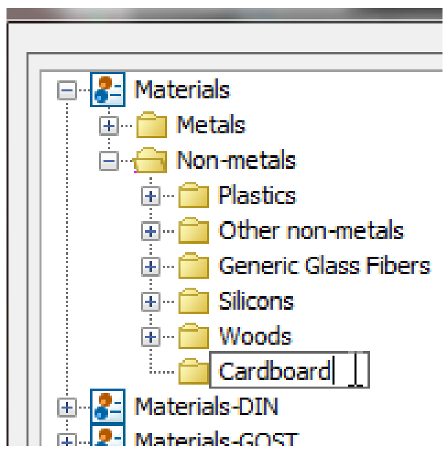
The first step is to select the material we will be using to create the container. Click on the Application button in the top left hand corner of the screen. Select the Properties option and then select Material Table.



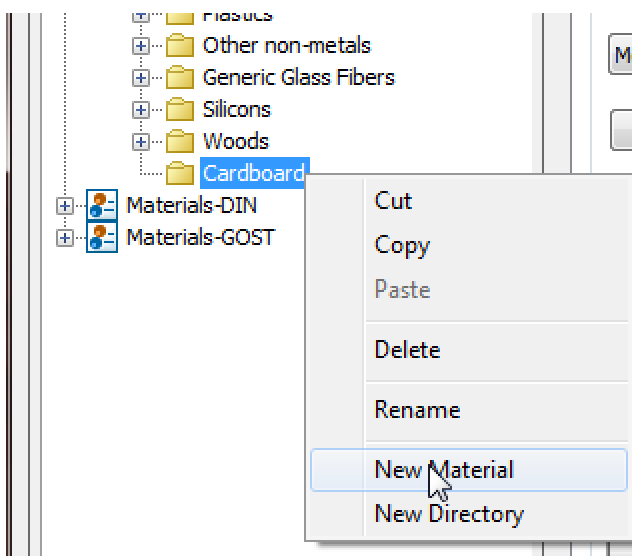
In the Material Table directory, expand the Non-metals by clicking on the plus sign next to it. Right click on Non-metals and select New Directory from the options.



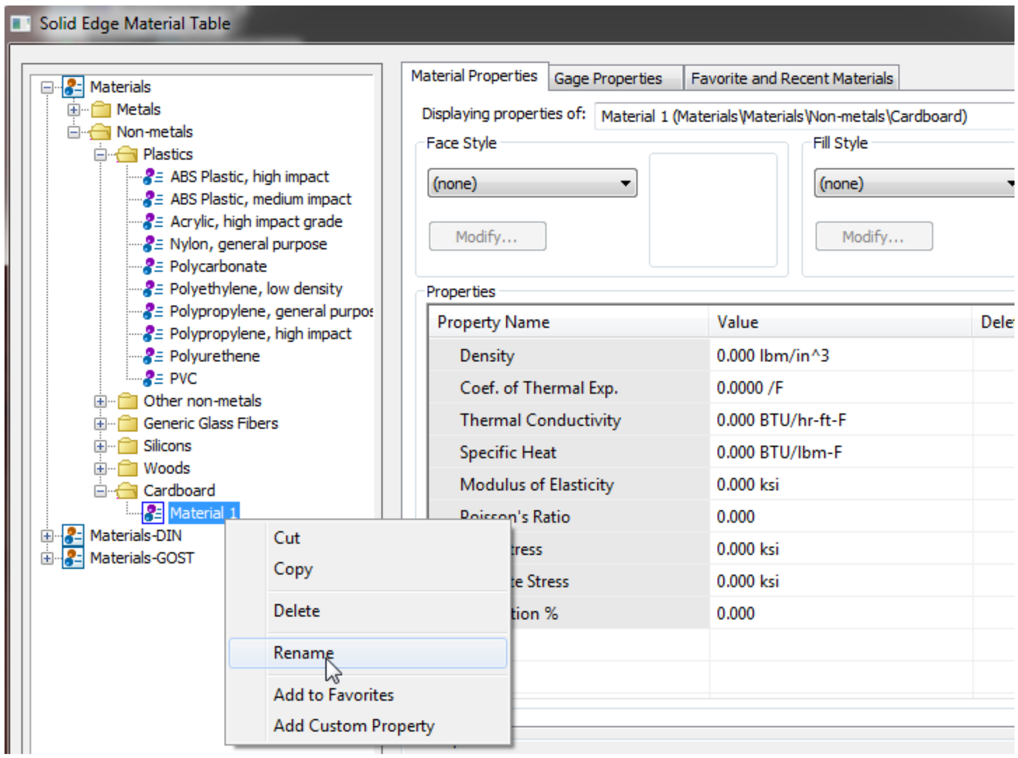
This will create a blank directory. Name the directory Cardboard.



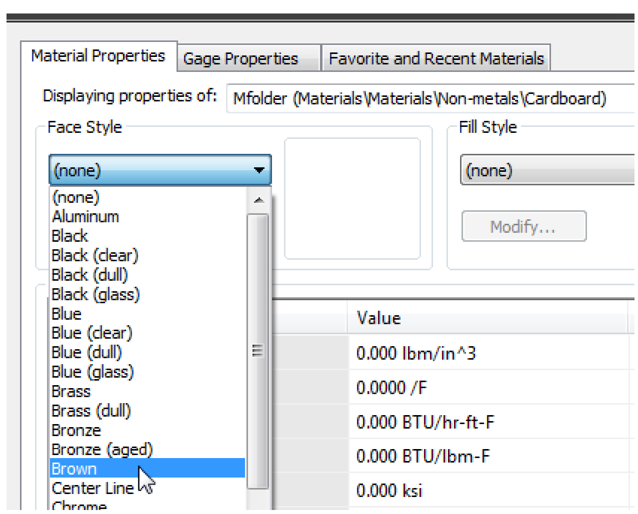
Now right click on the Cardboard directory and select New Material from the options.



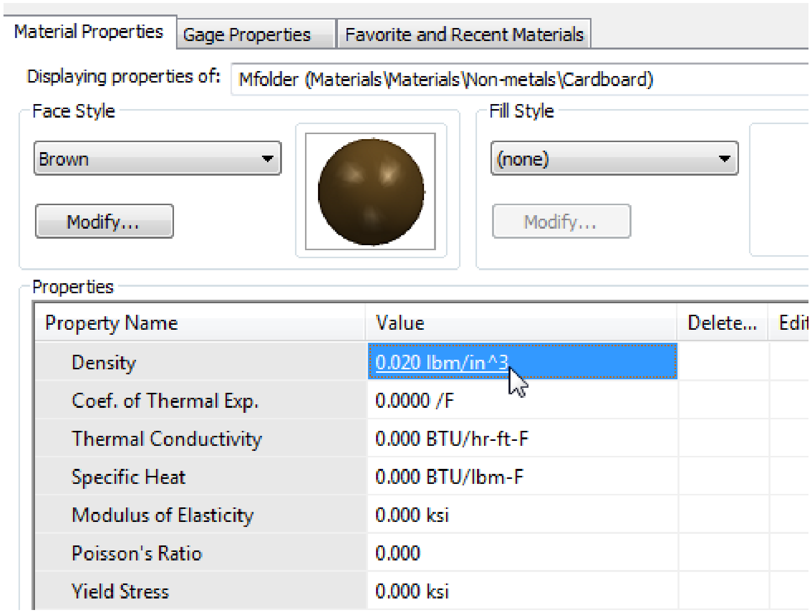
This New Material will appear on the right hand side of the window. The name will default to Material 1. Rename Material1 to retrieve it in the future. In this example we will use a file folder for our prototype. Right click on Material 1 on the left hand side of the window and select rename. Set the new name to Mfolder (short for manila folder).



On the Material Properties tab set the Face Style to brown. This selection will apply color to the material to display on your screen.

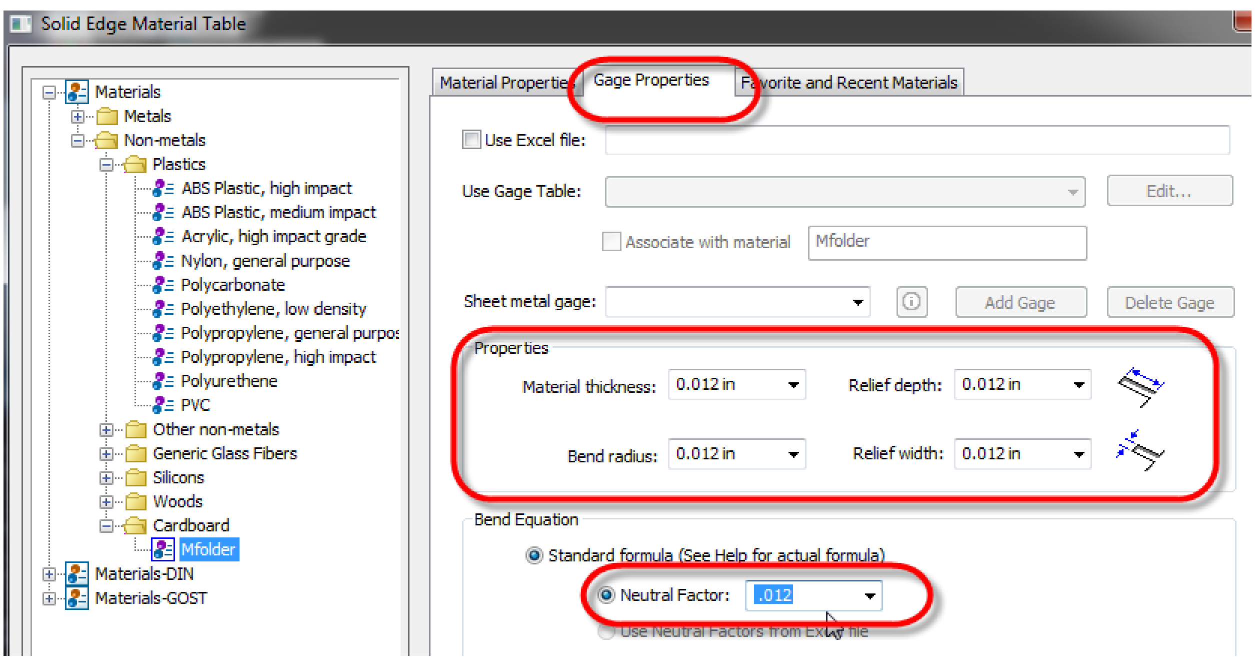


Double click on the Density properties and set the Value 0.020.



Then double click on the Modulus of Elasticity entry and enter 3.000 ksi. These two entries provide the program with information about how the material will behave.

Now select the Gage Properties tab from the options at the top of the window. The information on this tab will help the program calculate the size the sheet will have to be after folding. Measure the file folder thickness with a micrometer. In this example it is .012 inch thick. Insert this information in the appropriate entry fields on the dialog window.



At the bottom of the dialog box select Apply to Model and then Save.

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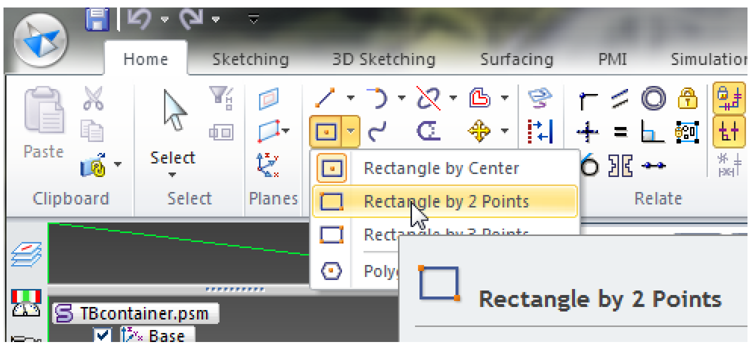
Creating a 3D Shape for the Flat Pattern

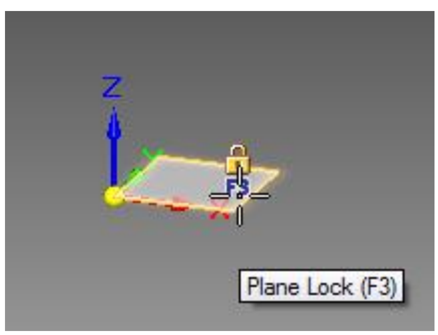
Folding material into a box shape applies some basic laws of physics. Two pieces of material cannot occupy the same space at the same time. If you see a warning about not being able to create a component (a red exclamation mark) you will have to back track on your thinking to figure out how to add clearance to the model.

The design calls for the top to be able to close and tuck in. Begin the design with the appropriate size rectangle. In this example the largest tennis ball can be 2.70 inches. To allow for some clearance the base unit will be 2.75 in. Since the top needs to fit inside the top will be 2.710 inches square.

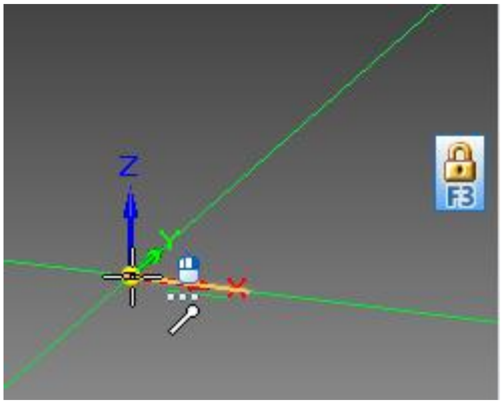
Begin by drawing a Rectangle by 2 Points.



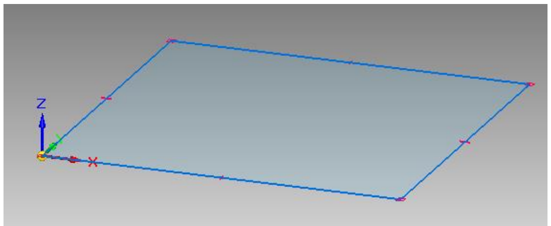
Slide the cursor over the X and select a drawing plane for XY. When the plane appears in the way you would like to begin the model, select the F3 key to lock the plane. The lock icon should appear on the right hand side of the screen.



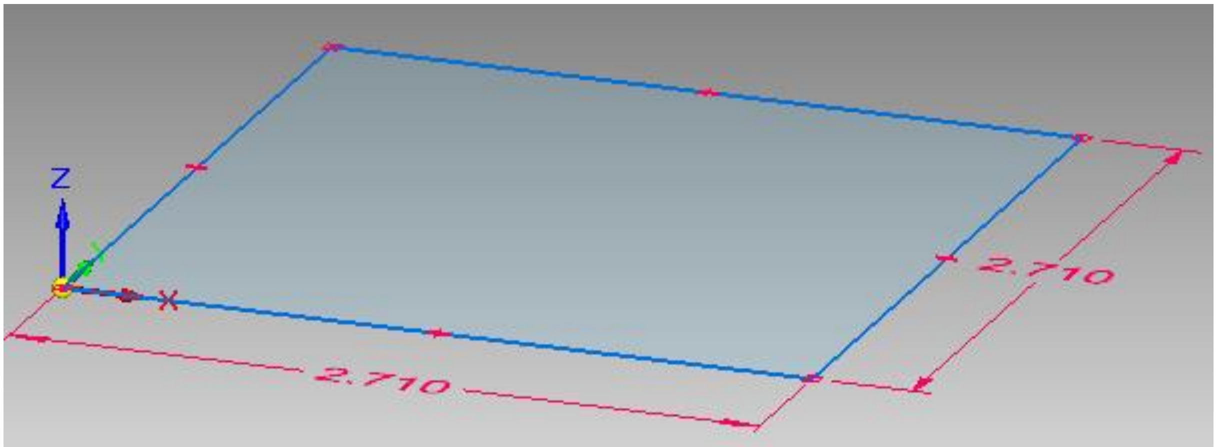
Lock the plane and select the origin for the first point.



Click on the location for the opposite corner. We can dimension the rectangle later.

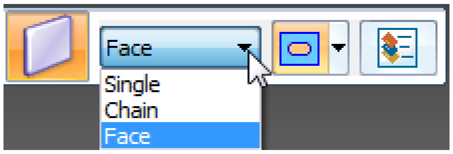


Use the smart dimension tool to size the rectangle to 2.71 inches on a side.

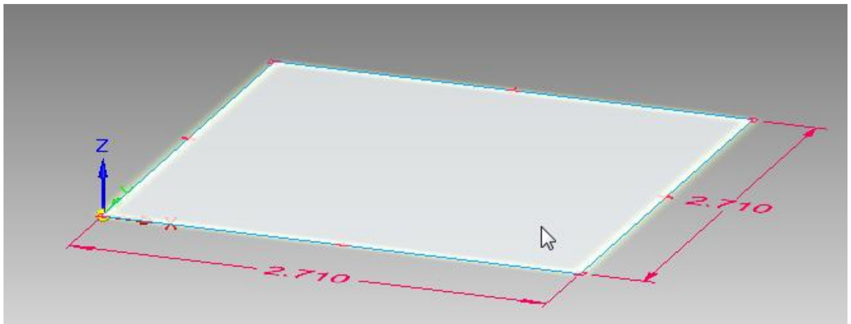


This is the size for the top of the example box. We now need to create a solid from the sketch. Select the Tab icon from the s
Sheet Metal section of the ribbon.

In the Tab Properties box select Face as the selection method.

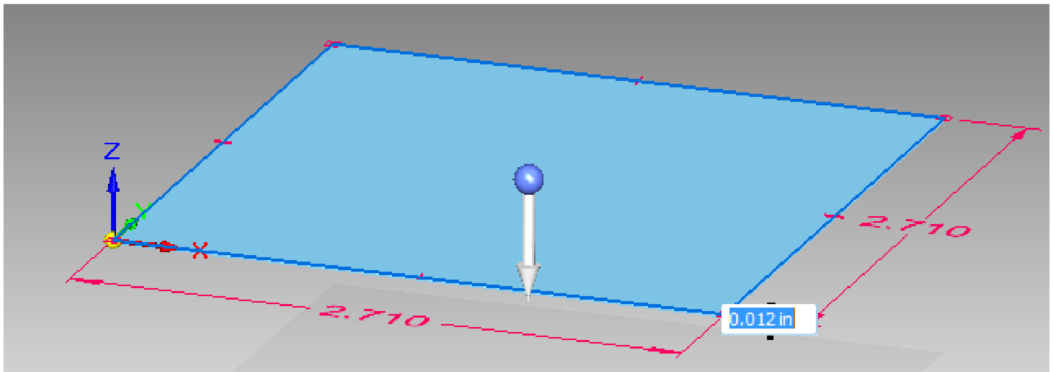


Click on the sketch you created.

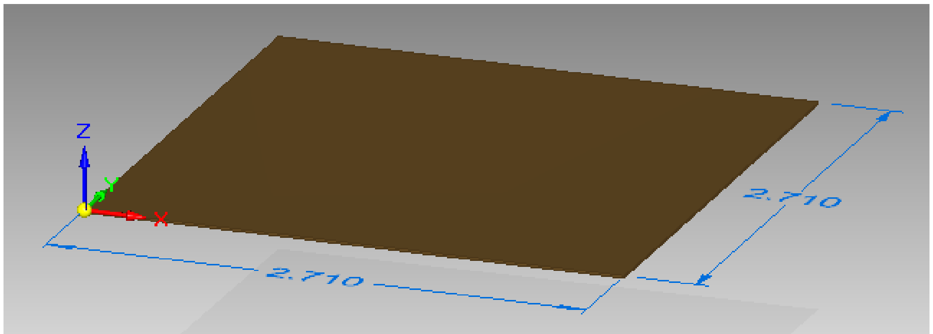


Right click to finish your selection.

Because the material was defined in advance, the thickness is automatically listed.

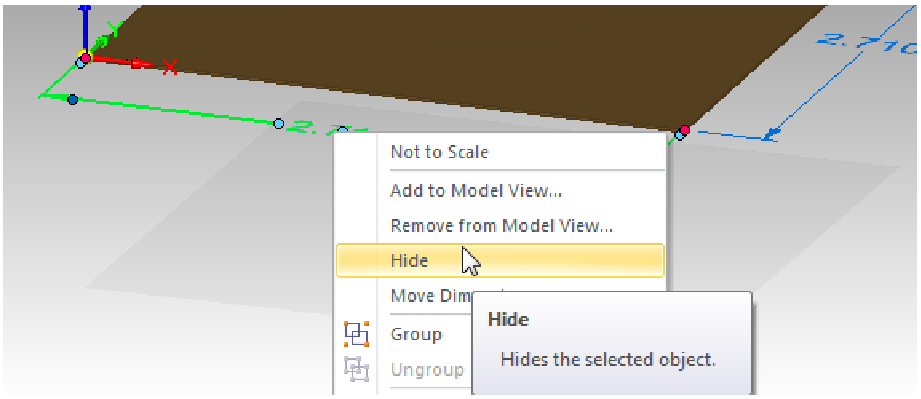


Right click a second time to accept the parameters listed. Your first solid appears in the brown color selected when you created the material.

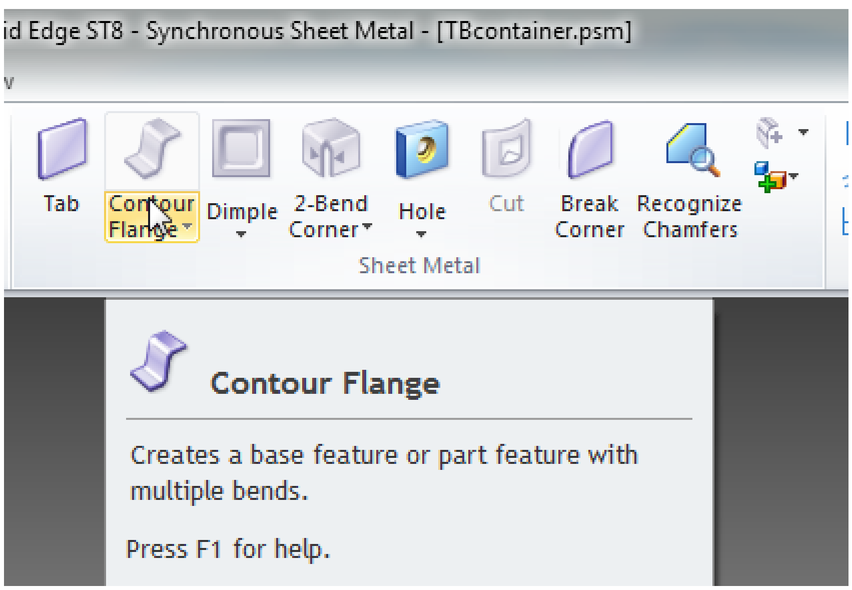


The dimensions can be hidden to provide a better view of the container as you develop it.

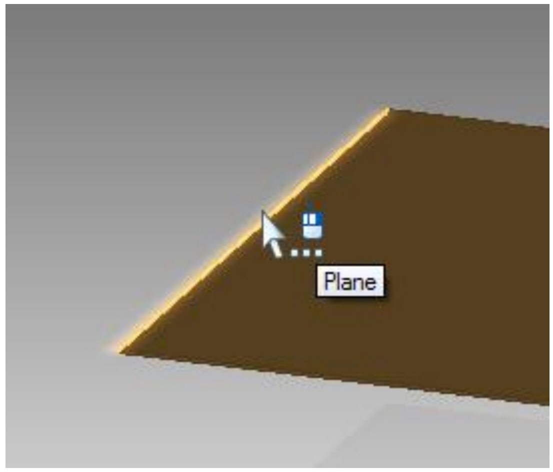
Right click on one of the dimension lines and select Hide from the options. Repeat the process for the other dimension.



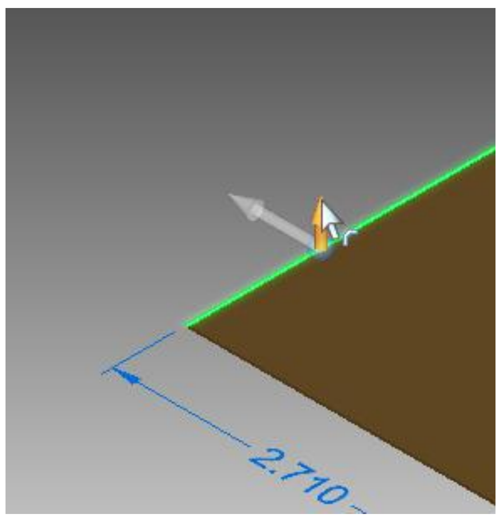
The next step is to add the back of the box. To perform this operation, select the Contour Flange tool from the Sheet Metal ribbon.



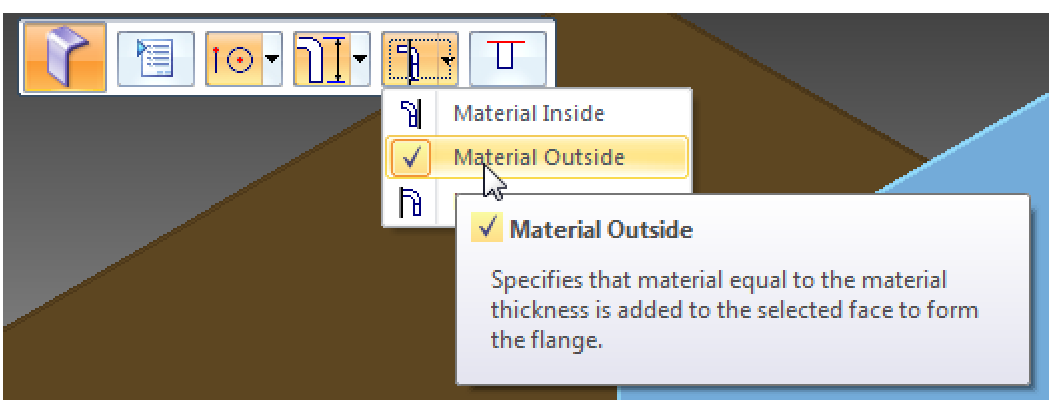
The program will expect you to select a surface. In this case we want the edge plane. Select the planes by left clicking on the Back Edge Plane.



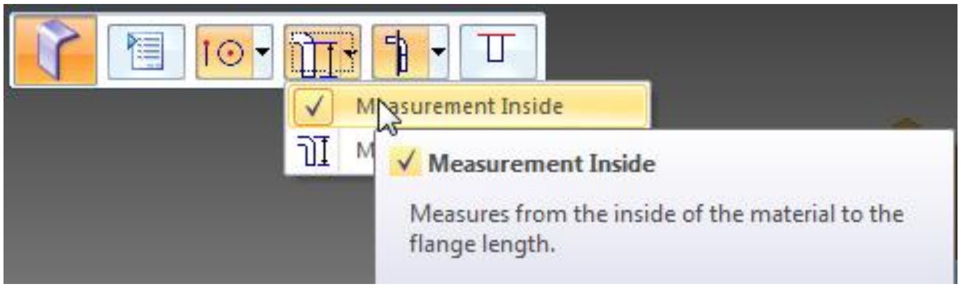
Select the Vertical Handle by clicking on it.



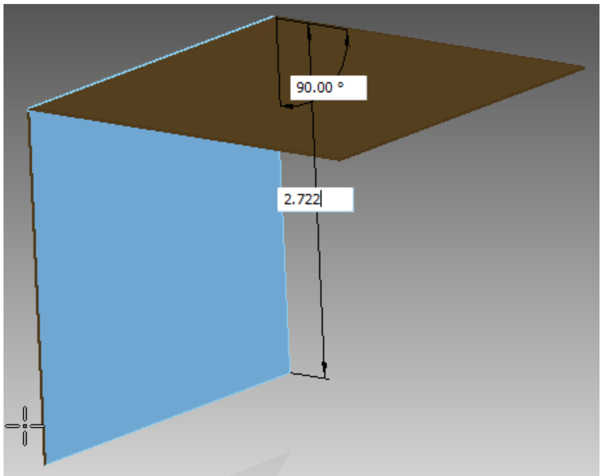
Select Material Outside. This will provide clearance with the rest of the box.



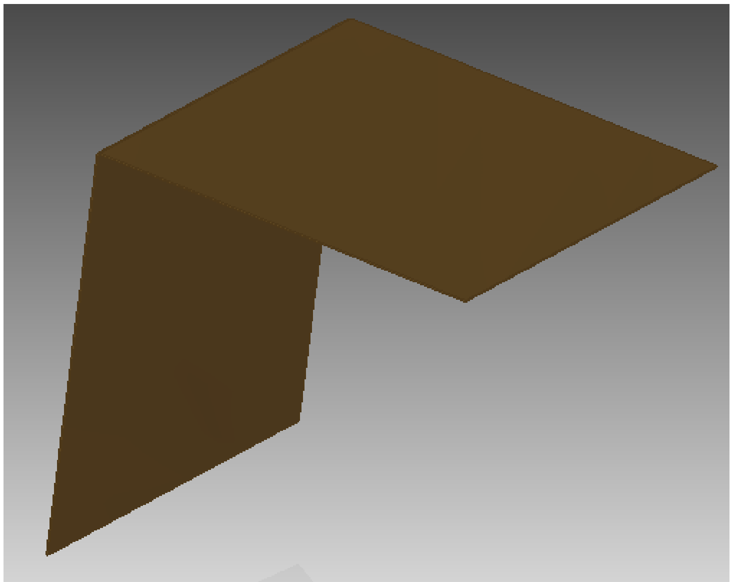
Set the measurement to the inside. This adds enough room for the ball.



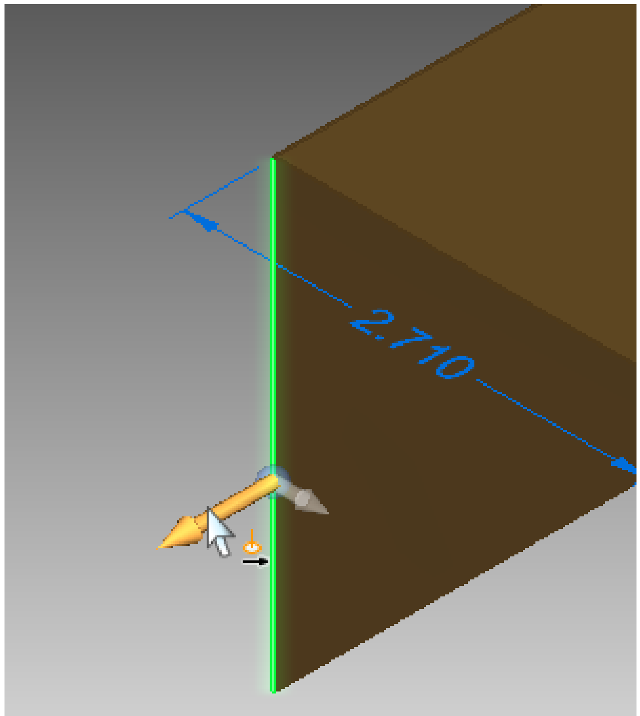
Drag the handle in the downward direction and enter the distance for the back of the box 2.722 (the 2.71 original height plus .012 which is the thickness of the bottom) this will leave room on the inside after the bottom is placed.



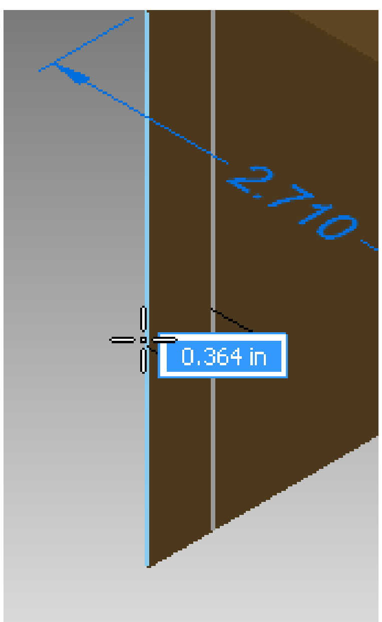
It should look similar to the picture below.

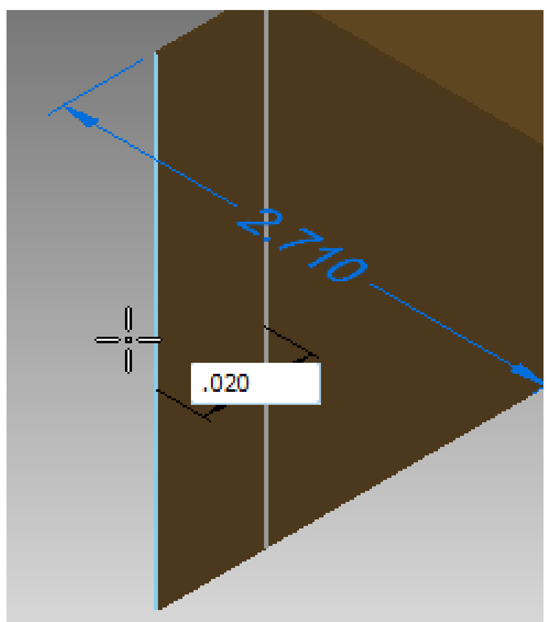


The back of the box should really be wider than the top as the top has to fit on the inside of the box. Hit the Esc key to be sure you are not in a command. Select one side of the back by left clicking on it. Then click on the handle parallel to the plane.

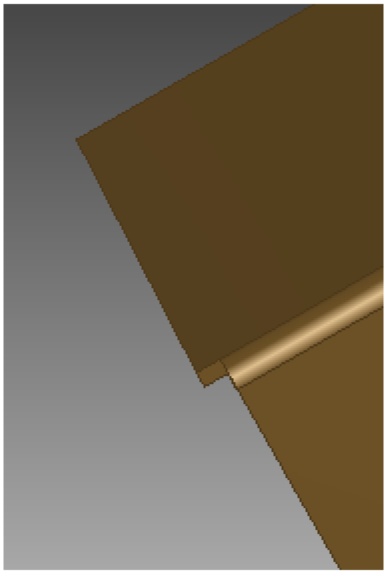


Pull the handle outward and enter .020 to add that distance to one side of the back.





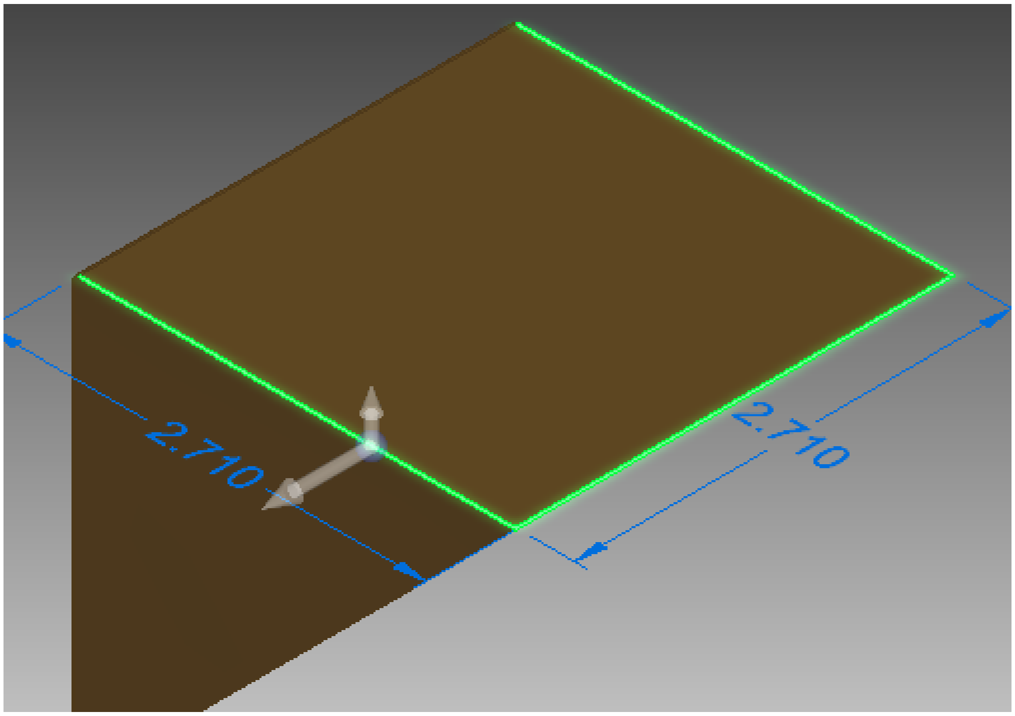
Once you hit the enter key you should see one side of the back sticks out beyond the top.



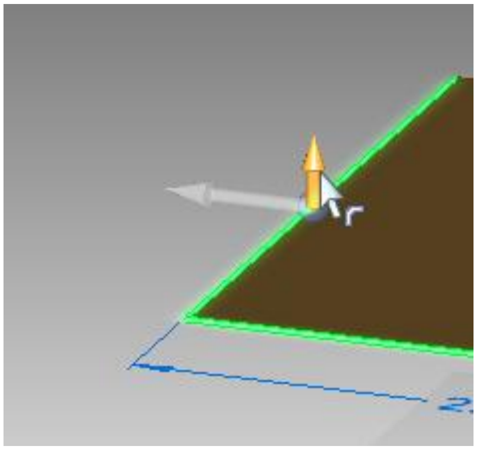
Repeat the process for the other side of the back. You should see the back sticking out on both sides at this point.

This is a good time to add the flaps to the top that will insert into the box.

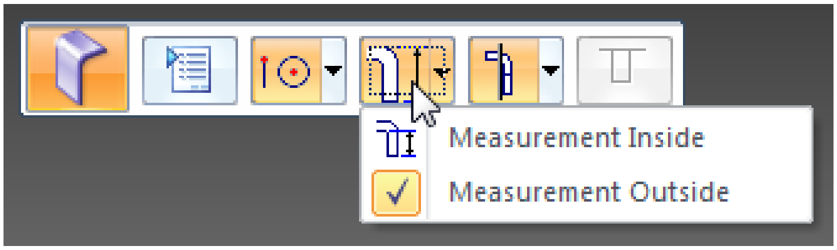
Select the Contour Flange command again. This time hold the control key down and select the three remaining sides of the top.



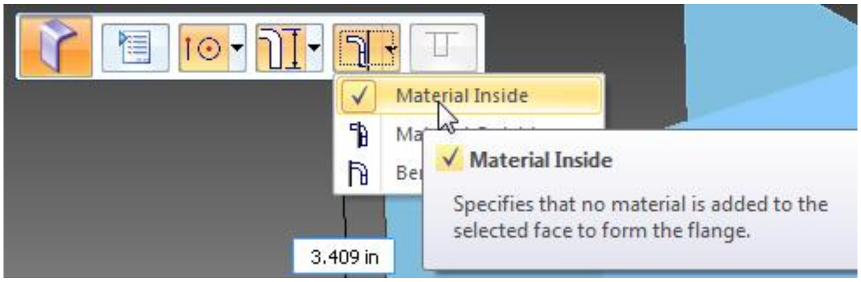
Click the Vertical Handle to indicate the direction you want the flaps to be created.



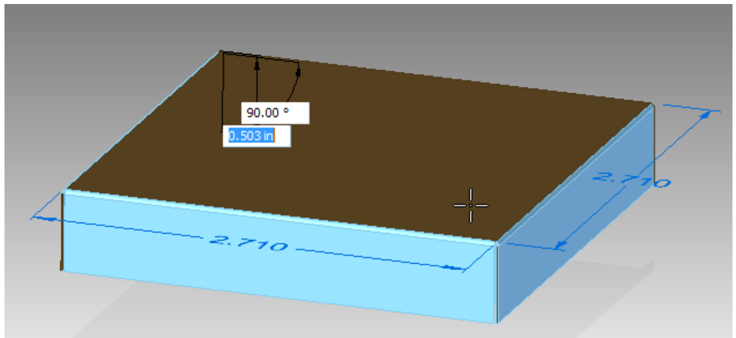
Once the flaps are showing you will see the options dialog box. Set the measurements to the outside option (Measurement Outside). This distance will be measured from the top of the top panel.



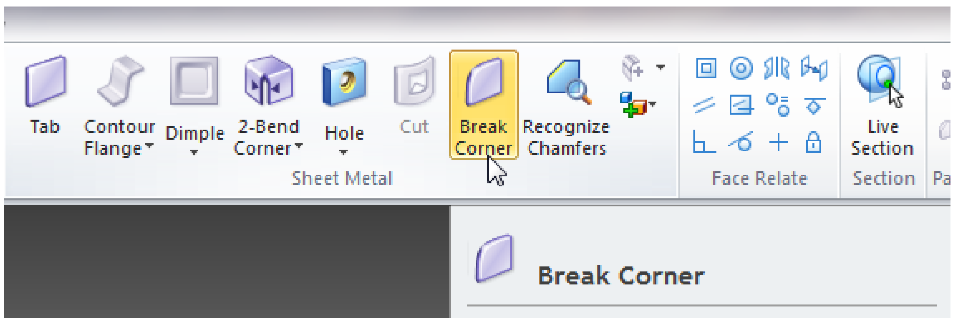
Then set the material to be on the inside (Measurement Inside). This will help later when clearances are needed.



Now move the mouse below the top panel to drag the flaps down. Enter in a value of .500 for a distance.

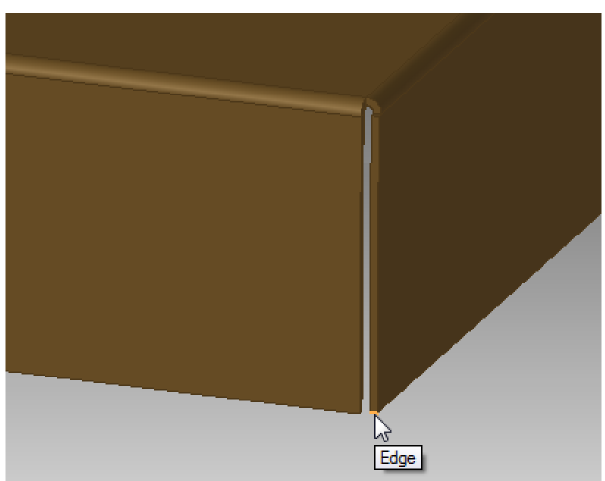


The three flaps will then be created. The flaps will be difficult to insert into the box if they are left in this state. Chamfer is a term used for a feature that breaks a corner typically at 45 degrees. On the Sheet Metal section of the ribbon there is a tool for Break Corner.



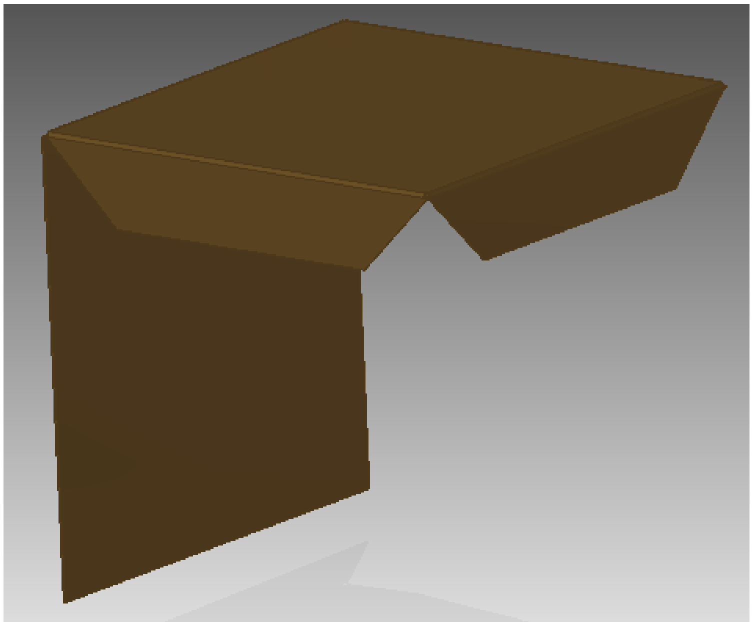
Select the Break Corner tool. In the dialog box select the chamfer.

Zoom into the corner to view the extremely small edge at the end of the flap. Click on the end of the flap selecting the edge similar to the picture below.

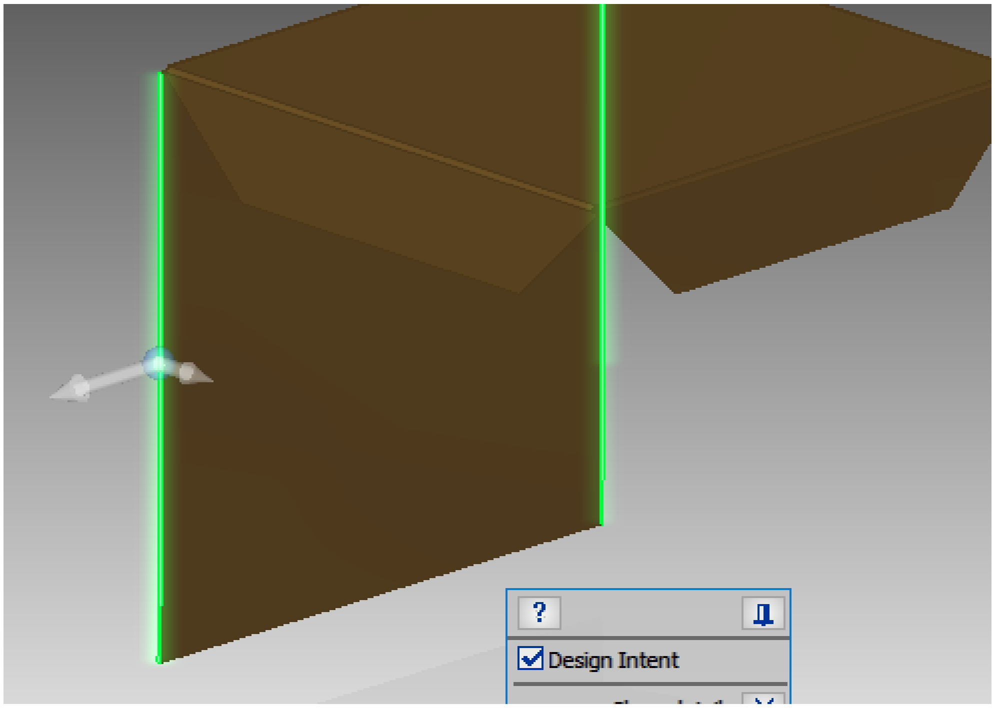


The last known value for the chamfer tool will show up. Change this value to 0.470.

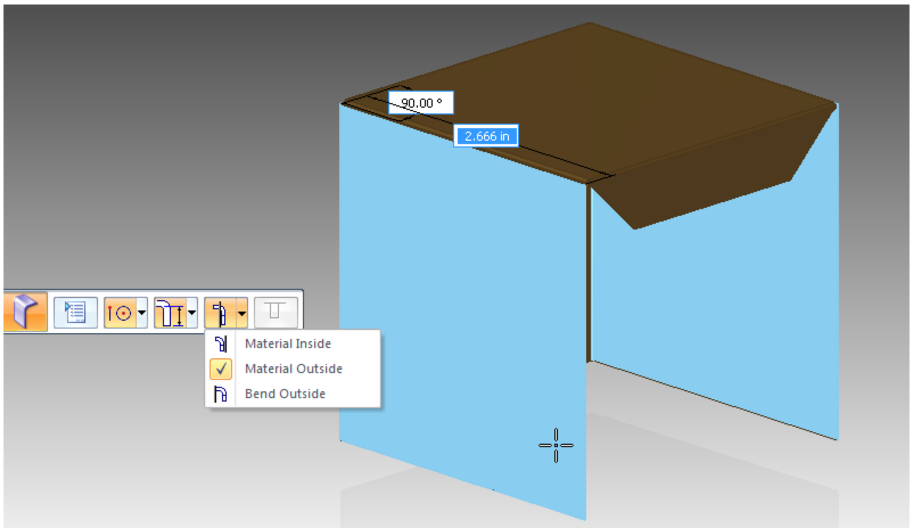
If the value is greater than the flap you will see an error. Repeat this process on the other corners at the bottom of the flaps. Each flap should have one chamfer on each end.



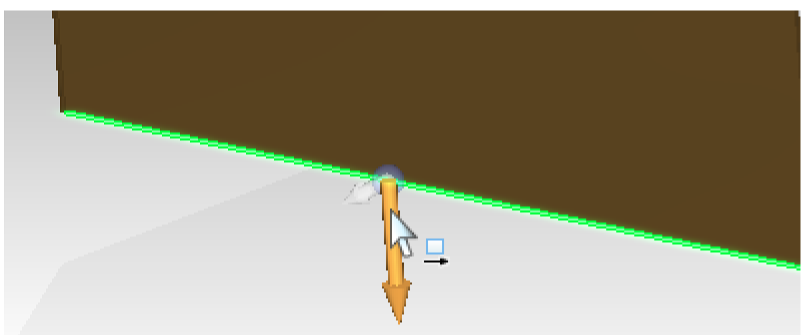
Once this is complete it is time to add the sides. Select the Contour Flange command again. Hold the control key down again and select the two sides of the back.



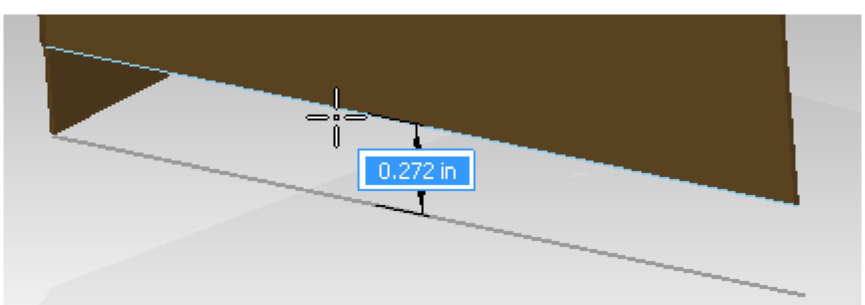
Click on the handle and drag toward the front of the box. Set the measurement to be on the inside and the material to be on the outside. Set the distance to be 2.697. (2.71 - .013) We will be adding a glue tab to the end of the side which will provide the correct interior dimension when the side is complete.



To be sure the bottom of the box stays fastened to the sides we add what is called a glue tab. Since this will take some space on the inside we need to shorten the sides enough. The distance .013 will provide just enough clearance to make the connection. Hit the Esc key to be sure you are not in a command. Click on the plane at the bottom of the side and select the handle pointing down.

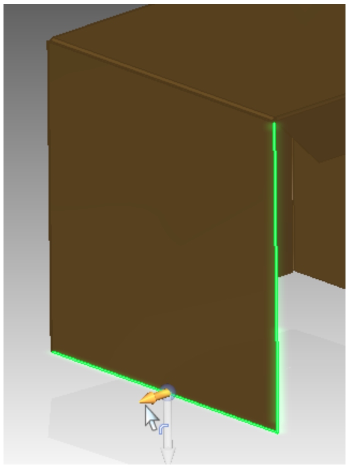


Pull the arrow upward and enter .013 for the distance.



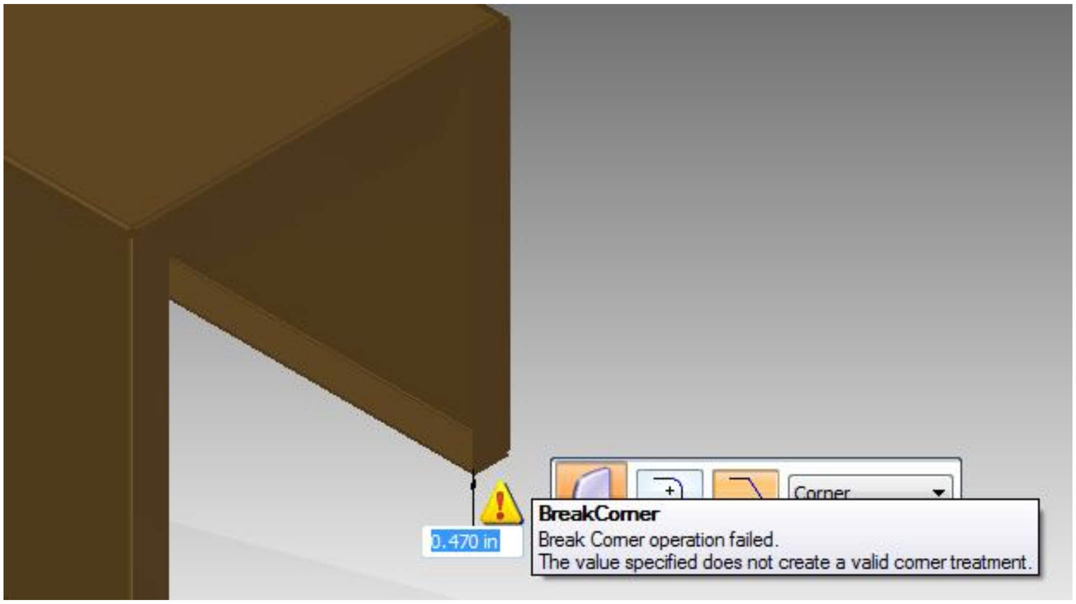
Repeat the process on the other side to finish the job of shortening the two sides just created.

Now we are ready to add glue tabs to the sides to hold the bottom and the front to the rest of the box. Select the Contour Flange command again. Select the bottom and front of one side.

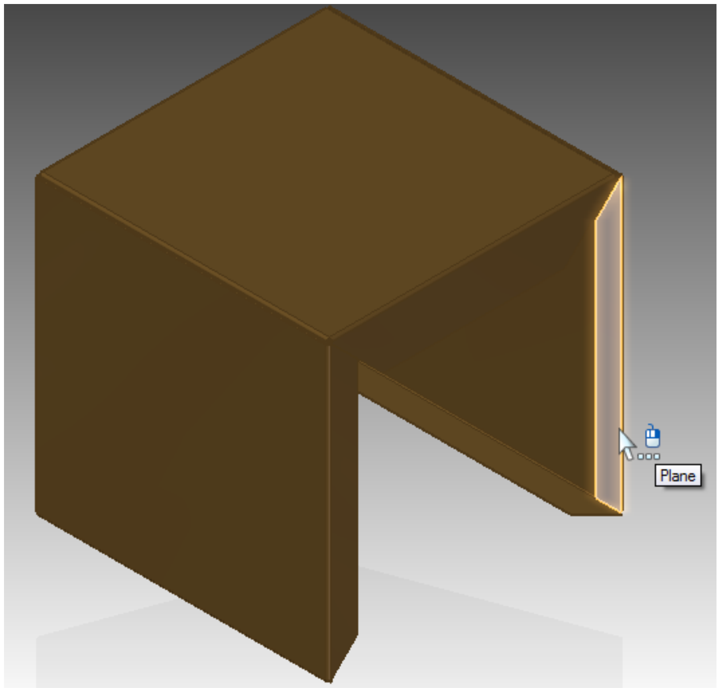


Select the handle that points out. Set the measurement to the inside and the material to the inside. Drag the handle toward the other side of the box. Enter a distance of .25. Repeat the process for the other side.

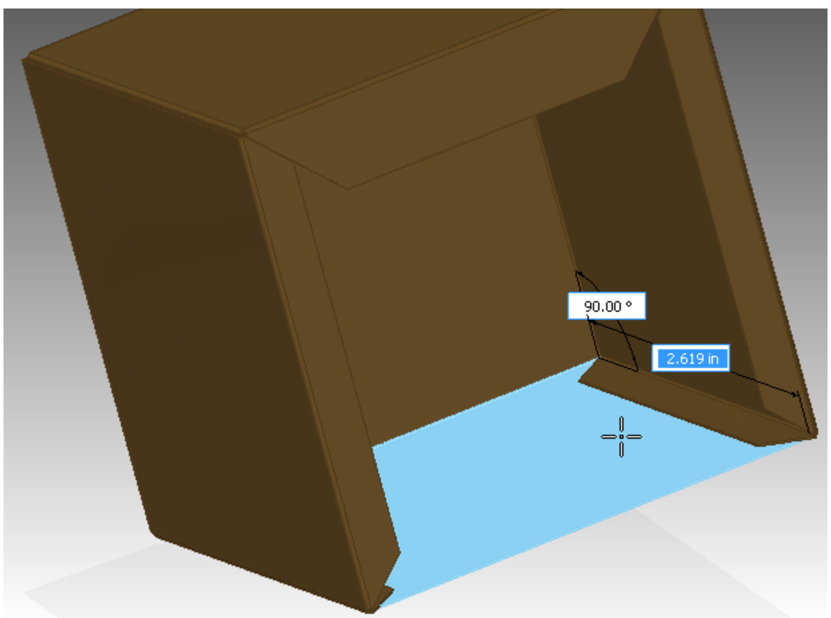
Chamfer the corners of the glue tabs. Select the Break Corner command. It will try to use the previous distance. In this case, that is impossible. You will see an error message that looks like the one below.



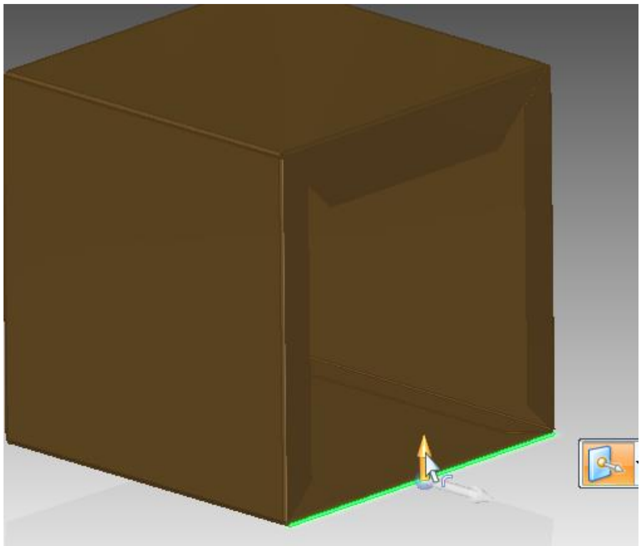
Highlight the value in the box and replace the distance. Use a distance of .23. When you strike the enter key the error message will disappear and the chamfer will be the correct size. Repeat the chamfer command on all the corners of the glue tabs.



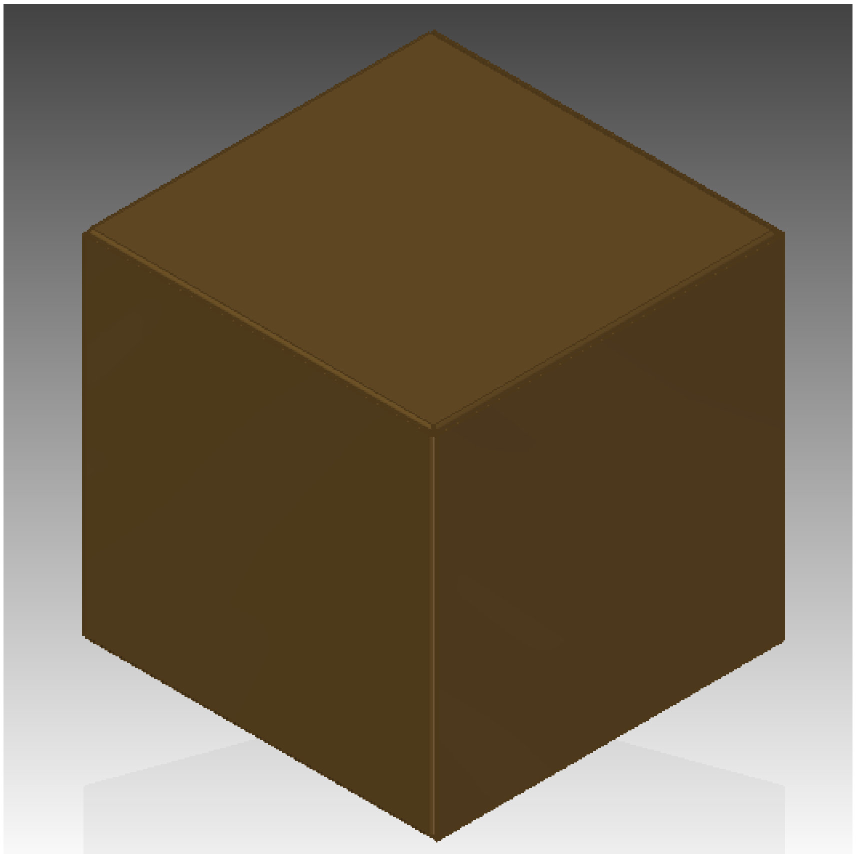
Complete the bottom of the box by selecting the bottom plane of the back of the box. Use the inside measurement and material on the inside. The distance will be 2.710.



To complete the basic box, select the plane at the front of the bottom. Set the dimension to inside and the material to the outside. A distance of 2.710 should be used.



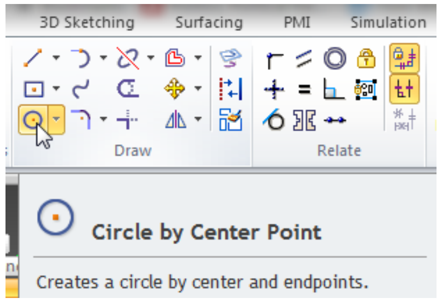
The basic box is finished.



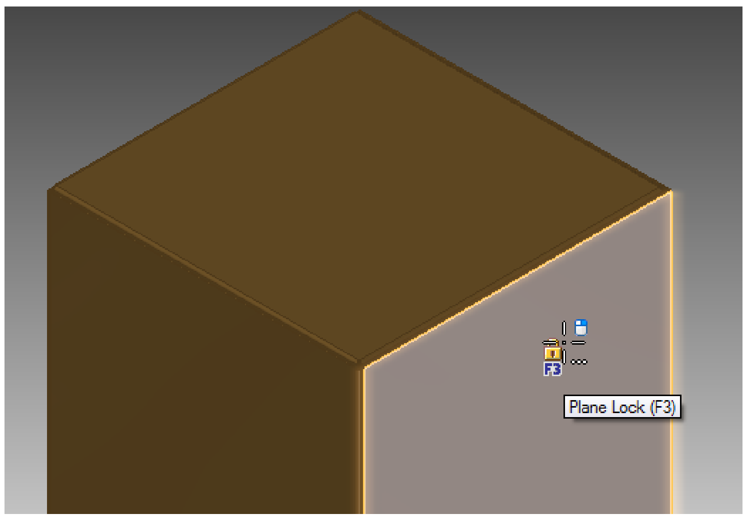
Back

Adding Sheet Metal Features

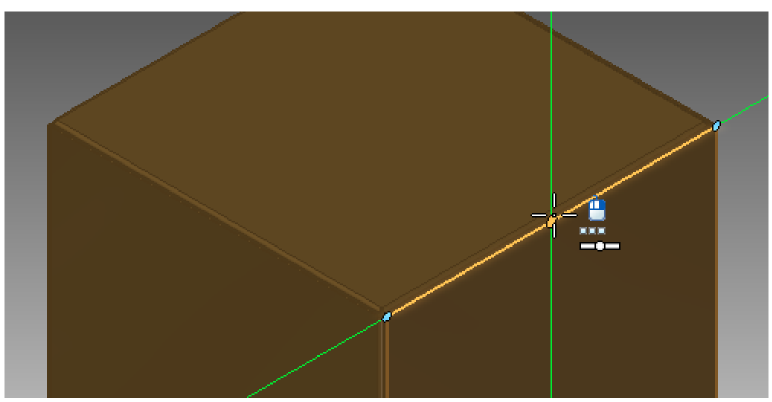
In order to ease entry when closing we will add a circular cutout to the front. Select Circle by Center Point from the Draw section of the ribbon.



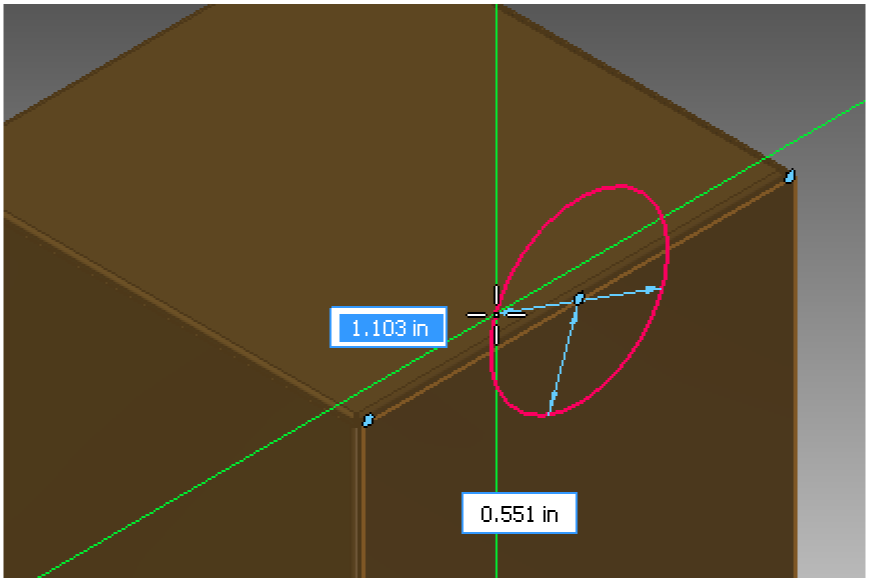
Hover over the front panel of the box. When the plane highlights select the F3 key to lock the plane.



Hover over the top line of the front panel and left click when you see the center mark appear.

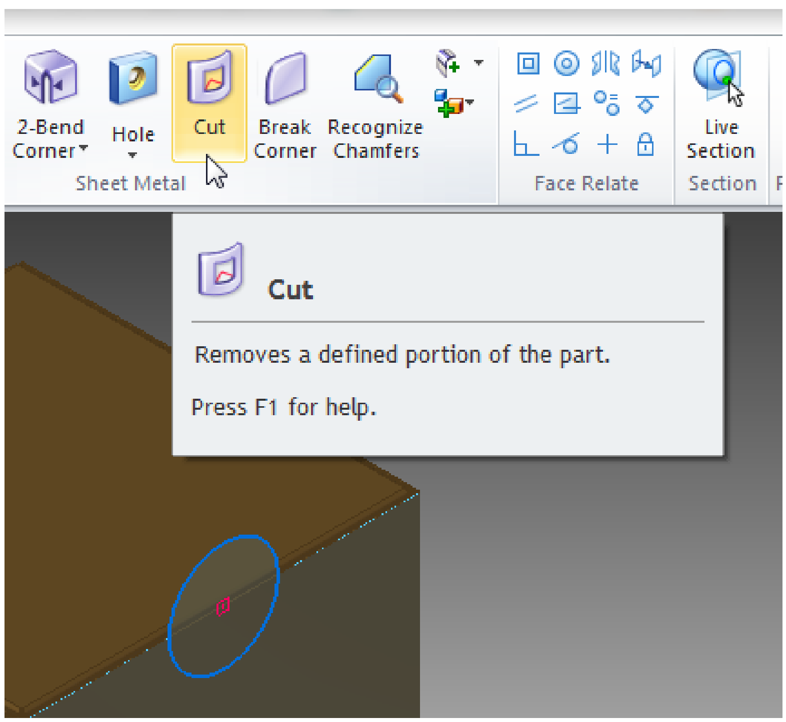


This will place the center of the circle on the center line of the top.

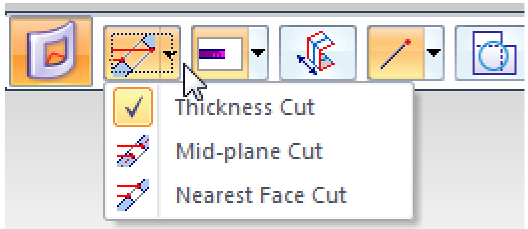


Enter a distance of .750

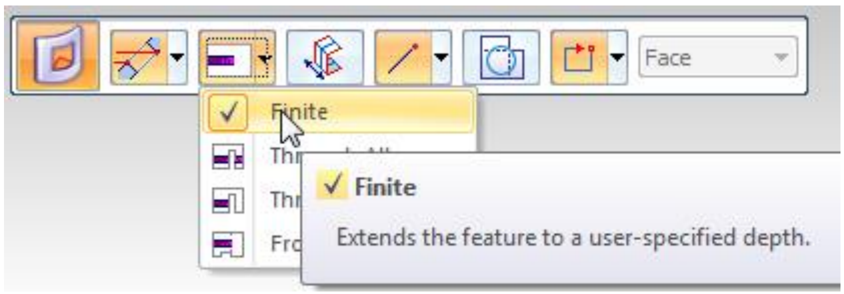
From the Sheet Metal section of the ribbon select Cut.



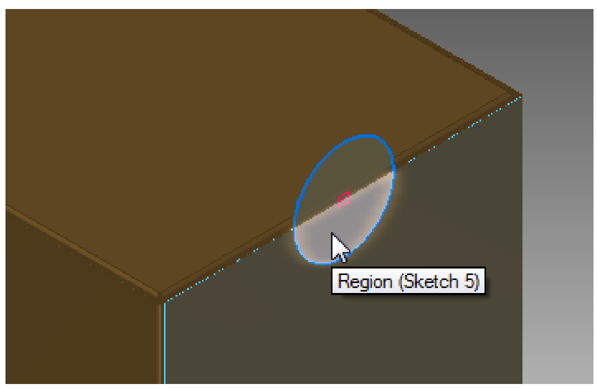
On the Cut settings dialog box select Thickness Cut.



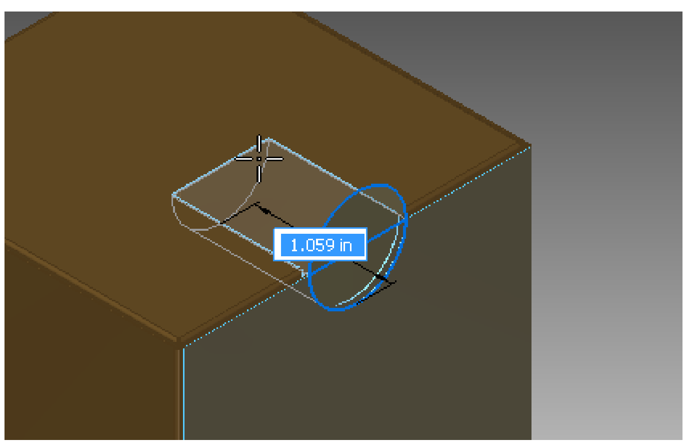
Select Finite for the depth of cut.



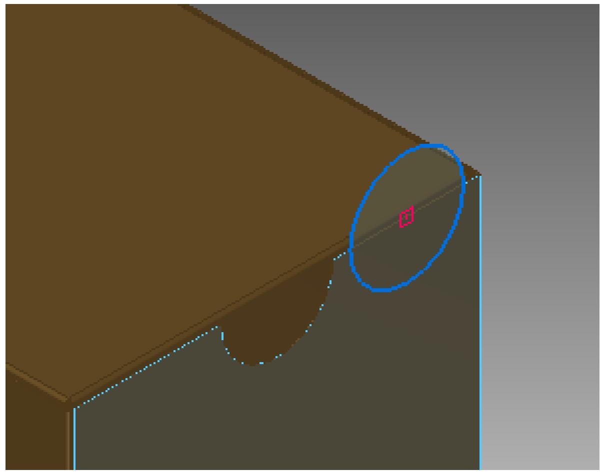
Now select the lower half of the circle just drawn.



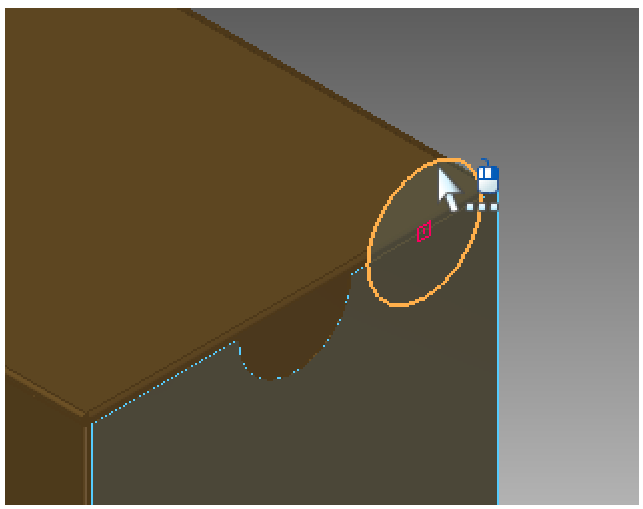
Right click to end selection and then move your mouse into the box.



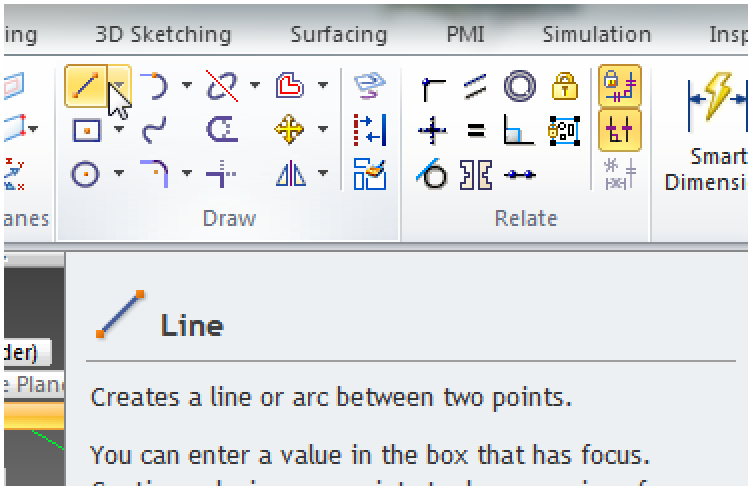
Enter a depth of .012 to only cut through the outside surface. Select the Enter key. The line across the middle of the circle will disappear. Hit Esc to end the command



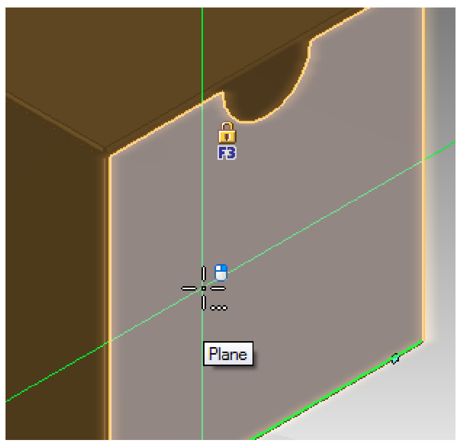
Highlight just the circle and press the delete key to remove the circle.



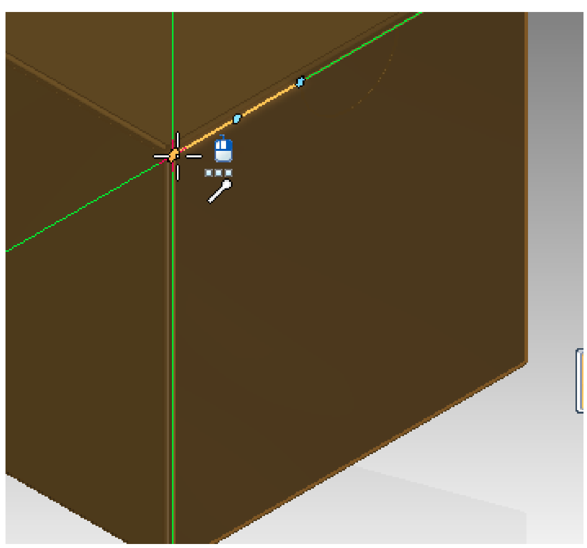
Frequently a package will have a window to display the contents. In the case we want two small windows; one on the top and one on the front. This will allow packages to be stacked and still allow consumers to see exactly what is inside. A diagonal line on a square passes through the center of the square by definition. In our case we want to position a hole directly in the middle of the front. Select the Line tool from the Draw Pallet of the ribbon.



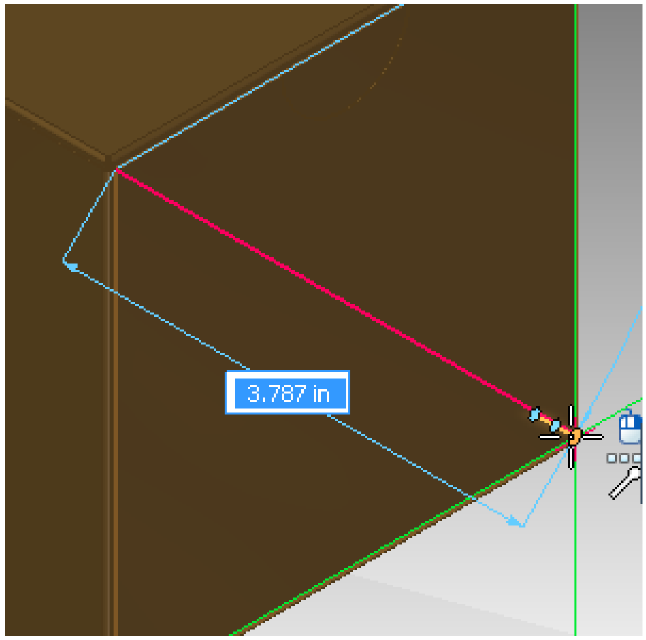
Hover over the front of the box until it highlights and then press F3 to lock the sketch plane.



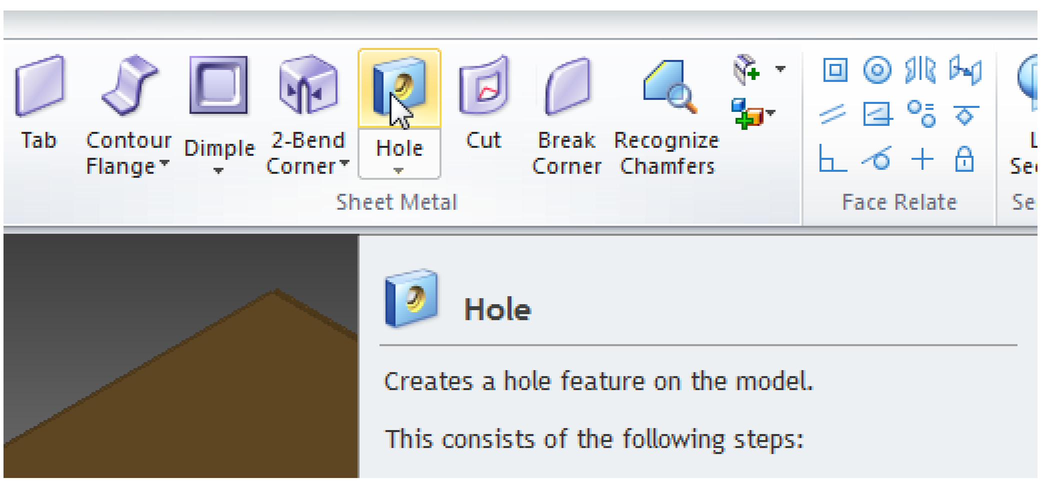
Find the corner of the top line and click to begin the line.



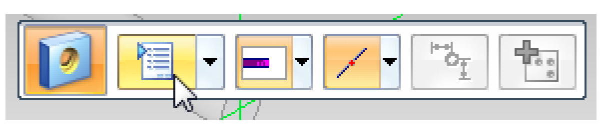
Stretch to the opposite corner and select the other corner.



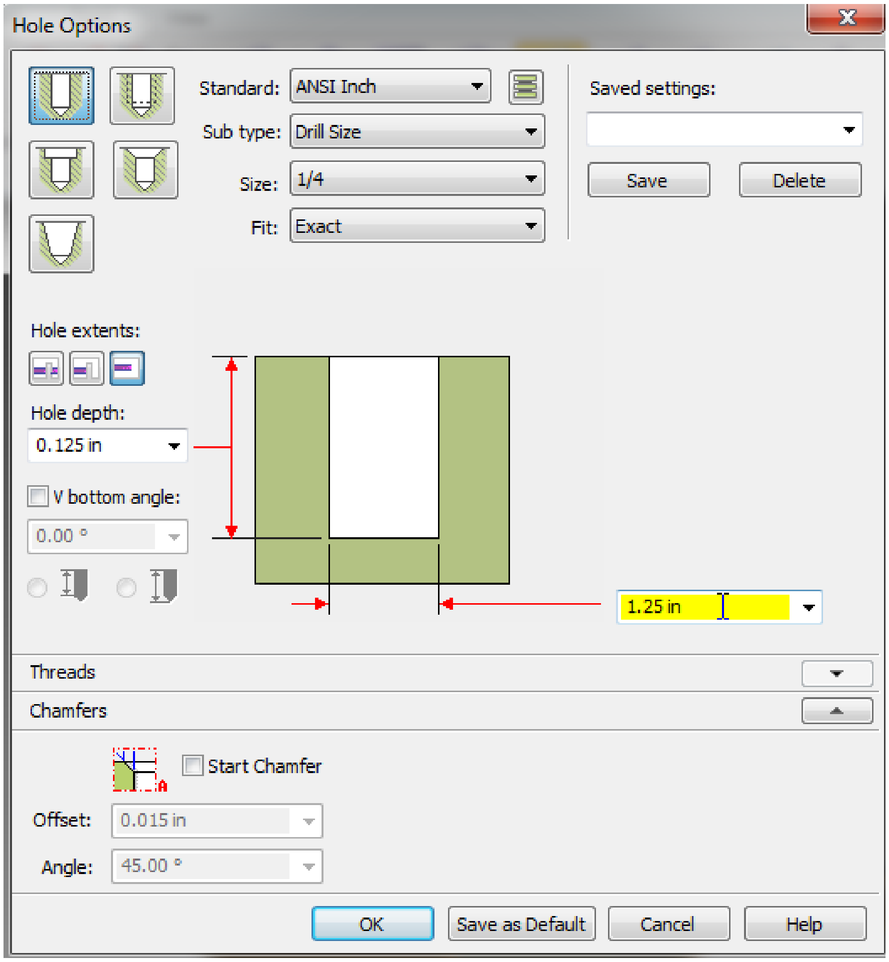
Press the Esc key. Now select the Hole tool from the Sheet Metal section of the ribbon.



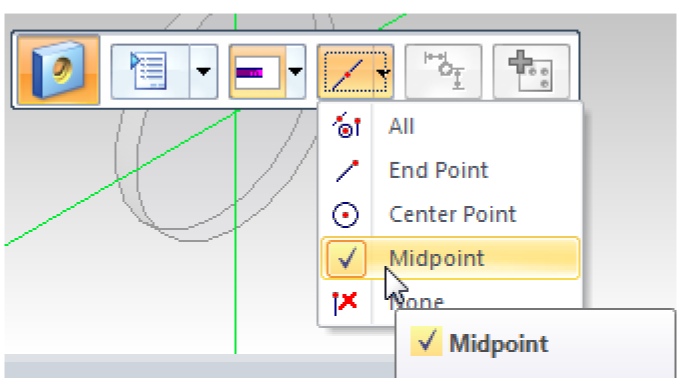
When the Hole dialog box opens select the Hole options icon.



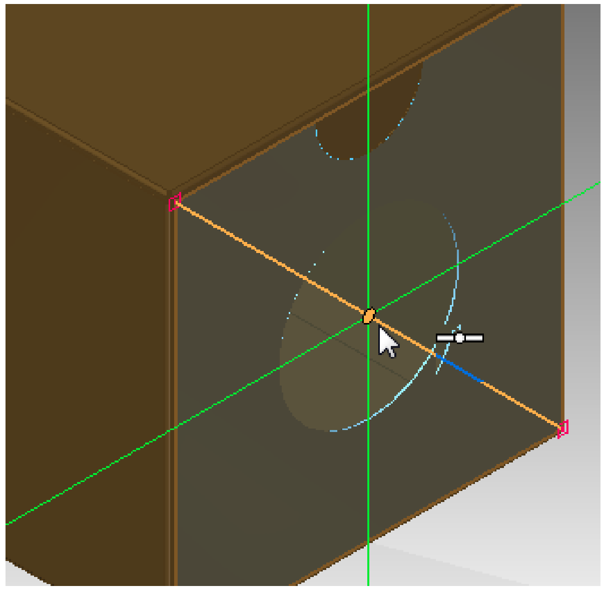
This will bring up the Hole options. In this case enter 1.25 as the diameter of the hole and .125 for a depth. This will cause the hole to pass through the outside of the front panel. Select OK.



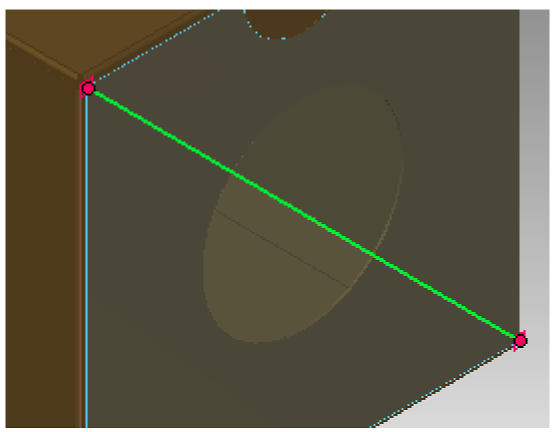
Now set the Key Point to the Midpoint setting.



Once you make your selection return to the front of the box and come close to the center of the line. It will show you that it has found the center point. Click to place the hole.

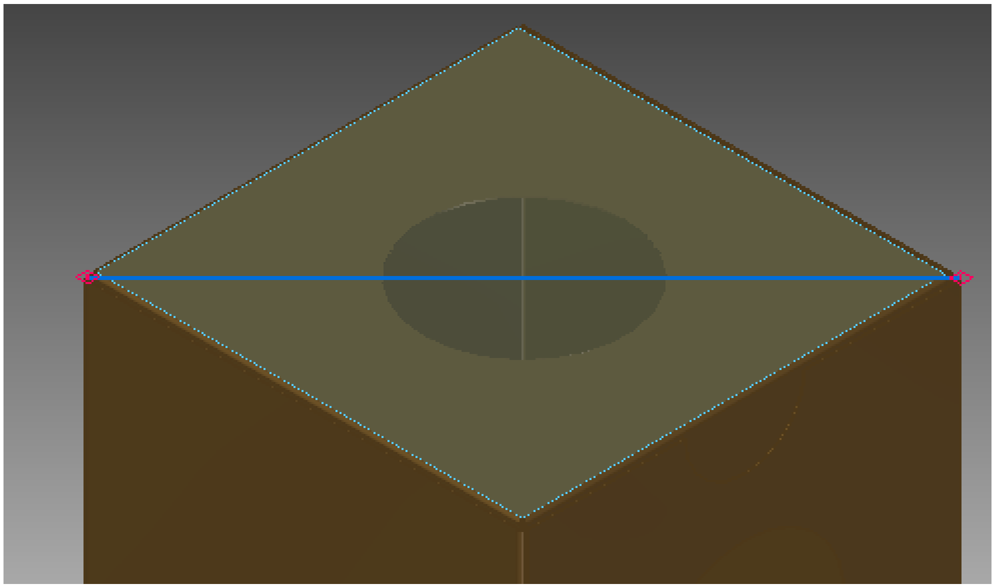


You should be able to see through your front panel. Press the Esc key to exit the command. Highlight your diagonal line. Press the delete key to remove the line.



Click on the lock in the upper right hand corner of the screen to remove the lock on the plane.

Repeat the process to place a hole in the top.



Delete the line after finishing creating the hole.

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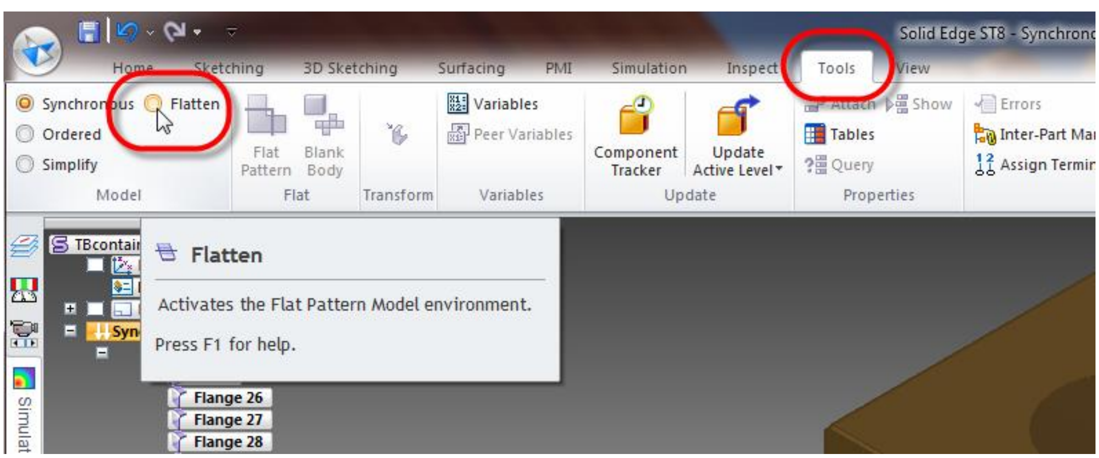
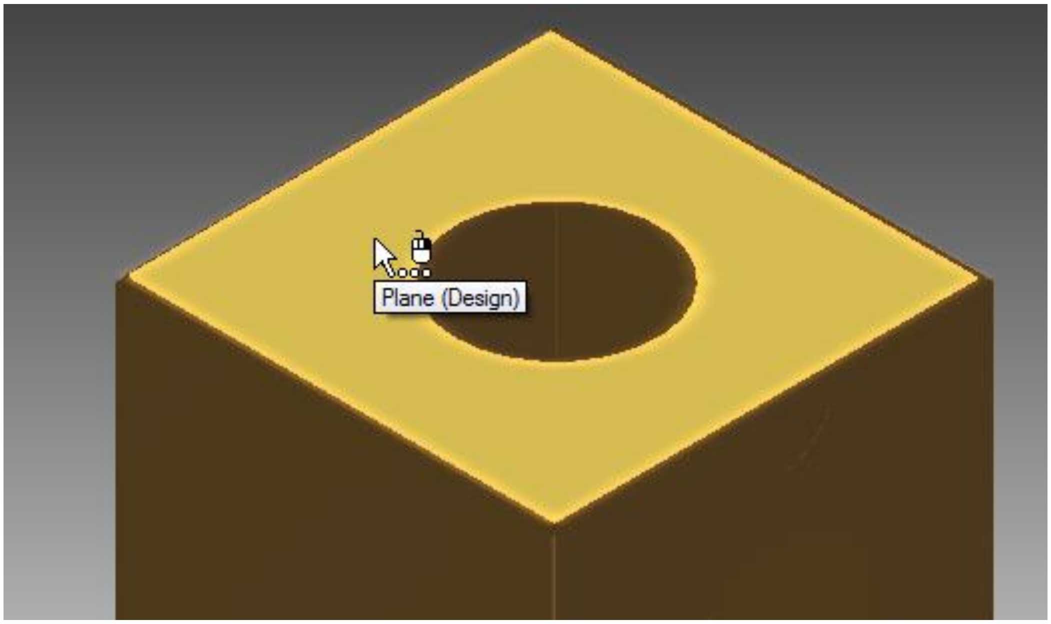
Creating the Flat Pattern

This example helped you create a three dimensional model of your finished container. To make this from a sheet of flat stock we need a pattern which will show us where to cut and where to bend our stock so we can create a box from the file folder.

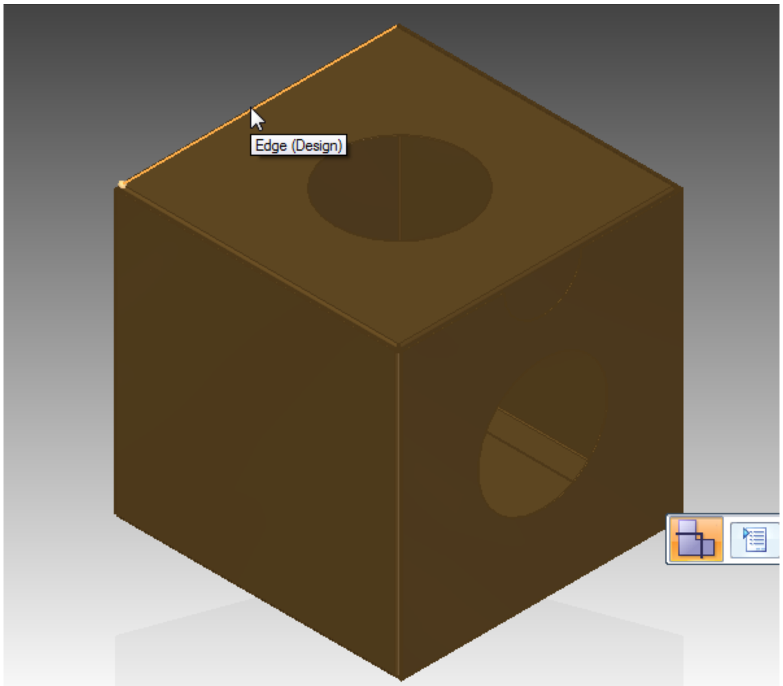
Select the Tools tab and then check the box for Flatten.



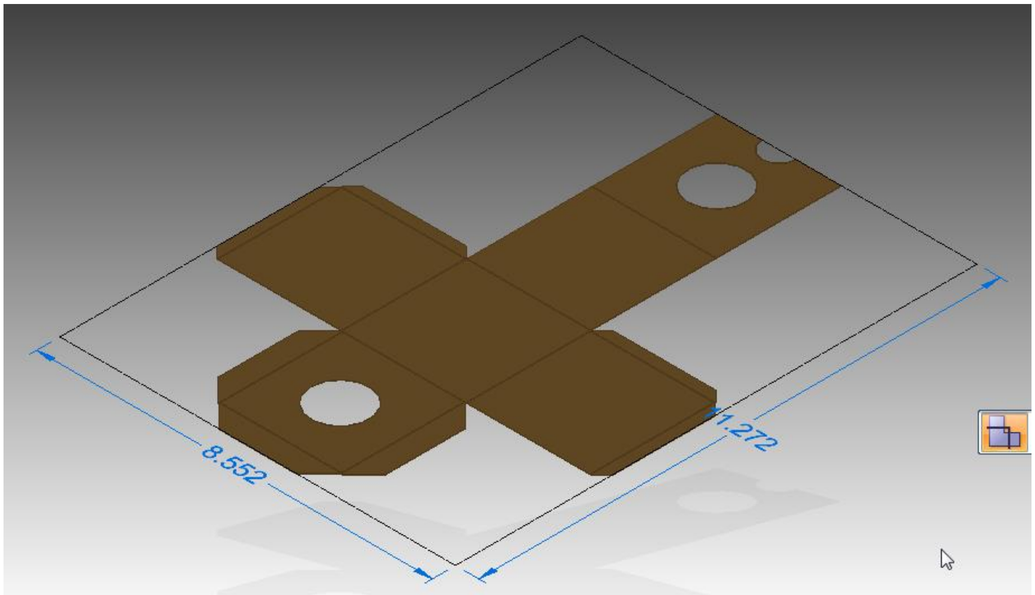
When creating the actual flat pattern it is important to know how to orient the flat pattern. The prompt will ask you to select a plane to be oriented upward in the flat. Select the top of the box.



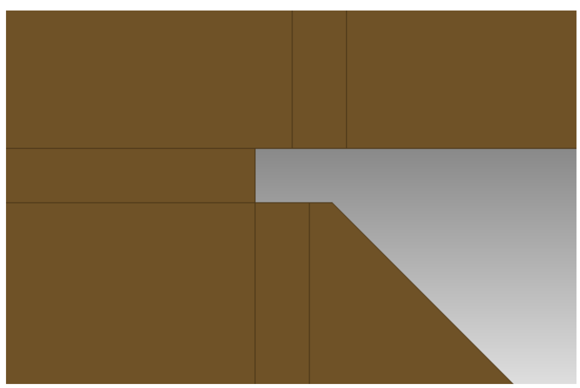
The prompt will ask you to select an edge to define the X-axis and origin. Select the line between the top and back panel.



Once you select the line you will see the flat pattern displayed. Study the pattern and identify the sides, front, glue tabs, top etc. The dimensions displayed identify the outer dimensions of the necessary sheet to cut and fold into the box.



Use your zoom tool to take a look to see how the program created the pattern.



What looked like single lines are really double lines which outline the section that will bend. Where the sides and bottom come together you will see the folds offset and a relief cut so when folded the rest of the shape will not deform.

Be sure to save your file.

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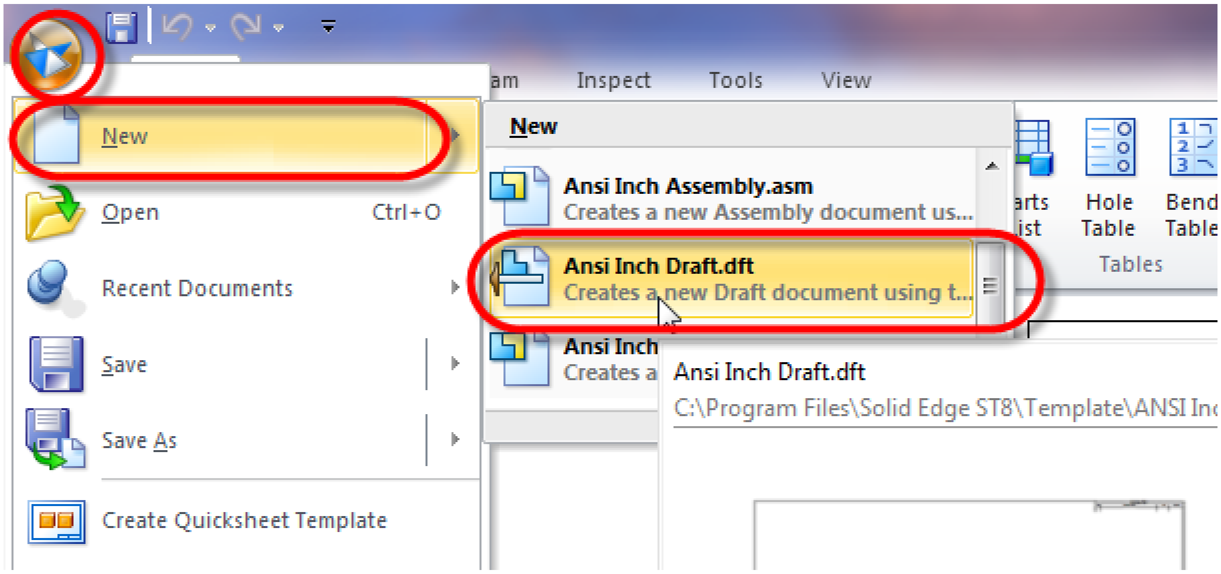
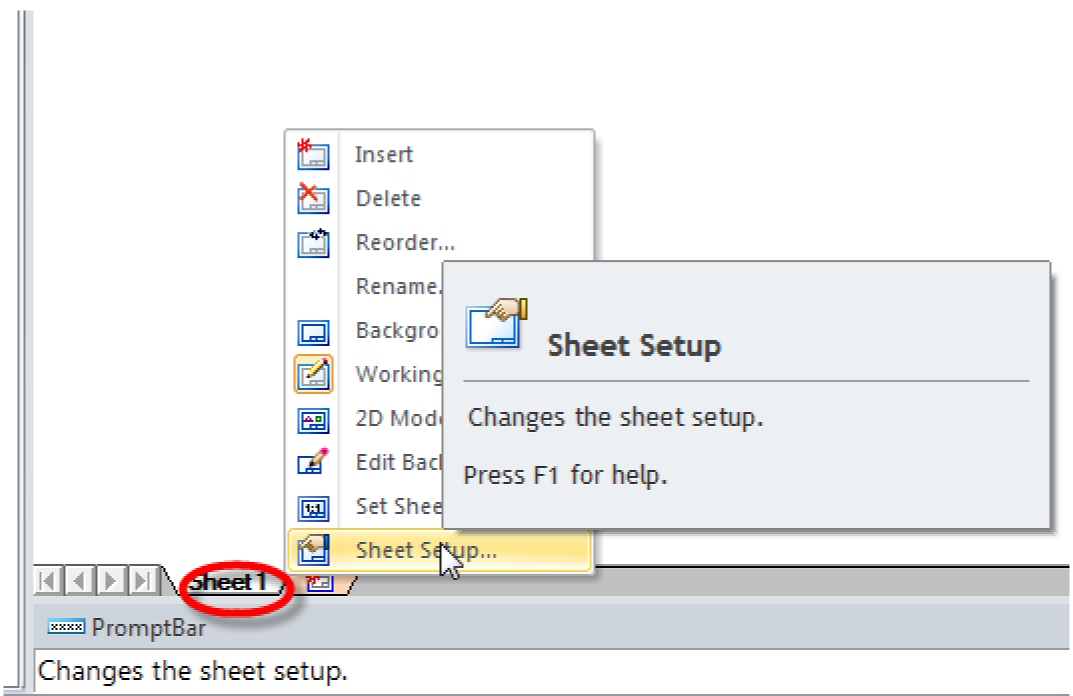
Flat Pattern Printing

Printing a pattern involves placing the flat pattern on a Draft sheet of the appropriate size.

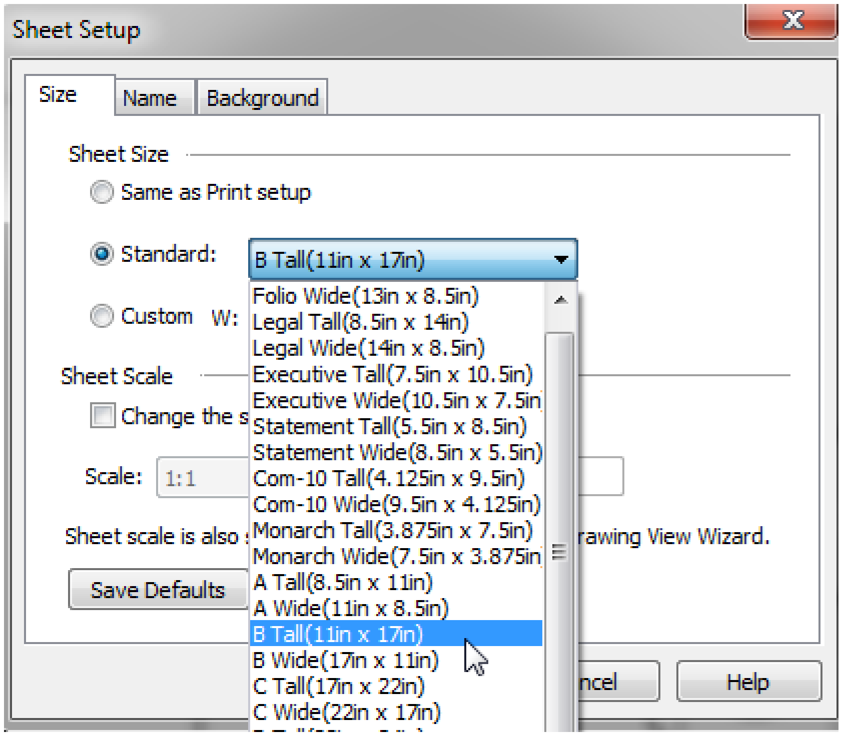
Begin a new Draft document. Click on the Application button in the upper left hand corner. Select the New option then find the Ansi Inch Draft.dft template.



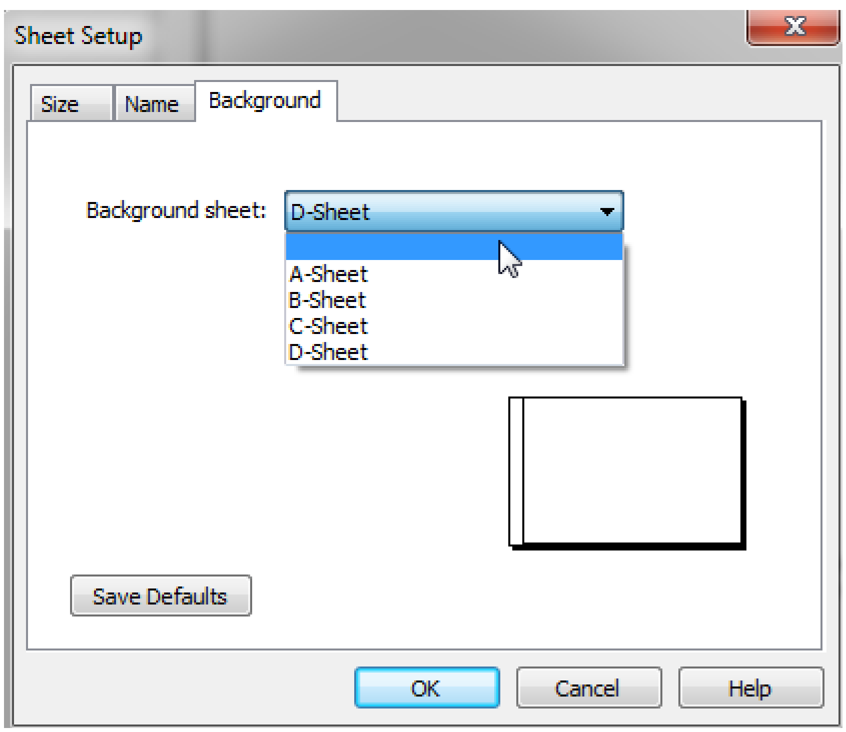
This opens the default sheet. Since the actual size of our part is larger than 8.5 x 11 we will need a larger sheet size. Check with the instructor to see what sizes your printers can print. Change the sheet size by right clicking on the Sheet 1 tab at the bottom of the window.



This example will change sheet size to a B sized sheet as our printer can print B sized paper. On the Size tab change the paper to B Tall (11 in x 17in).

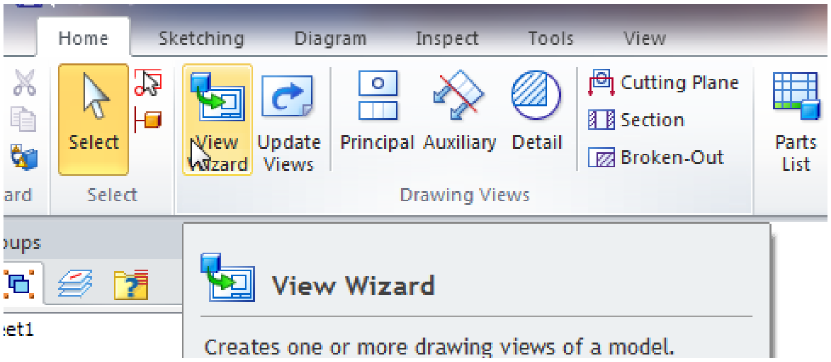


Click on the **B**ackground tab. Select the Blank line. This will remove the border.

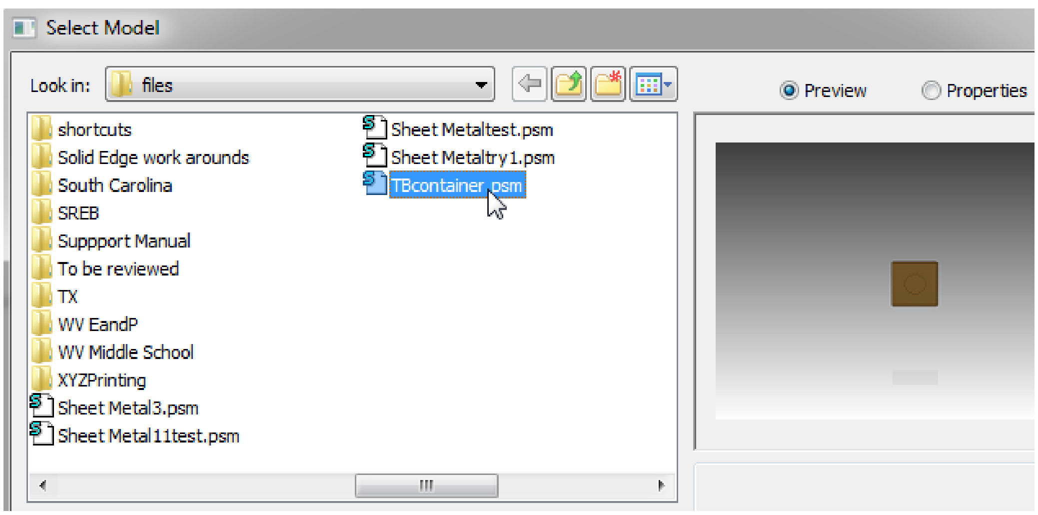


You should now see a simple black rectangle on the screen.

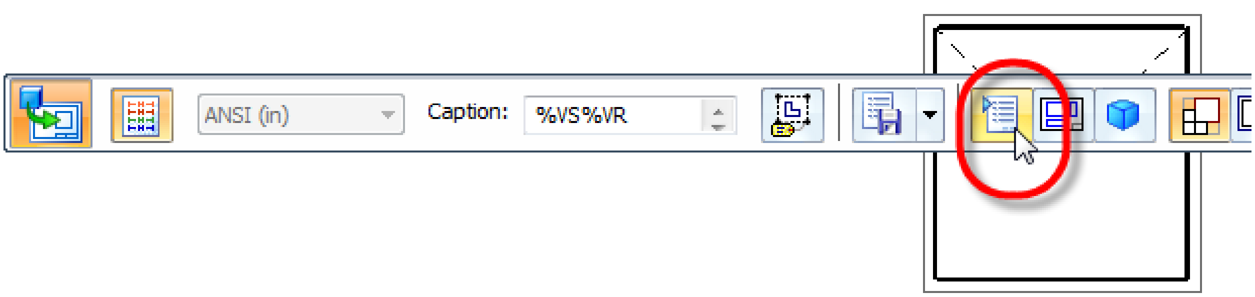
This defines the paper area you have to work with. On the Home tab select the view wizard.



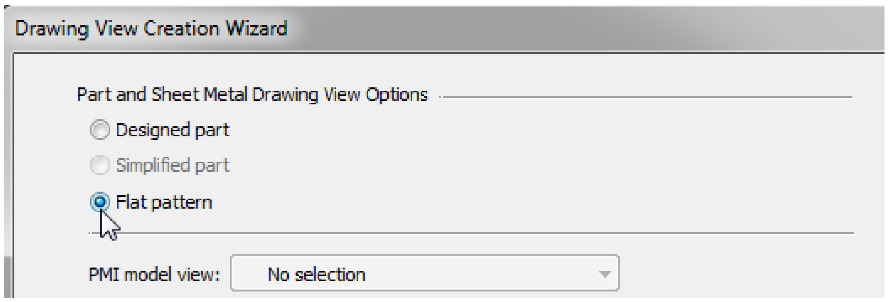
This will open the Select Model dialog box. Select your file from your storage location. It will look for files that have the .psm extension. Select the tennis ball container that you created. Select the open button.



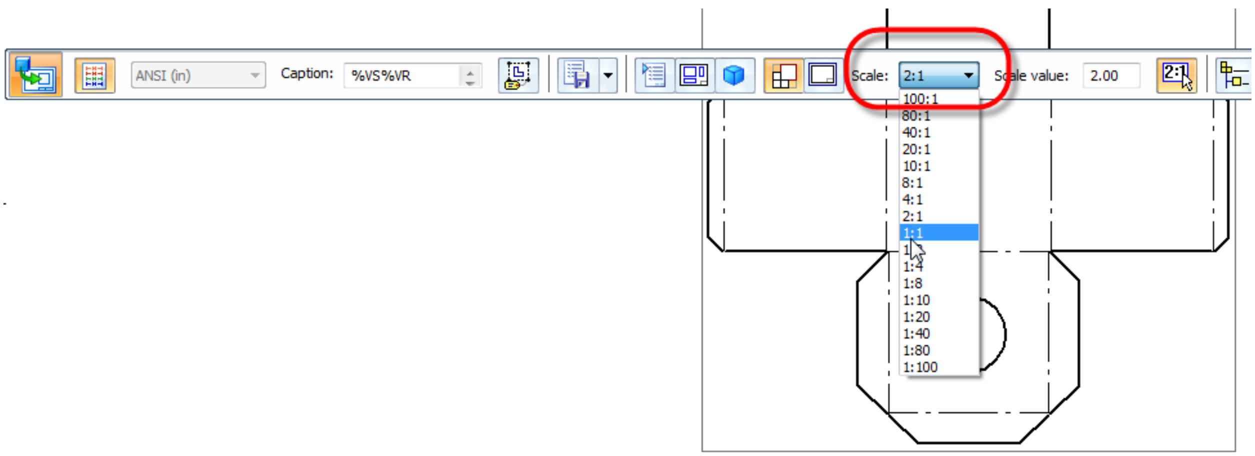
You will see the object chasing your mouse around the screen and the View Wizard tool bar. Select the Drawing view creation wizard.



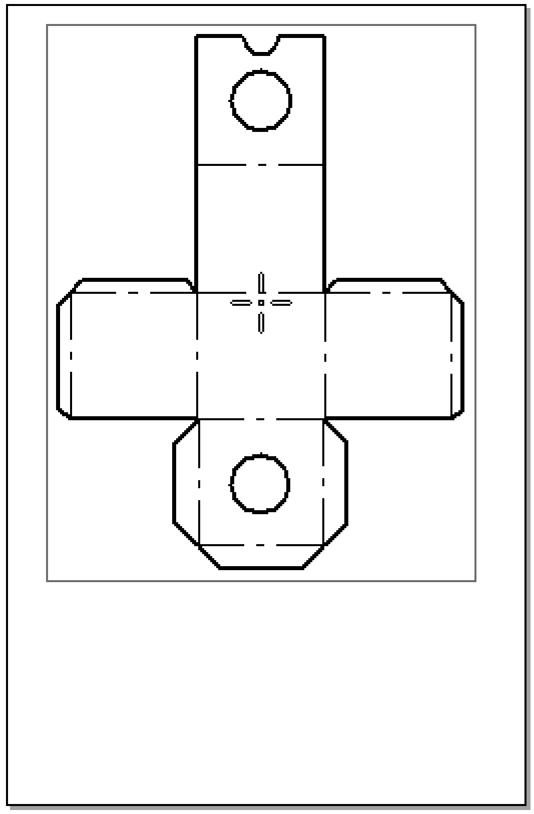
This brings up the Wizard dialog box. Select Flat Pattern from the choices. Select OK.



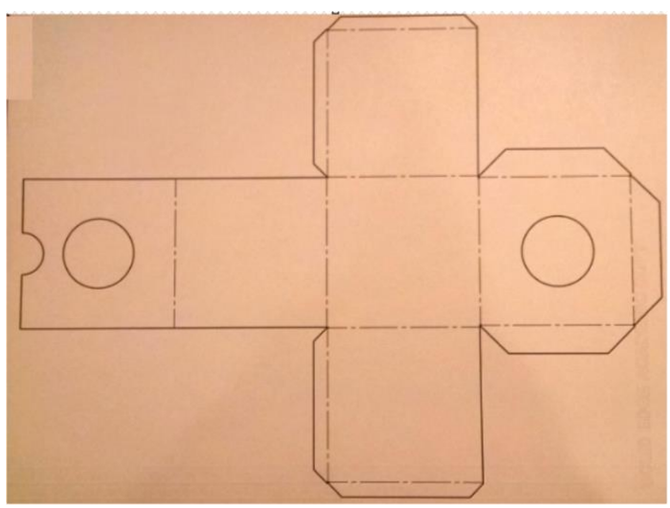
When you click on OK you will see the flat pattern chasing you around the screen. Change the scale to 1:1 to get the pattern actual size.



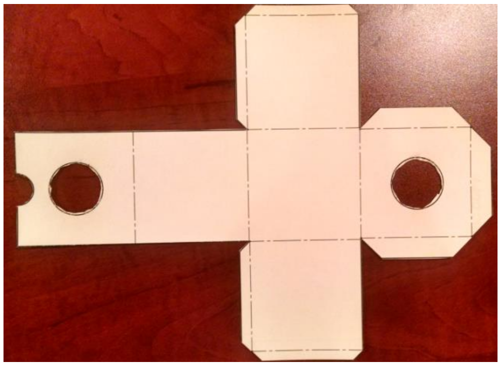
You will see the image of your pattern shrink to actual size in relation to the paper.



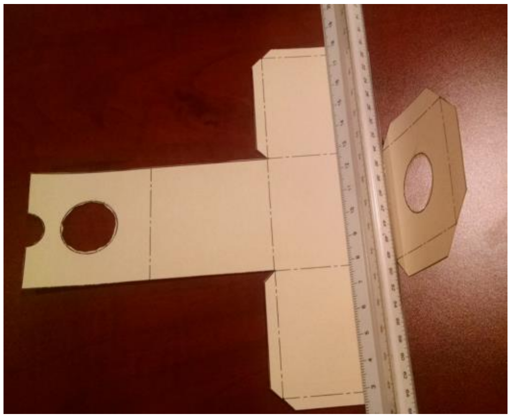
Get permission from the instructor to print the sheet. This example was printed on an old file folder that was cut to fit the printer.



Carefully cut on the solid object lines.



Use a straight edge and fold each line. Some lines are slightly offset from each other. Care must be taken to be sure the pattern is folded on the fold lines.



Pre fold all the lines. Use glue or tap to fasten the glue tabs to the other surfaces.

Test the box with a tennis ball to be sure your container is the correct size.

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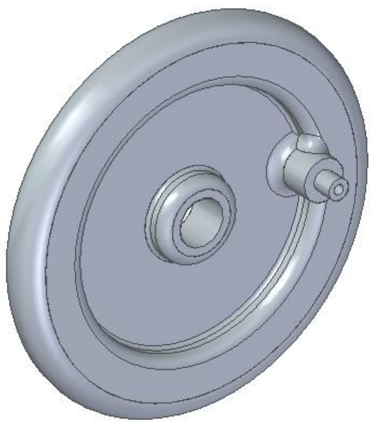
Rendering with KeyShot

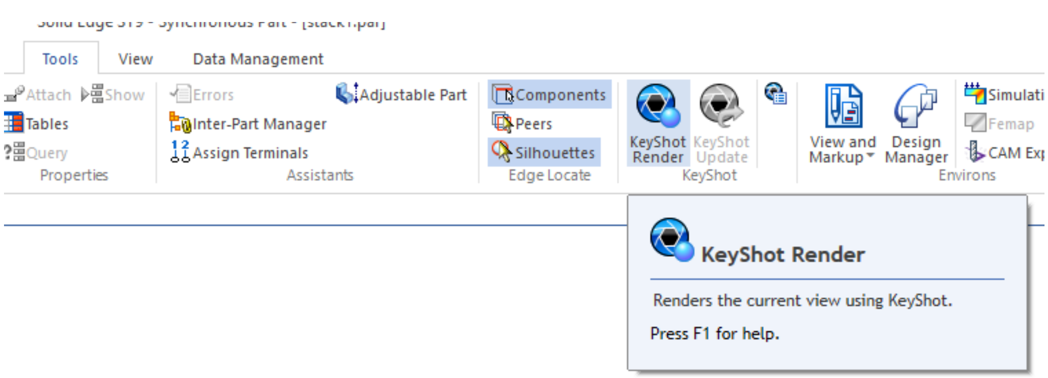
Rendering is the process of creating an image with color, texture, shading, shadow, and lighting resulting in a realistic image. Renderings are used in movies, advertisements and other sales tools.

Open an existing file. This example will use the wheel part from previous tutorials.



While the color improves the blandness of the design it doesn’t reach out and grab the viewer. Rendering adds reflections and textures to the wheel allowing for it to resemble a real object. KeyShot Lite is a rendering tool that is included with Solid Edge.

While your part or assembly is open in Solid Edge, select KeyShot Render from the KeyShot section of the tools ribbon.

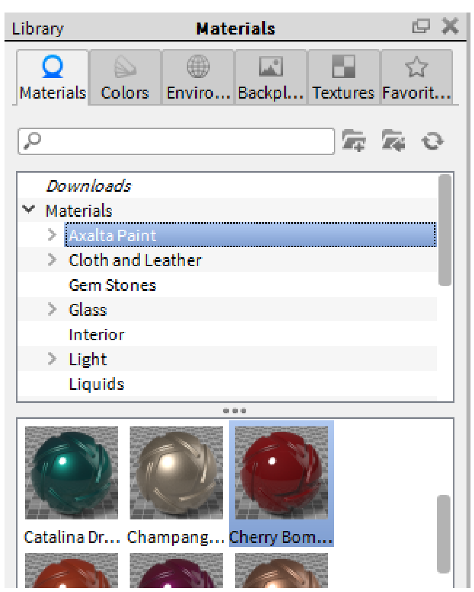


This will automatically open your file in the KeyShot Render software.

The wheel's texture is somewhat improved over the original CAD model. The part will be seen in the middle of the screen. Your Library will be located on the left and your project window will be on the right side of the screen. It is possible to control how you are looking at your part by changing the position of the camera with your mouse. To move your design left, right, up, or down (pan) hold the center wheel of your mouse down and move the mouse. To rotate the image, hold the left mouse button down and move the mouse. To zoom in and out, use the mouse wheel without holding it down. Arrange the model on the screen until you are comfortable with the results.

Materials

In the Library on the left side of the screen, select the Materials tab. Under Materials, select Axalta Paint. This will open the available colors.



Apply a color to your model by selecting the color and dragging it to the location on the part.

Shadows and reflections are automatically created as the material is applied. To change the color simply drag another color to replace the original. Experiment with the colors until you are pleased with the results.

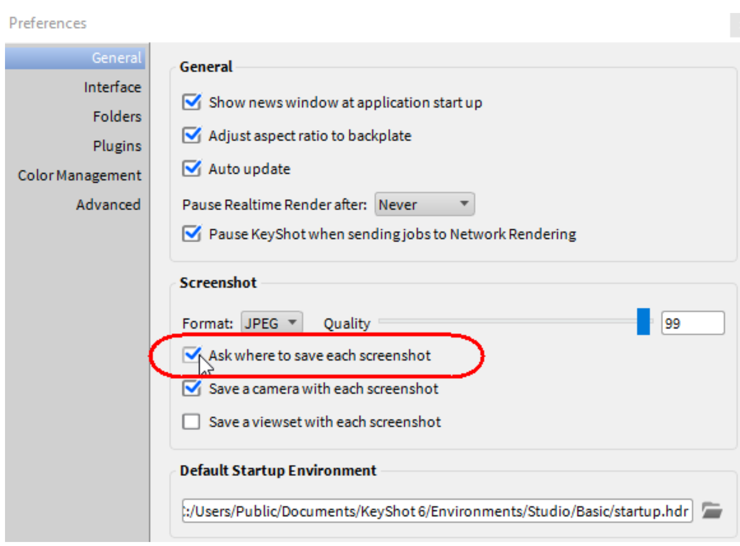
Environments

Next, select the Environment tab. This tab controls the lighting used. The default is called Startup. Try different lighting schemes to see how the visual representation changes.

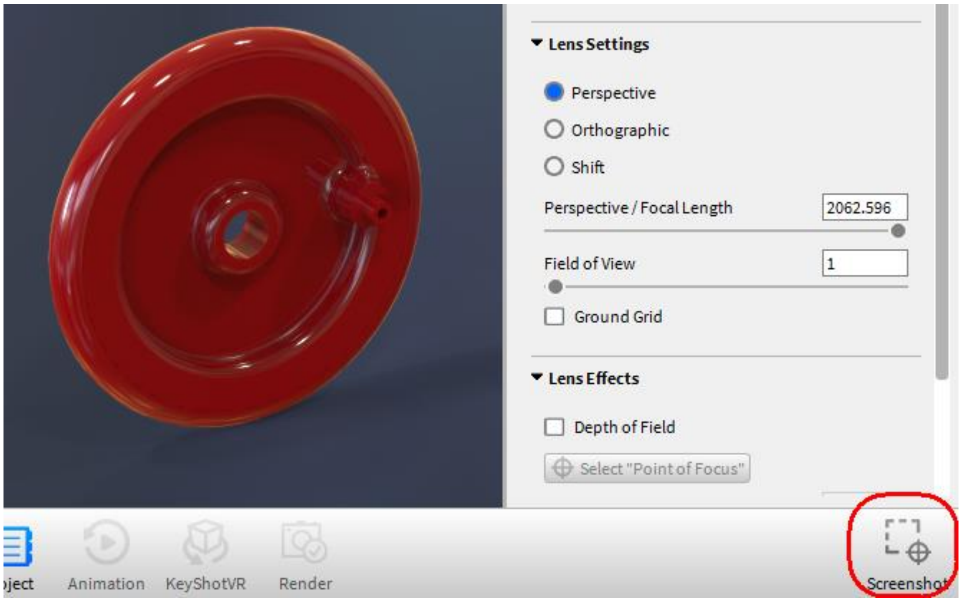
Change background environments to meet your needs.

Try textures, lighting, and materials until you have a feel for how to best present your part. When you are satisfied with the results you can save a screenshot of the image. By default, the software will save the screenshots to a folder C:\Users\Public\Documents\KeyShot 6\Renderings. This might not be the best location to find your images quickly. Change this setting at the Edit Pull Down menu and selecting Preferences from the options.

On the General tab, place a check in the box for “Ask where to save each screenshot”



Select the box for Save changes by selecting the icon at the lower right of the screen.



You will be prompted for a location. Select a folder you can access. Name the file to be retrievable at a future time. It will be saved with a .jpg extension to enable insertion into a PowerPoint presentation or an engineering report.

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SIEMENS

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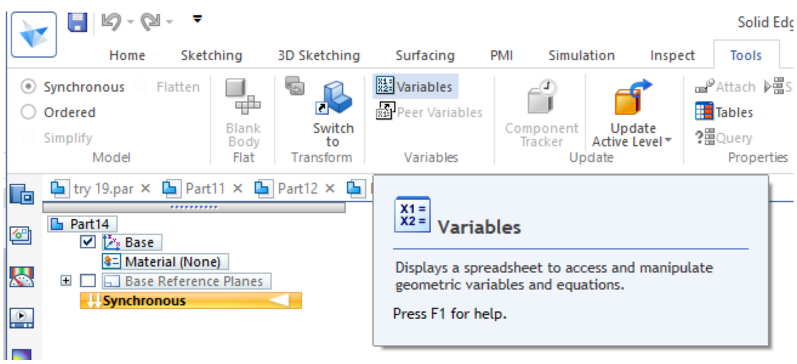
Dimensioning with Equations and Variables

Variable table

All dimensions used in a Solid Edge 3D model appear in the Variables table. As the dimensions are created they are given a designation following the protocol built into the software.

Create a new part.

From the Tools tab on the ribbon select Variables from the variables section. This will display the variable.



The Variable table should have two entries at this point. As materials are assigned these entries change. The part name will display the name assigned to the part. In this example is it part14.

Part14:Variable Table

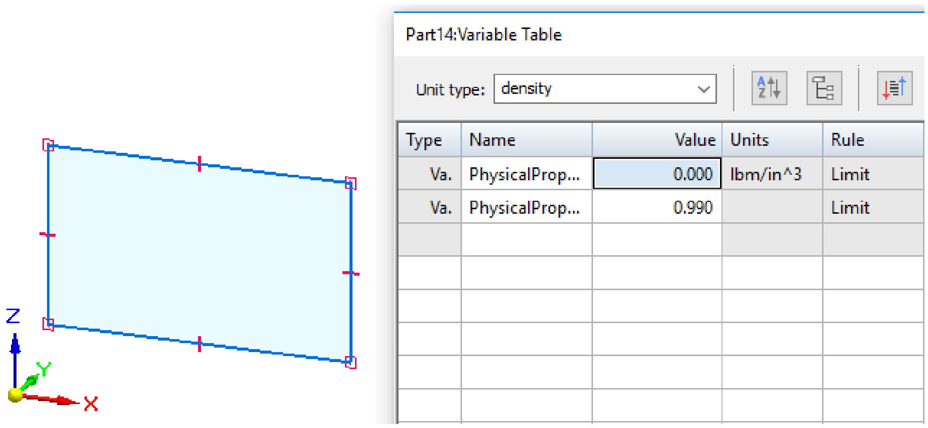
Unit type: density

Help

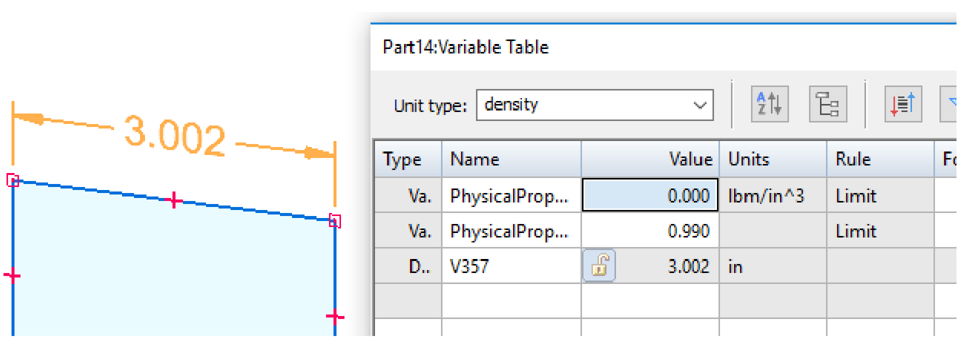
Type	Name	Value	Units	Rule	Formula	Range	Expose	Exposed Na...	Comment
Va.	PhysicalProp...	0.000	lbm/in^3	Limit		[0.000 l...	☑	Density	
Va.	PhysicalProp...	0.990		Limit		(0.000;1...	☑	Accuracy	

Move the table off your drawing area and leave the table open so you can see and edit dimensions as they are created.

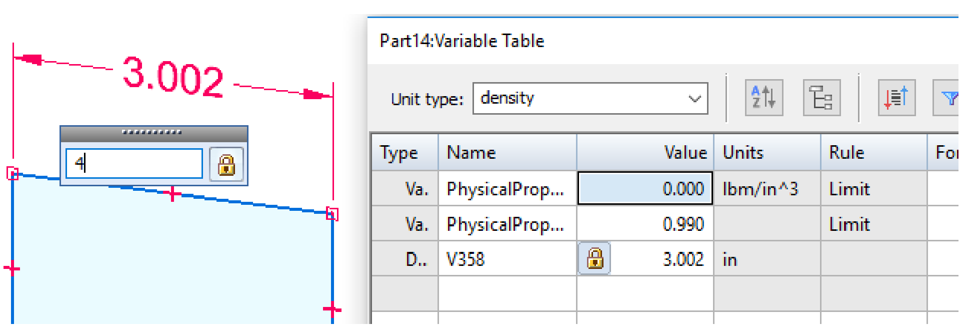
Enter the Sketch environment and create a rectangle.



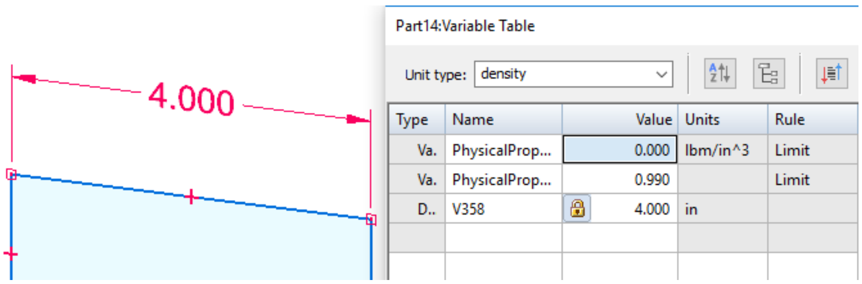
Since no dimensions are assigned they do not show up yet. Add a dimension on the top line of 4”. As soon as you click on the top line you will see the dimension has been assigned a name and it will show the current dimension. In this example the name is V357 and it displays 3.002 in which is the current value.



As you key the number “4”, the dimension will not change until you hit the enter key as the model has yet to change.

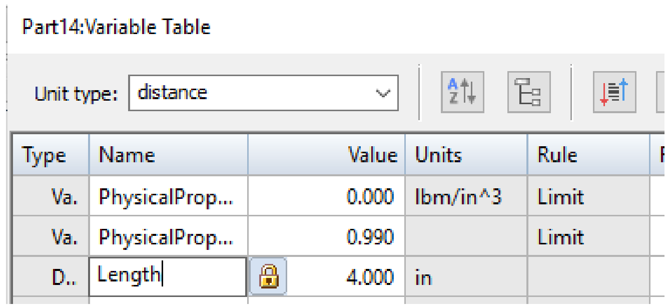


After accepting the dimension, the model changes and the value entered appears.



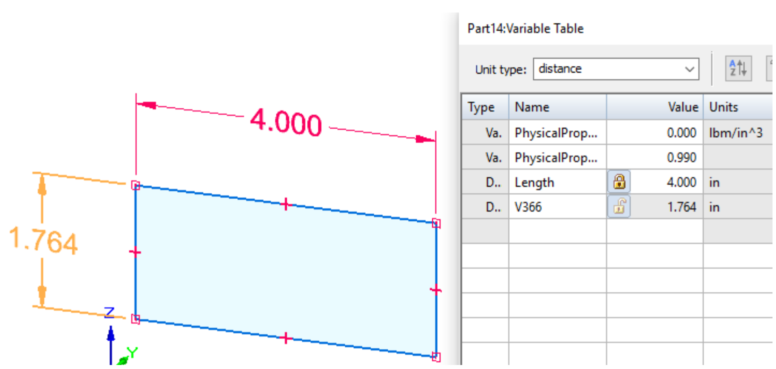
Type	Name		Value	Units	Rule
Va.	PhysicalProp...		0.000	lbm/in^3	Limit
Va.	PhysicalProp...		0.990		Limit
D..	V358	🔒	4.000	in	

Since the name V357 or V358 are not indicative of what the dimension is, it is possible to rename the dimension. Click on the dimension in the table and enter in the name "Length" to retrieve at a future time. Selecting the Enter key saves the name.



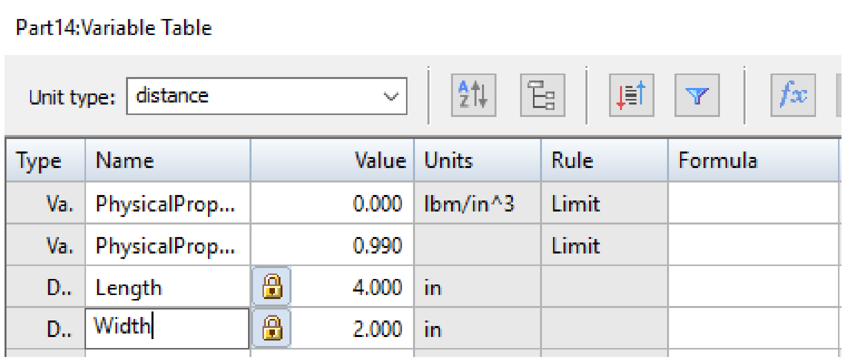
Type	Name		Value	Units	Rule
Va.	PhysicalProp...		0.000	lbm/in^3	Limit
Va.	PhysicalProp...		0.990		Limit
D..	Length	🔒	4.000	in	

Now dimension the width of the rectangle to 2 inches.



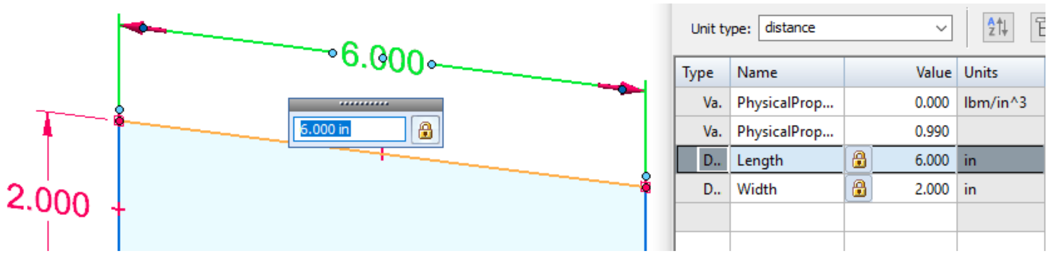
Type	Name		Value	Units
Va.	PhysicalProp...		0.000	lbm/in^3
Va.	PhysicalProp...		0.990	
D..	Length	🔒	4.000	in
D..	V366	🔓	1.764	in

As soon as the line is selected the table automatically creates the entry. Assign the dimension to 2". Rename the dimension to "Width".



Type	Name		Value	Units	Rule	Formula
Va.	PhysicalProp...		0.000	lbm/in^3	Limit	
Va.	PhysicalProp...		0.990		Limit	
D..	Length	🔒	4.000	in		
D..	Width	🔒	2.000	in		

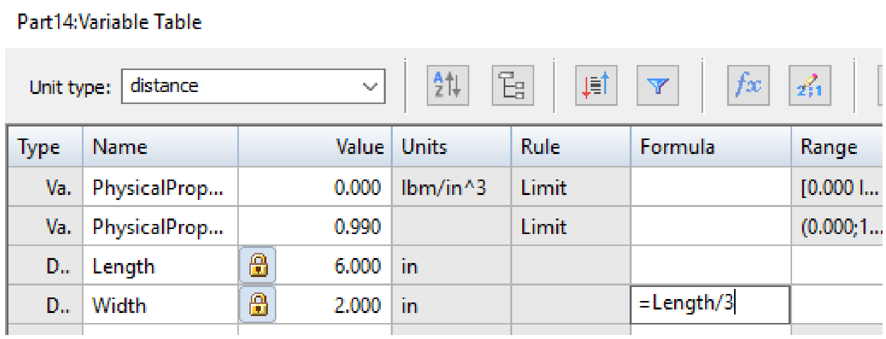
Now change the length of the rectangle to 6 inches and see how the table is affected.



The table automatically updates to keep up with any changes.

The width did not change when the length was changed. If you want your drawing to always have this proportion we can tie the two dimensions together with a formula.

On the table enter the phrase =Length/3 into the formula section on the width line.

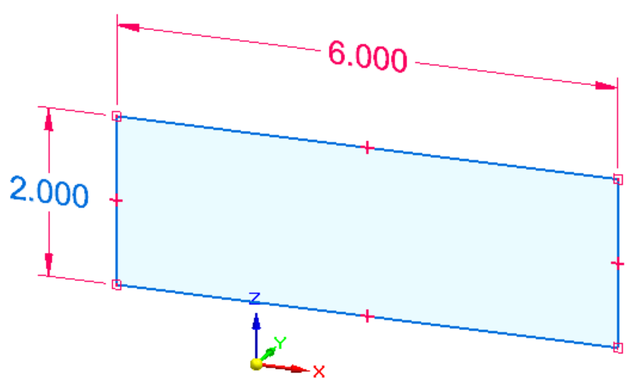


Part14:Variable Table

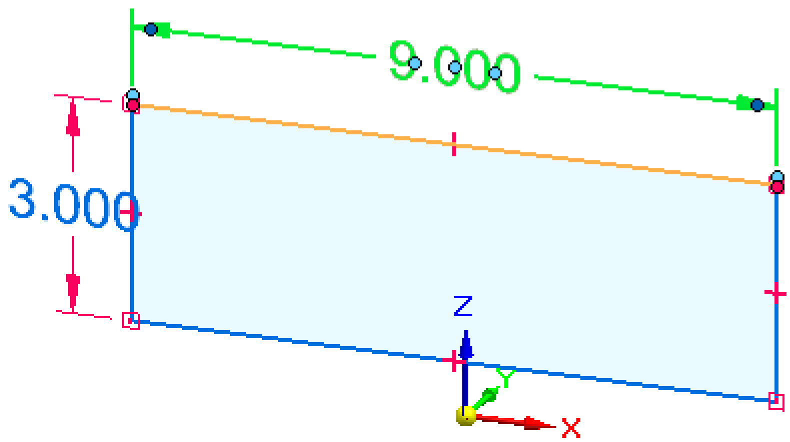
Unit type: distance

Type	Name		Value	Units	Rule	Formula	Range
Va.	PhysicalProp...		0.000	lbm/in^3	Limit		[0.000 l...
Va.	PhysicalProp...		0.990		Limit		(0.000;1...
D..	Length	🔒	6.000	in			
D..	Width	🔒	2.000	in		=Length/3	

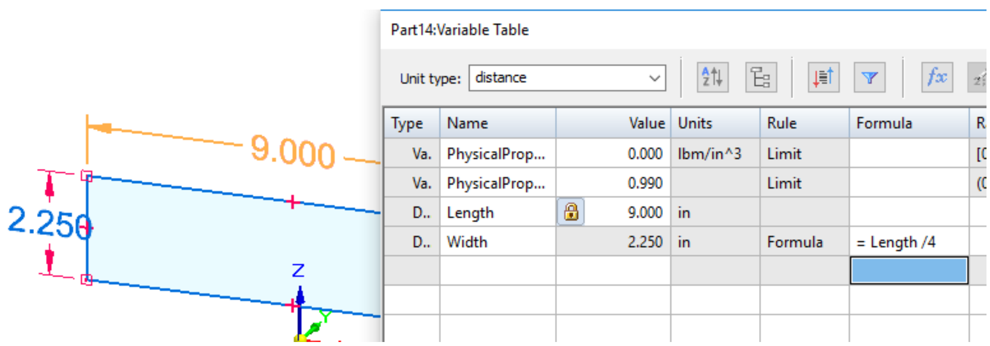
Notice that once you complete the entry the color of the dimension changes. This is an indication that the dimension is determined by formula.



Now the width of the rectangle is always going to be 1/3 of the length. Change the 6” dimension to 9”. What should happen to the width?



We might want to change the proportion so the width is only ¼ of the height. On the table change the formula for the width to the phrase =Length/4.

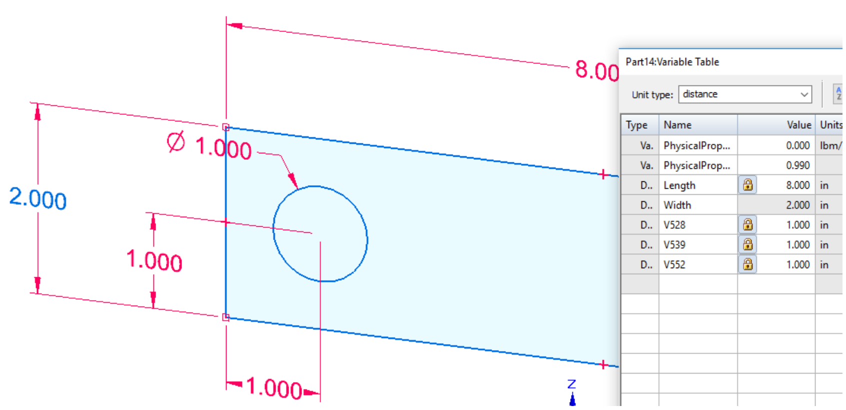


The part automatically updates.

Change the length to 8.

Draw a circle in from one end of the rectangle.

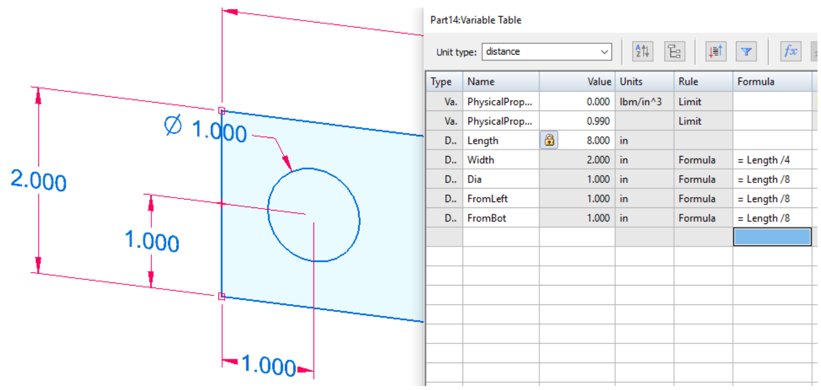
Add a dimension of 1 inch to the diameter of the circle. Then add dimensions of 1 inch to the center in both vertical and horizontal directions.



Rename the dimension so it represents something you can recognize. The circle is renamed Dia.

Type	Name		Value	Units
Va.	PhysicalProp...		0.000	lbm/in^3
Va.	PhysicalProp...		0.990	
D..	Length	🔒	8.000	in
D..	Width		2.000	in
D..	Dia	🔒	1.000	in
D..	FromLeft	🔒	1.000	in
D..	FromBot	🔒	1.000	in

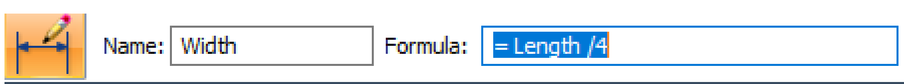
We can assign a formula to each. Enter the phrase =Length/8.



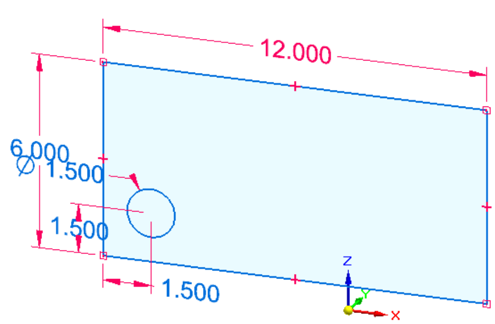
Type	Name	Value	Units	Rule	Formula
Va.	PhysicalProp...	0.000	lbm/in^3	Limit	
Va.	PhysicalProp...	0.990		Limit	
D..	Length	8.000	in		
D..	Width	2.000	in	Formula	= Length /4
D..	Dia	1.000	in	Formula	= Length /8
D..	FromLeft	1.000	in	Formula	= Length /8
D..	FromBot	1.000	in	Formula	= Length /8

The dimensions turn blue as you enter the formula. Now change the length of the rectangle to 12. What happens to all the other dimensions?

Now double click on the blue dimension for width. This opens a dialog box on the work area. We can change the formula here.



Change the formula to =Length/2. Notice the change in the drawing.



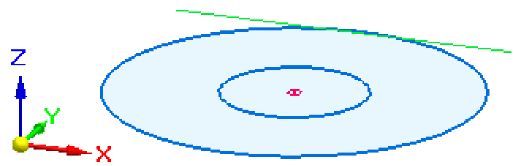
Change your other formulas to place the hole in the center of the rectangle.

Controlling a part with Excel

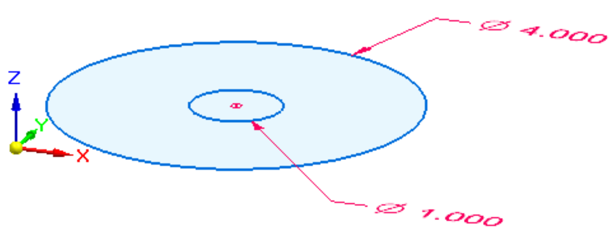
We can similarly build a 3D part with formulas so the part retains an identifiable shape. Many brands are identified by shape alone. If you design everything with only a few dimensions to change you can very quickly change the size without sacrificing the identifiable shape. The same is true of things such as socket wrenches or other products of variable sizes. Frequently the changes in a family of parts are not enough to require their own drawings. Dimensions are given in their own table. With a 3D solid model it is possible to link a table in Excel to the variable table and then use Excel to drive the changes in the part.

This exercise will help you create families of table driven parts.

Begin a new part. Lock onto the XY plane. Create a sketch with a circle.



Add dimensions similar to the picture below.



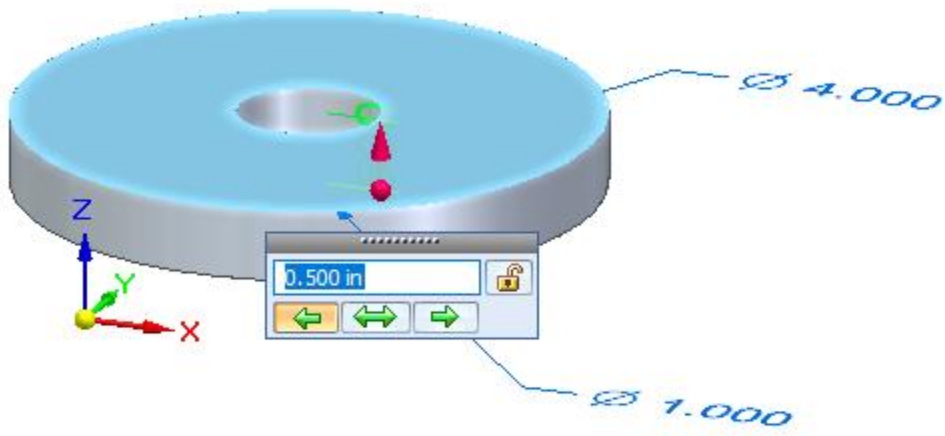
Open the variable table and change the names to match the ones below.

Part1:Variable Table

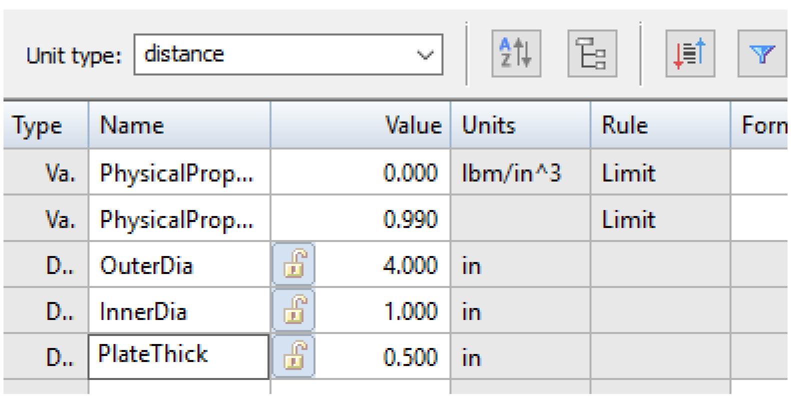
Unit type: density

Type	Name		Value	Units	Rule	Form
D..	OuterDia		4.000	in		
D..	InnerDia		1.000	in		
Va.	PhysicalProp...		0.000	lbm/in^3	Limit	
Va.	PhysicalProp...		0.990		Limit	

Extrude the circle sketch to a distance of .5



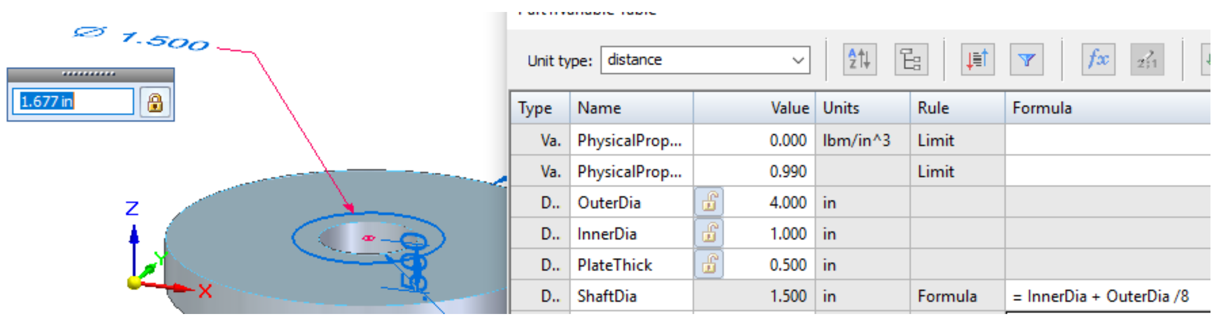
In the variable table change the name to PlateThick.



Unit type: distance

Type	Name	Value	Units	Rule	Forn
Va.	PhysicalProp...	0.000	lbm/in^3	Limit	
Va.	PhysicalProp...	0.990		Limit	
D..	OuterDia	4.000	in		
D..	InnerDia	1.000	in		
D..	PlateThick	0.500	in		

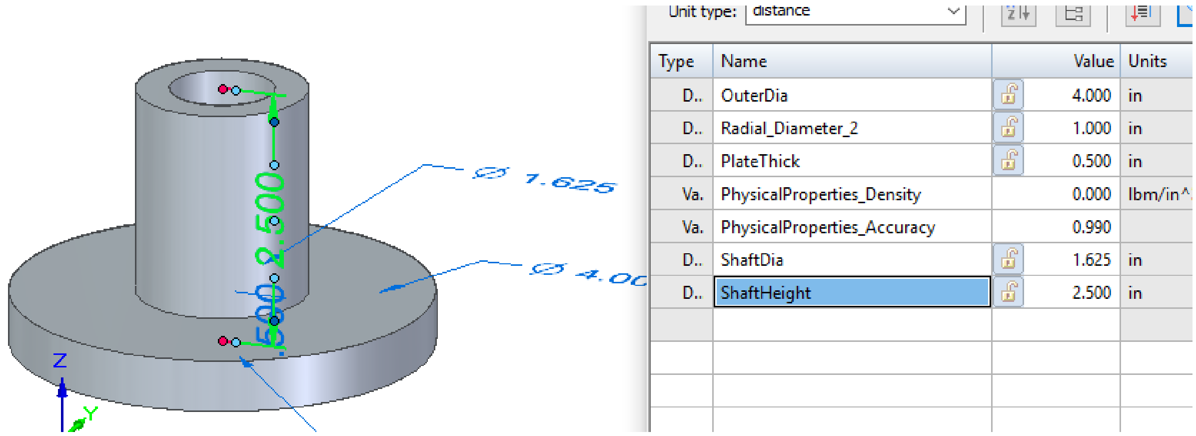
Place a circle on the top. For the dimension use 1.5”



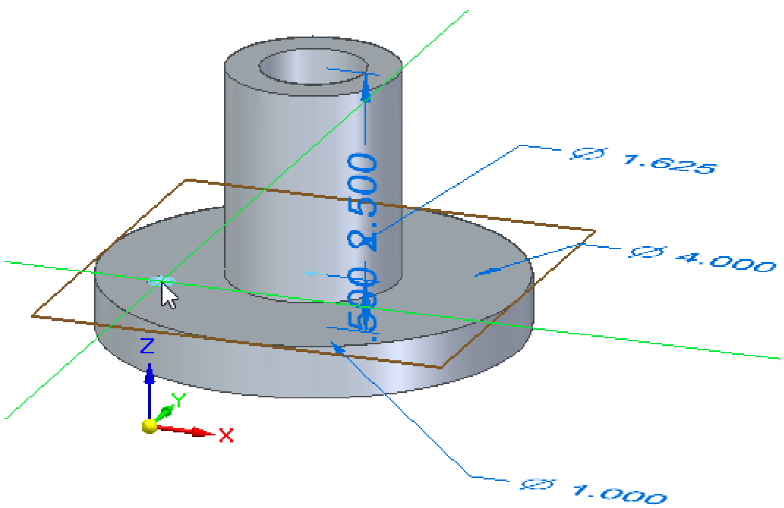
Unit type: distance

Type	Name	Value	Units	Rule	Formula
Va.	PhysicalProp...	0.000	lbm/in^3	Limit	
Va.	PhysicalProp...	0.990		Limit	
D..	OuterDia	4.000	in		
D..	InnerDia	1.000	in		
D..	PlateThick	0.500	in		
D..	ShaftDia	1.500	in	Formula	= InnerDia + OuterDia /8

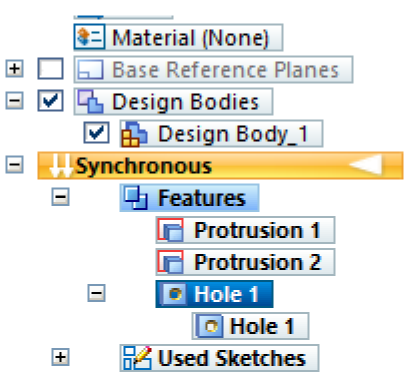
Extrude the shaft upwards a distance of 2.5”



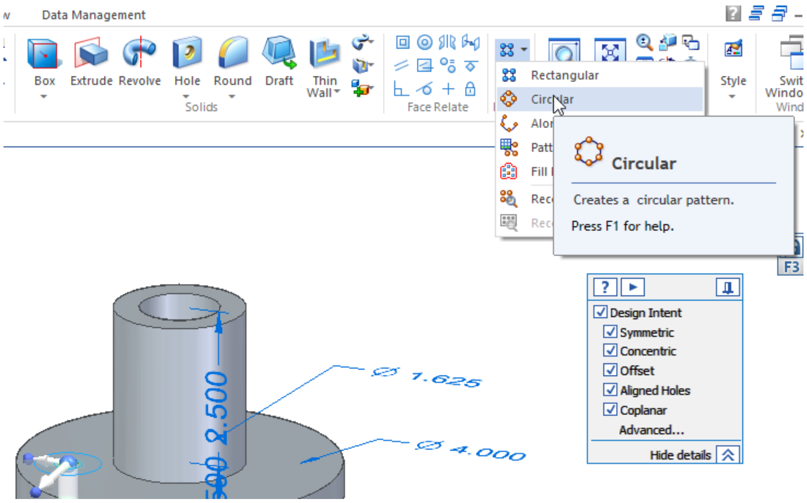
Place a hole on the plate. Don't worry about dimensions.



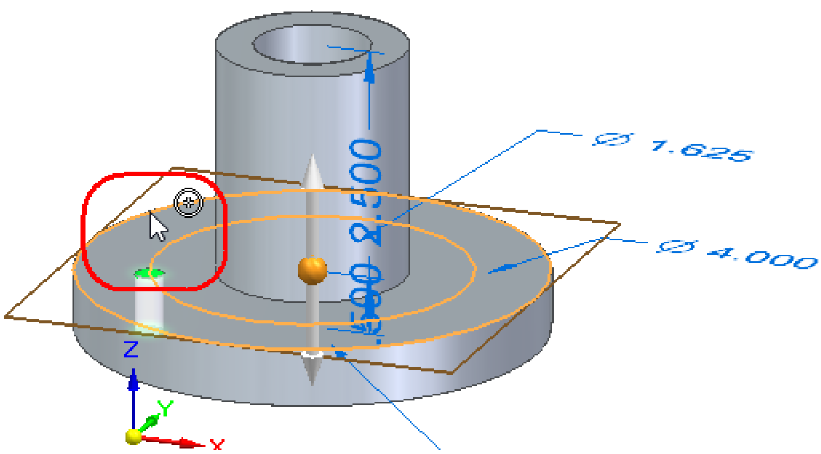
Highlight the hole in the Synchronous section of the tree.



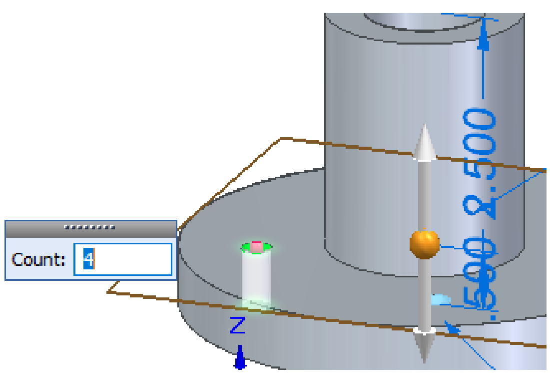
Use the Circular Pattern command found in the Pattern section of the Home ribbon.



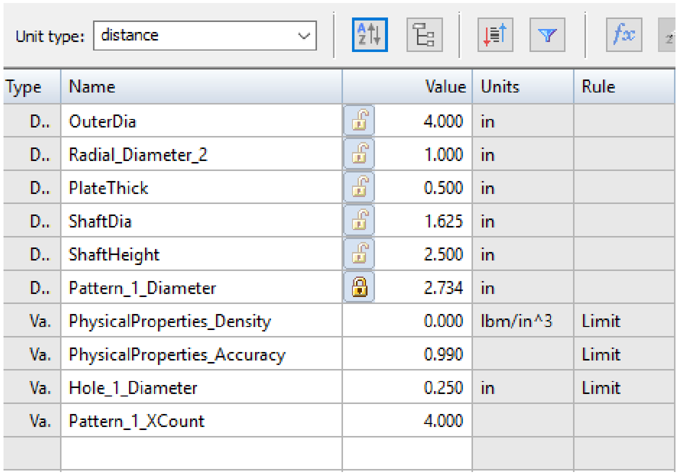
Slide your mouse over the curved edge until you see the center mark and then select to capture the center of the part.



Use a count of 4.



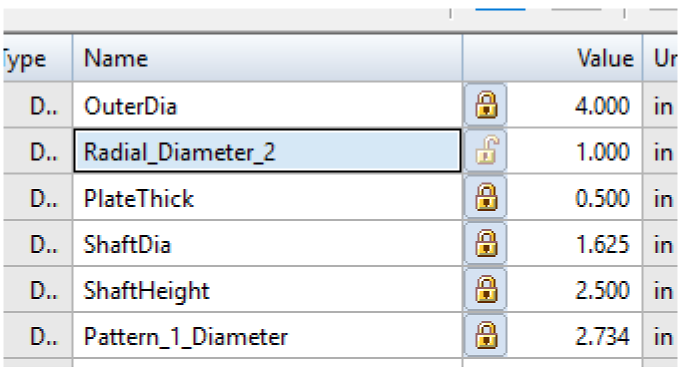
Your table should resemble this one.



Unit type: distance

Type	Name		Value	Units	Rule
D..	OuterDia		4.000	in	
D..	Radial_Diameter_2		1.000	in	
D..	PlateThick		0.500	in	
D..	ShaftDia		1.625	in	
D..	ShaftHeight		2.500	in	
D..	Pattern_1_Diameter		2.734	in	
Va.	PhysicalProperties_Density		0.000	lbm/in^3	Limit
Va.	PhysicalProperties_Accuracy		0.990		Limit
Va.	Hole_1_Diameter		0.250	in	Limit
Va.	Pattern_1_XCount		4.000		

Lock the dimensions by clicking on the open padlocks to allow for the insertion of formulas. Leave the inner diameter unlocked.

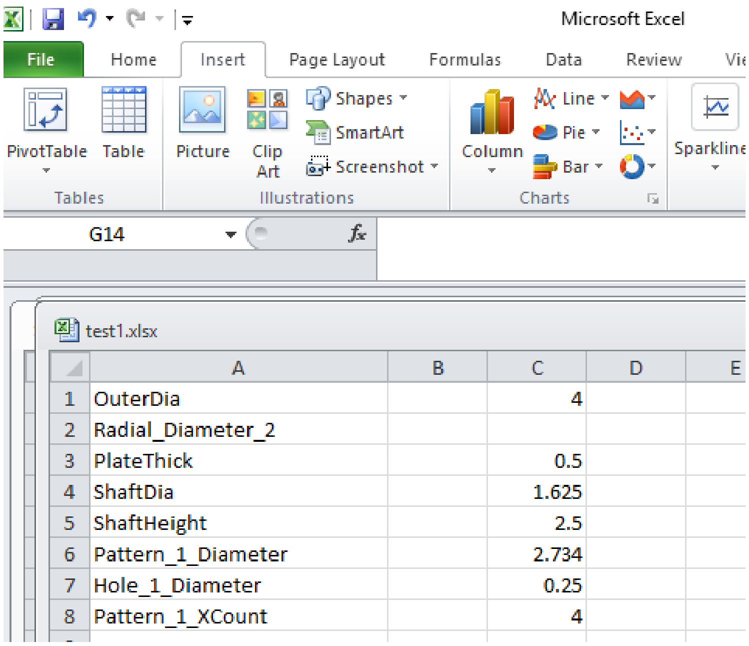


Type	Name		Value	Ur
D..	OuterDia		4.000	in
D..	Radial_Diameter_2		1.000	in
D..	PlateThick		0.500	in
D..	ShaftDia		1.625	in
D..	ShaftHeight		2.500	in
D..	Pattern_1_Diameter		2.734	in

Save your part.

Excel

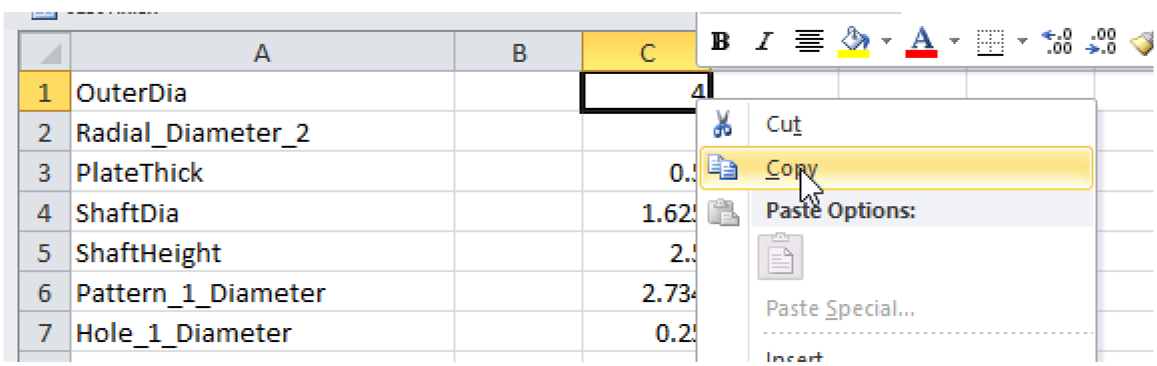
We can control the part using an Excel table. To do this we need to create the table. Open Excel and enter in the following data. These will represent three different versions of our part.



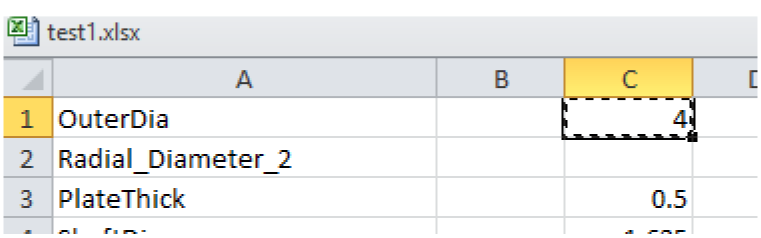
This Excel file contains the information for the part.

Save the file to a location you can easily find. Delete unused sheets.

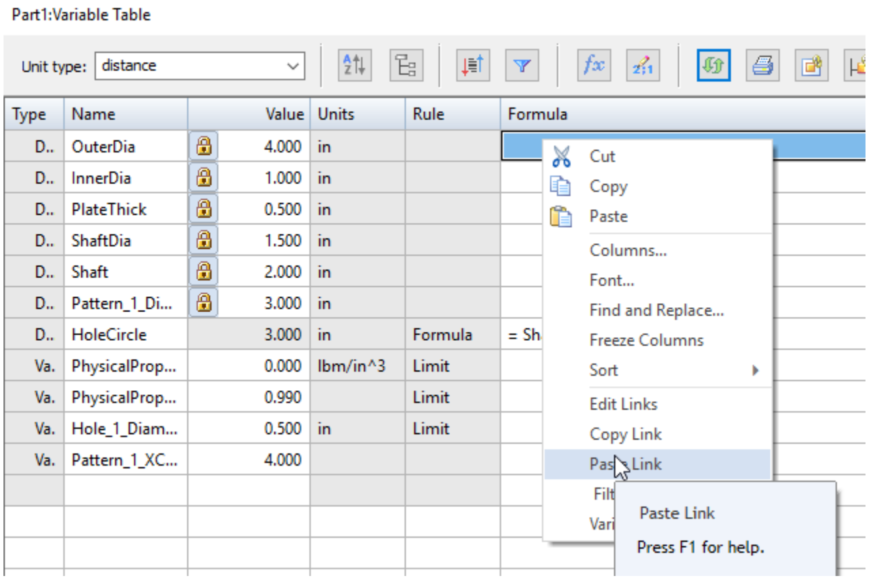
The next step is to assign the cell to the appropriate place in the Variable Table in Solid Edge. Click in Cell C1 on the Excel table, then right click and select copy.



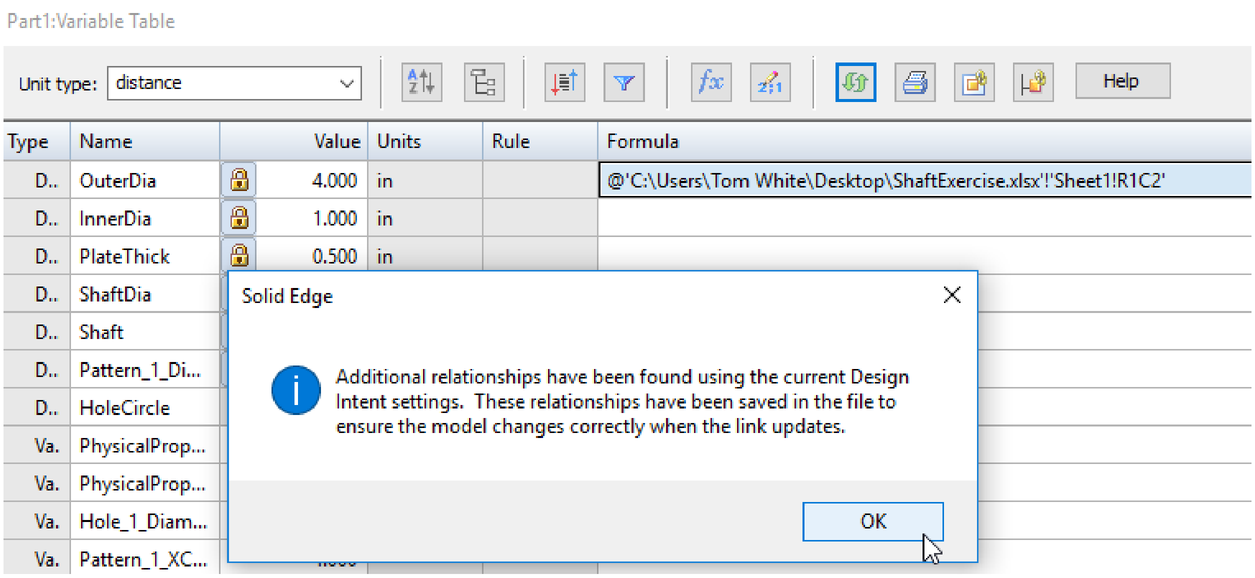
The cell will highlight.



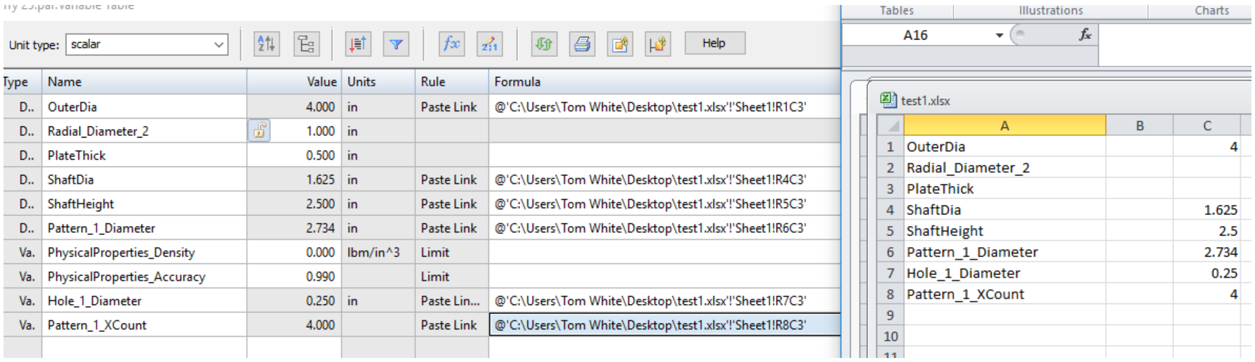
Move to the Variable Table in Solid Edge and find the OuterDia row. Right click in the formula cell and select paste link to create the link into the formula cell.



You will see the formula appear as well as a message from the software. Select OK.



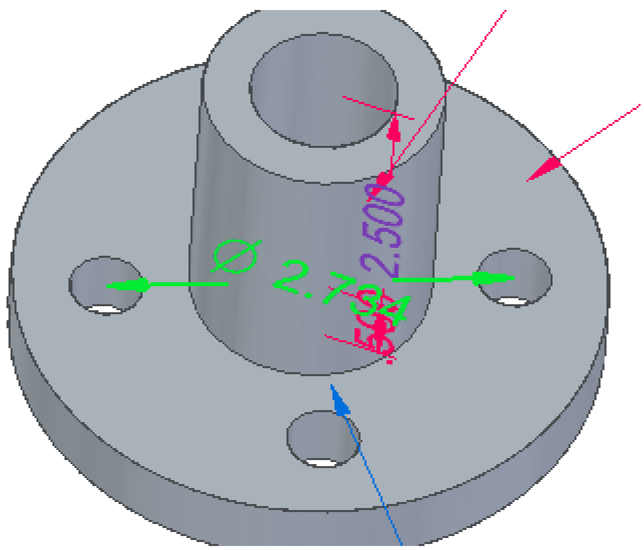
Continue linking the cells in column C in Excel with the appropriate places in the Variable Table.



On your Excel spread sheet change the Hole_1_Diameter to .375. Select Enter

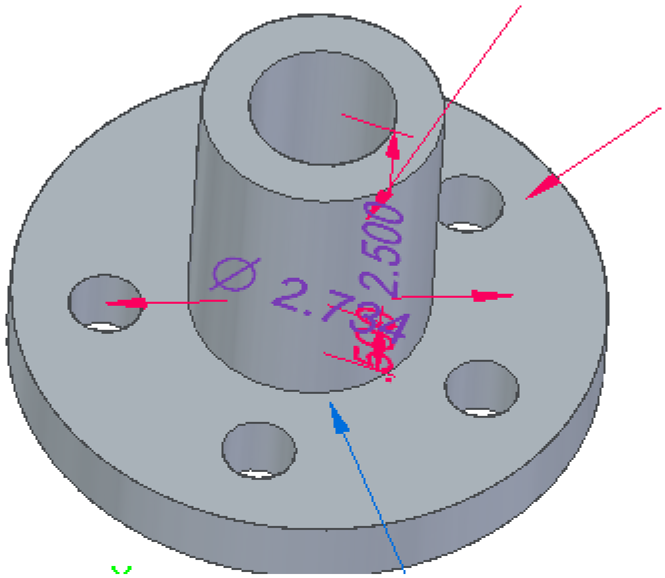
What happens?

Change the dimension to .5 on your spread sheet.

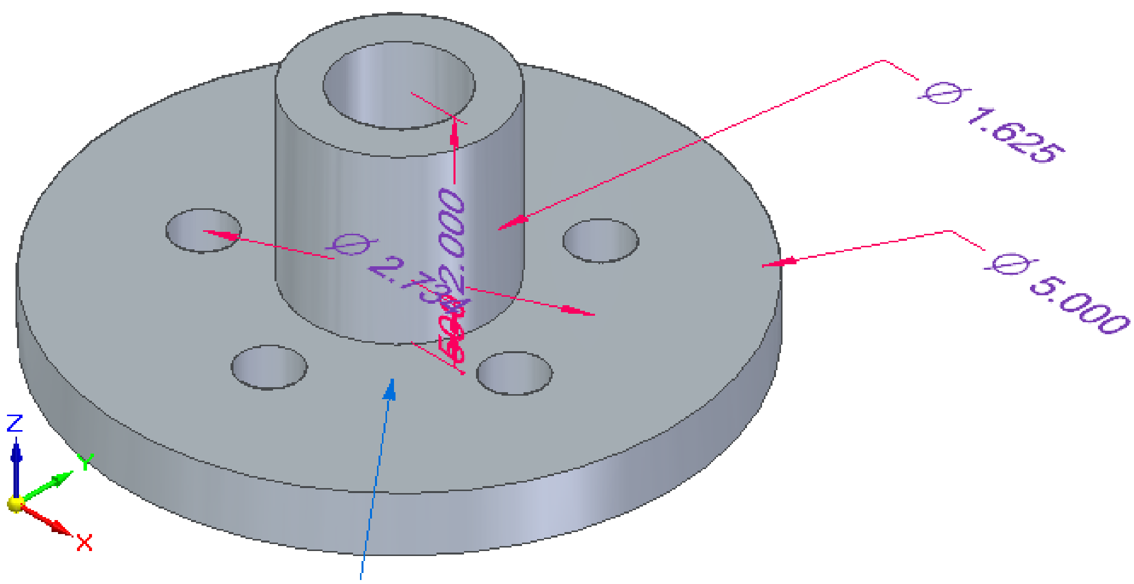


Change the Pattern_1_XCount value to 5 and select enter.

There are times when you must double click on the part to have it refresh.

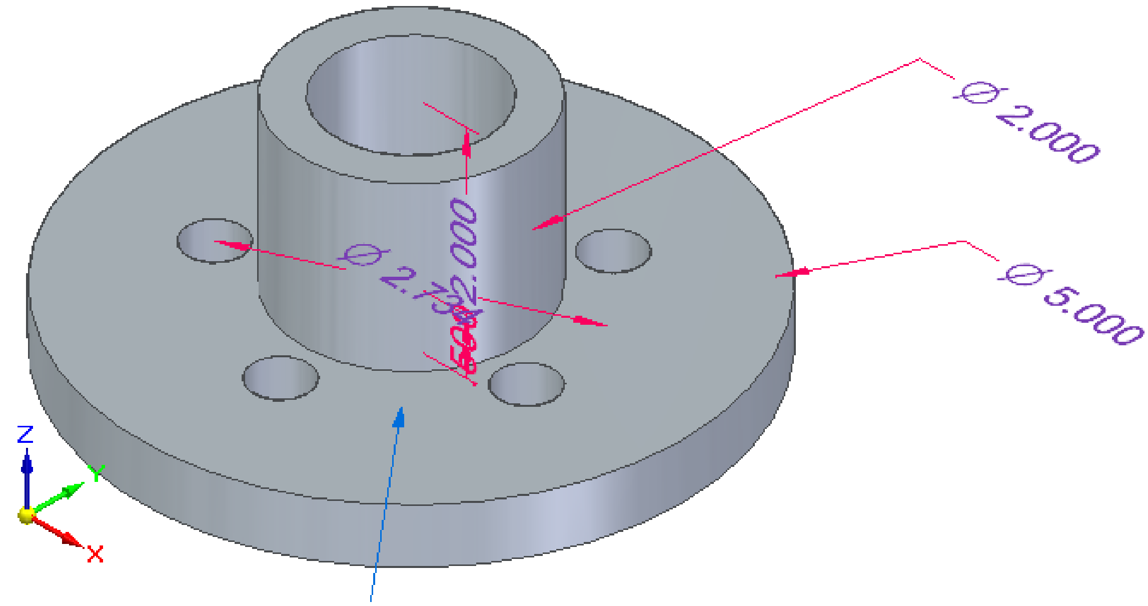


Change the ShaftHeight to 2. Hit enter. Then change the ShaftHeight to 2 and Hit enter.

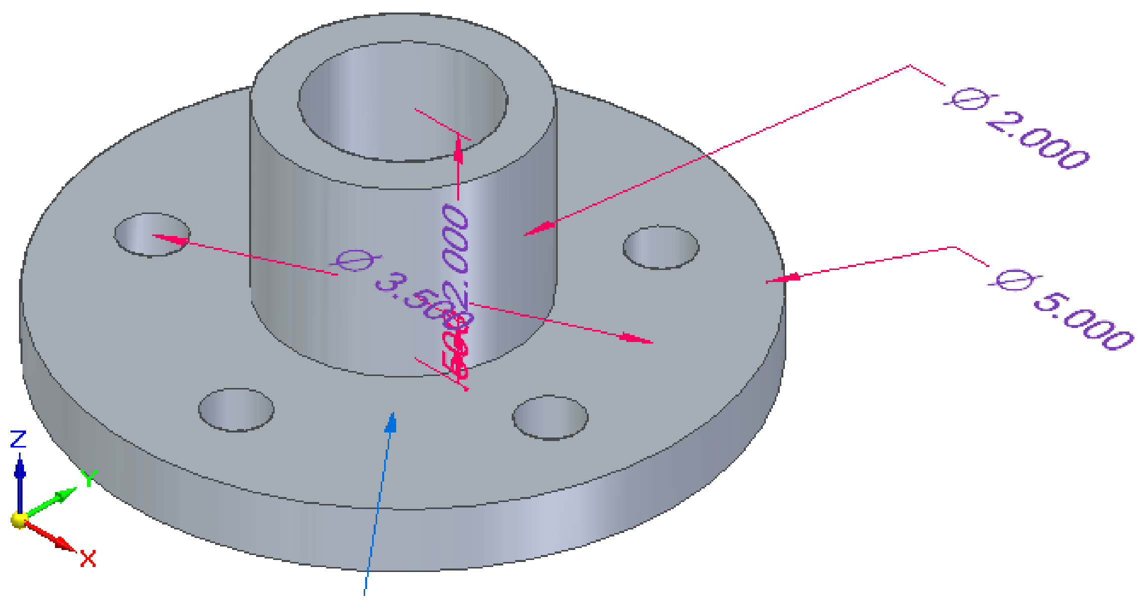


Change the ShaftDia to 2. Hit Enter.

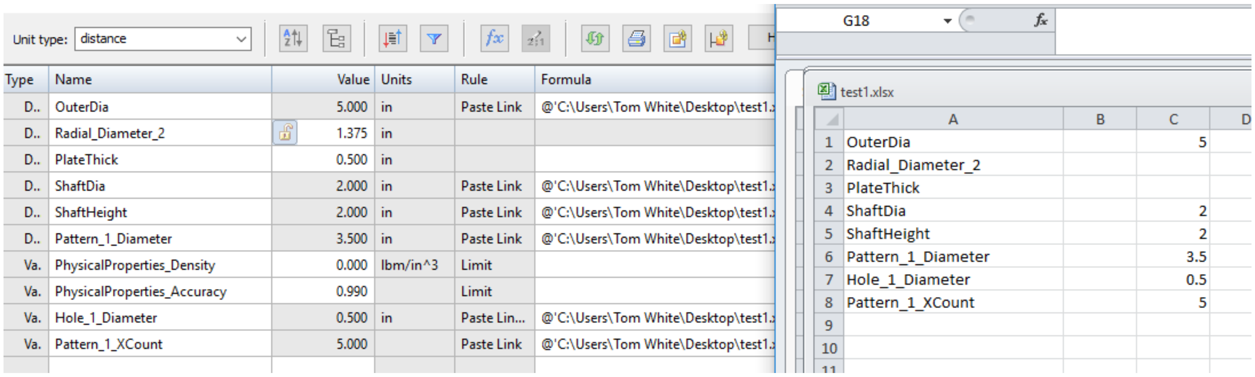
Was there another dimension that automatically changed?



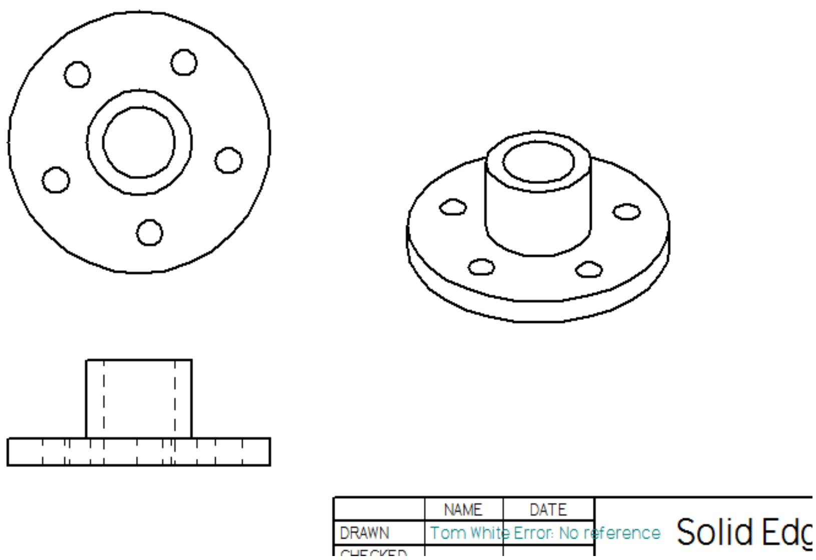
Change the Pattern_1_Diameter to 3.5 and hit enter.



Dimensions must be changed in an order that makes sense. By linking to the Excel table you can make changes to the design faster and can create multiple objects from the same build.

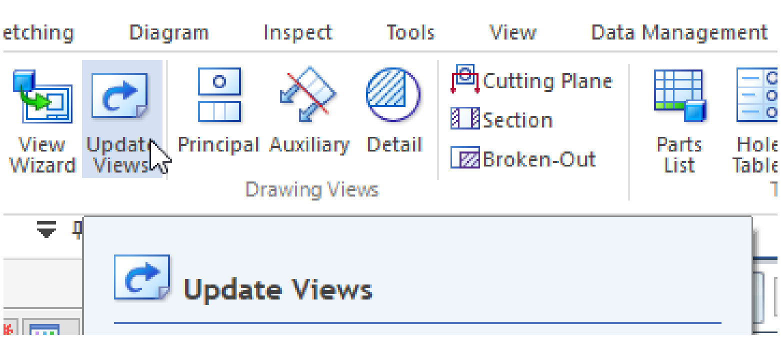


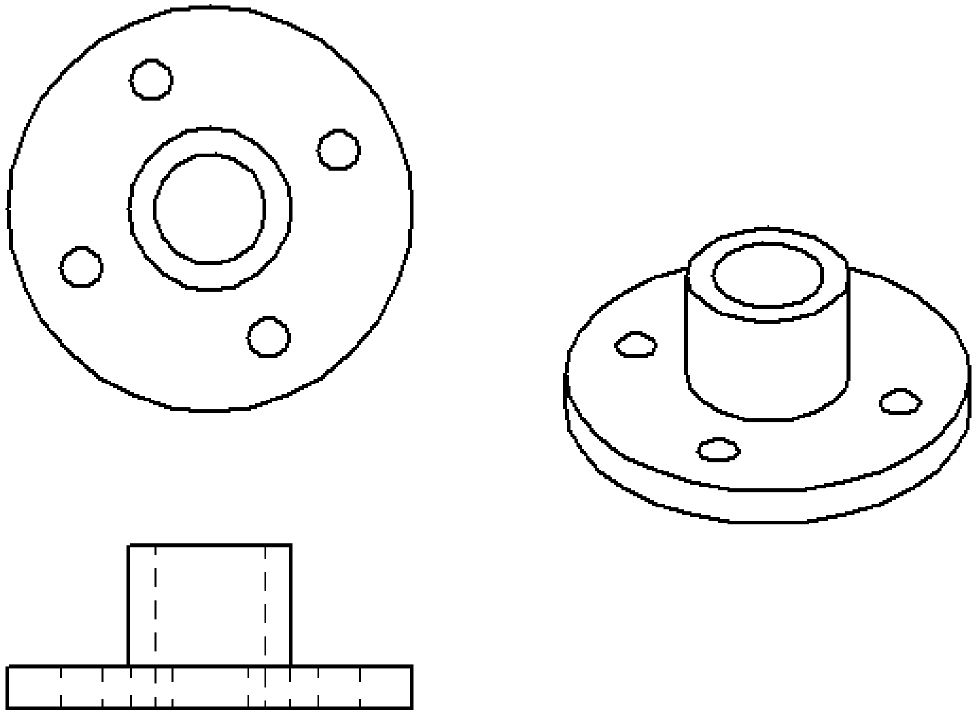
Create a draft from the part you just created. Place a front, top and isometric views of the part. It will resemble the part below.



Return to your Excel spread sheet and change the Pattern_1_XCount to 4 and hit enter.

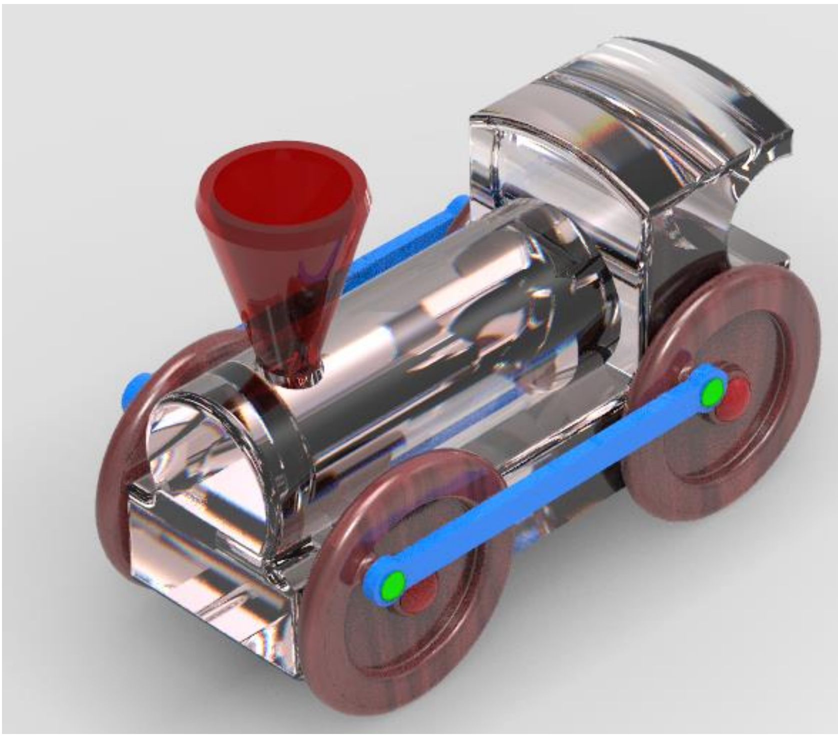
On your Draft View select the link to update views.





Back

Introduction to Assemblies



Download the components for this exercise from
https://drive.google.com/open?id=0B_7sFhPxnoaXd3N3bGc5OUZzOEU

Extract the part files and place them in a folder on your computer where they can be retrieved.

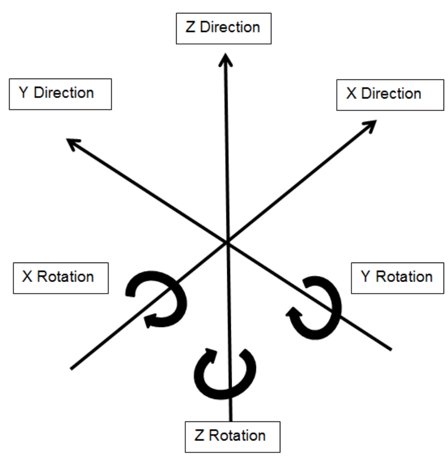
The assembly leads to an understanding of the various types of geometric relationships. The parts will be used to create drawing views, presentation views, exploded assembly drawings, and can be exported to 3D printers.

Customization of the Engine and/or its parts is greatly encouraged as well as the construction of other cars and equipment that might be included with the engine set. One challenge is to create a simple coupling system in order to connect other cars to the engine. Constraining the cars together so normal motion is maintained can be interesting. Different types of track pieces combined with formulas create motion.

Introduction:

To this point we have been using Solid Edge as a 3D solid modeling tool. It has been used to create accurate digital models for analysis and planning purposes. Another function that allows for accurate design and analysis is the assembly modeling process. An assembly is a collection of parts and subassemblies positioned in a meaningful way. This is done by establishing the geometric relationships between the parts. The parts can be in their final orientation, or have freedom of movement in translation and rotation. By defining how the parts go together and establishing the relationships between the parts you can see how the assembly of components will actually behave. You define all aspects or rules of the assembly. Without the relationships between the parts all you would have is a box of parts.

Solid Edge has assembly geometric relationships that describe the relationships between two parts. With no relationships, they move in the X, Y, or Z axis freely as well as being able to rotate about any or all of those axis. The graphic below shows a representation of the six degrees of freedom of parts.



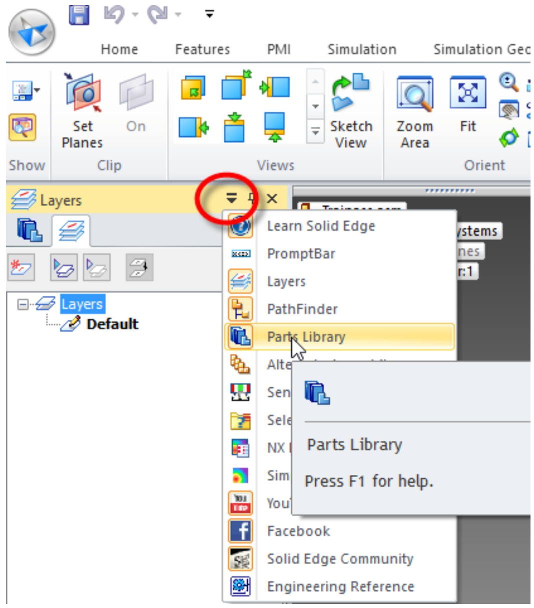
When relationships are applied, the degrees of freedom between the parts are reduced. To permit a part to move, do not apply a relationship that blocks movement. To acquire motion in the x-axis you cannot apply a relationship that defines an exact X position in relation to another part. This leaves a degree of freedom that allows for movement of that part. As constraints are applied they appear in the assembly path finder. To remove a geometric relationship, right click on the relationship and delete it.

Instructions:

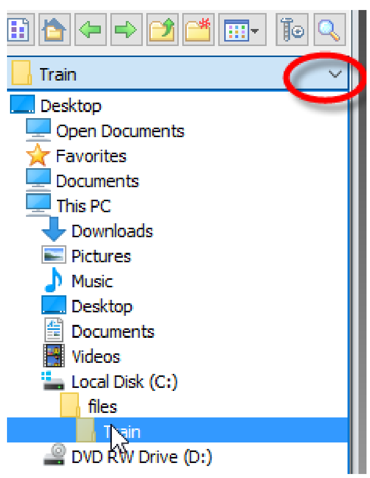
Be sure to have the parts for the engine downloaded before attempting this tutorial.

Create a new Assembly file.

Arrange your window to have access to the Parts Library. The Parts Library is normally on the left side of the screen. If not, select the down arrow next to the pin and select Parts Library from the options.



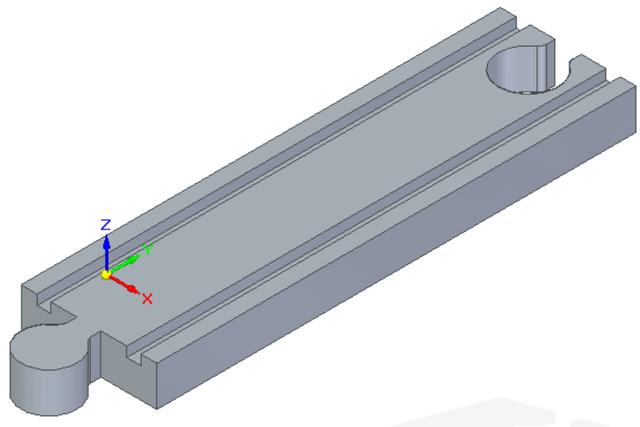
Navigate to the folder where the downloaded files are stored. Select the down arrow next to the existing file and browse to the desired directory.



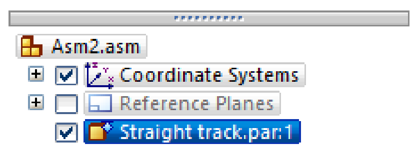
The various parts created are shown in the library.

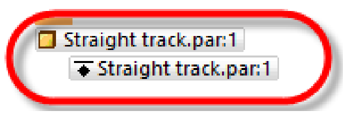
Left click and hold on your straight track and drag it to the screen. Once you are on the work area release the left mouse button. The track will appear.

Once you let go the actual object will be on the screen.

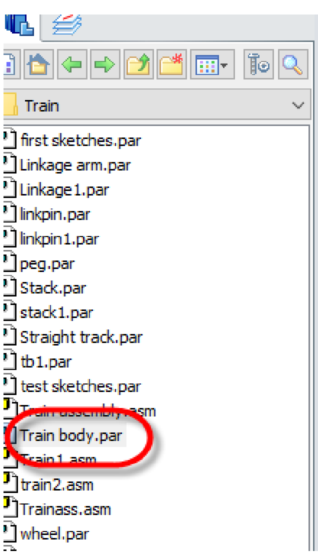


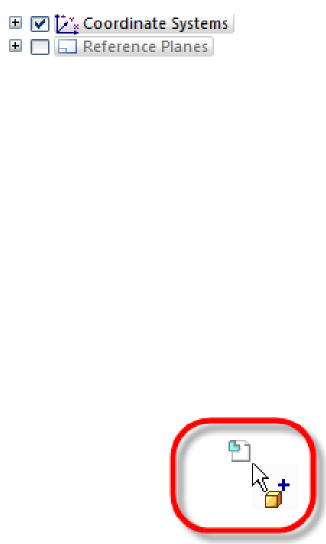
Highlight the track in the path finder. Below you will see the report of the geometric relationships that exist. You will see an icon meaning the part is grounded. This means the part will not move from its position.

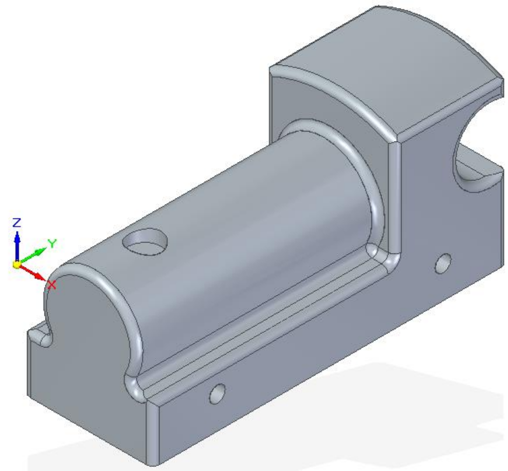




Drag the engine body out from the library.

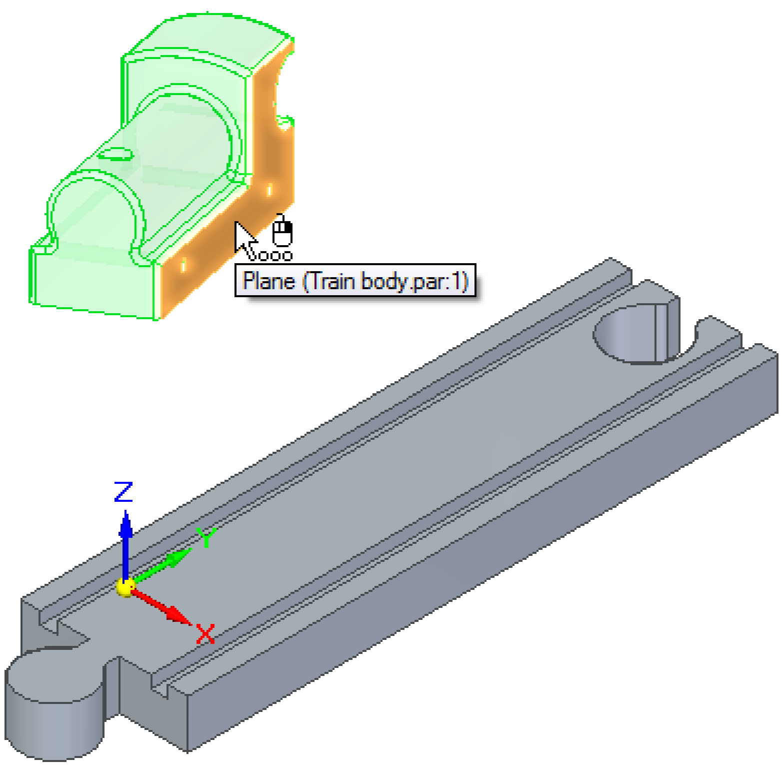






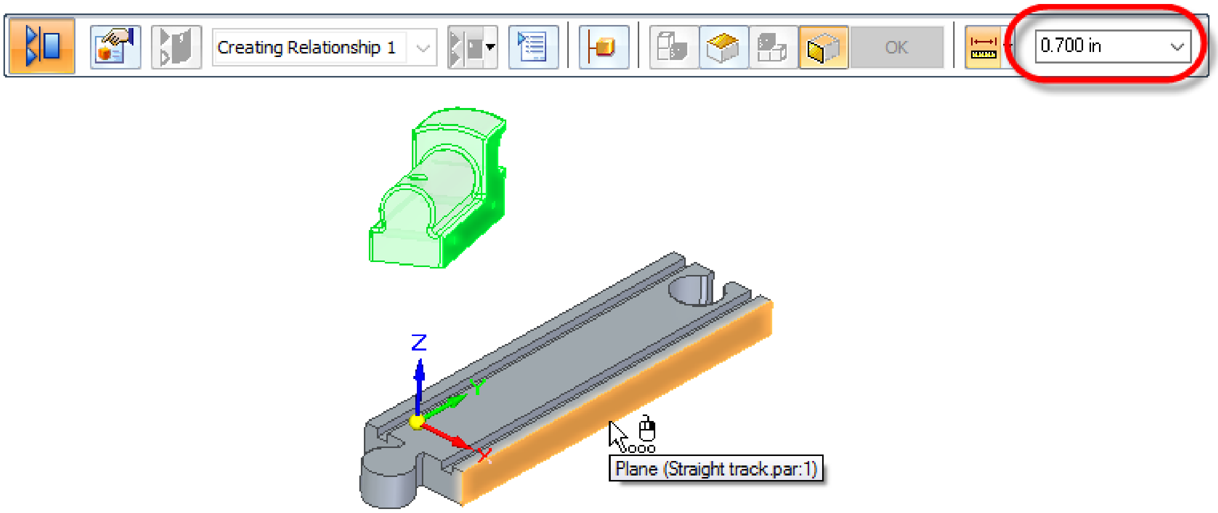
This also opens the relationship dialog box. This dialog box allows us to select how the components go together. The program is intelligent, and can make assumptions on how things go together. By selecting certain geometry the program will figure out the appropriate relationship to apply. This function is flash fit and is the default for the relationship dialog box.

Select the side of the engine body. It will highlight.

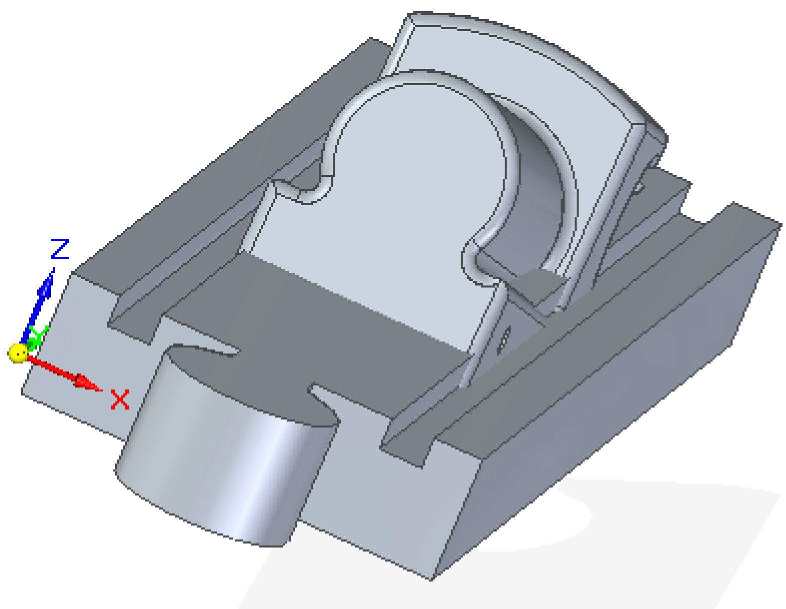


In the dialog box enter .7 in for the offset.

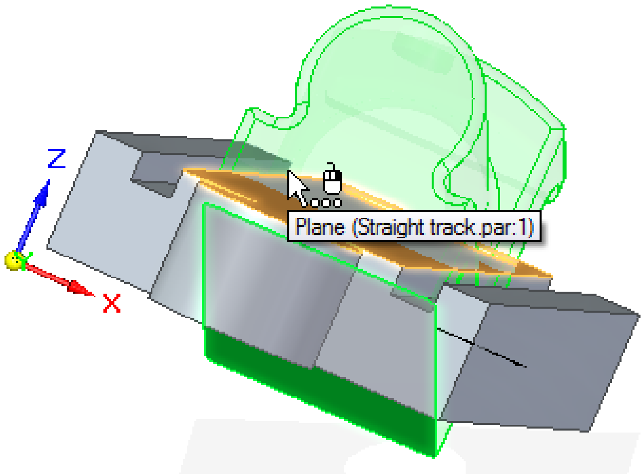
Select the side of the track



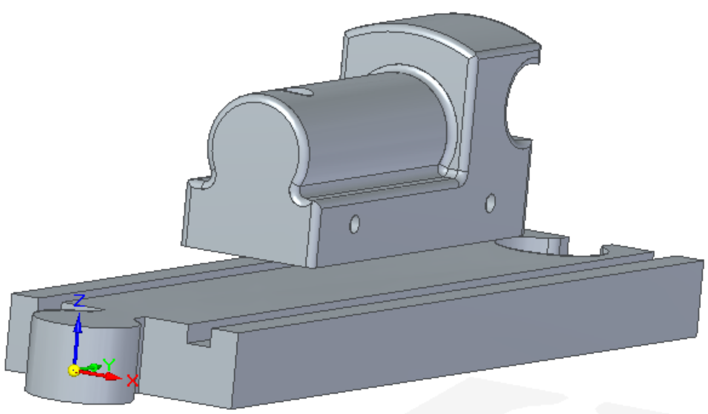
As the relationship takes hold you will see that the engine body is in the center of the track. It is not set above the track and in the case below it satisfies the relationship by sitting in the middle of the track.



Rotate the view somewhat to see the bottom of the train body. Apply a mate constraint with a .500 in offset to the top of the track. Click on the bottom of the engine body and then the top of the track.

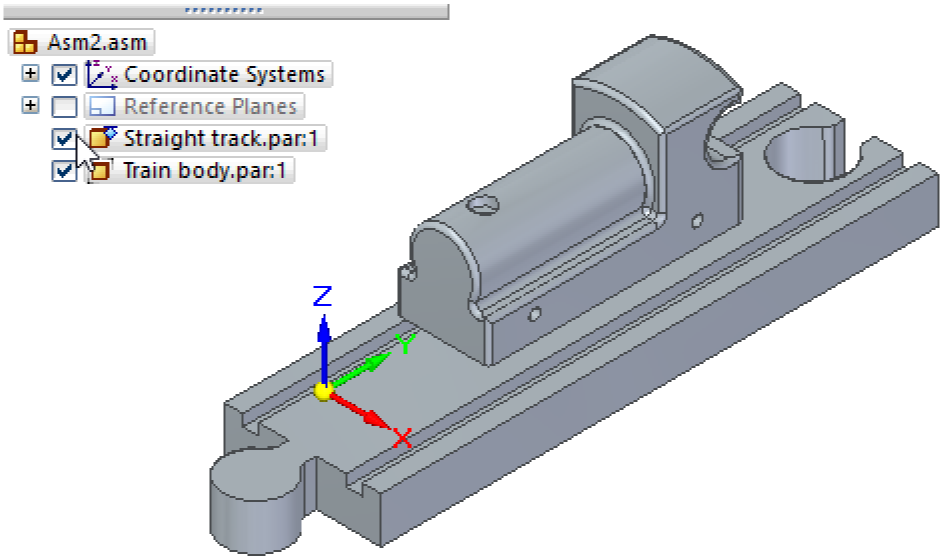


Once accepted you will see the engine body floating above the track. The offset used in placing the engine body allows for the wheels to be added later.

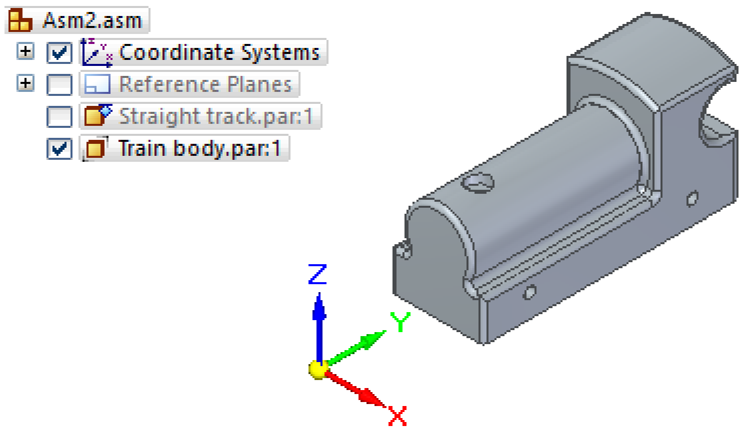


Since the track is in place and working on the rest of the engine components do not require the track, the visibility can be turned off for the time being. This will allow better access to the components you will be working on. We can turn the visibility on later.

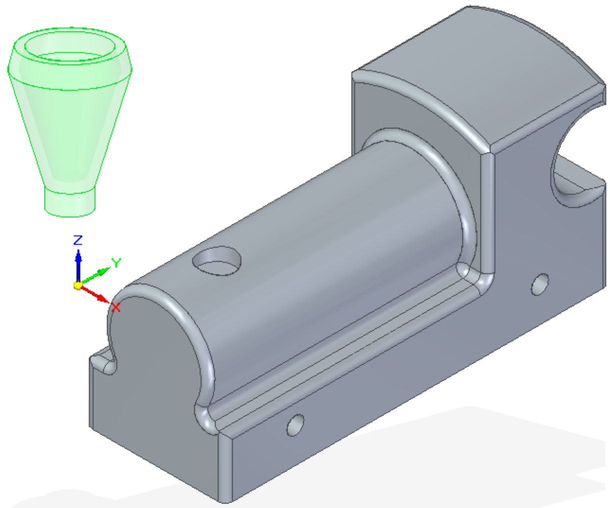
Find the track in the path finder.



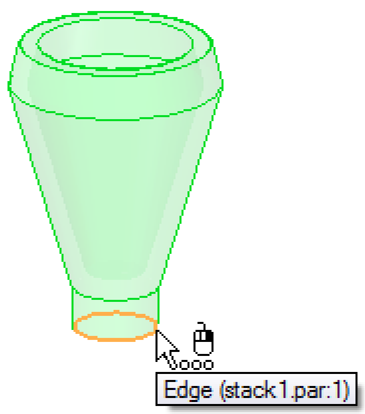
Uncheck the straight track and it will disappear while you work.



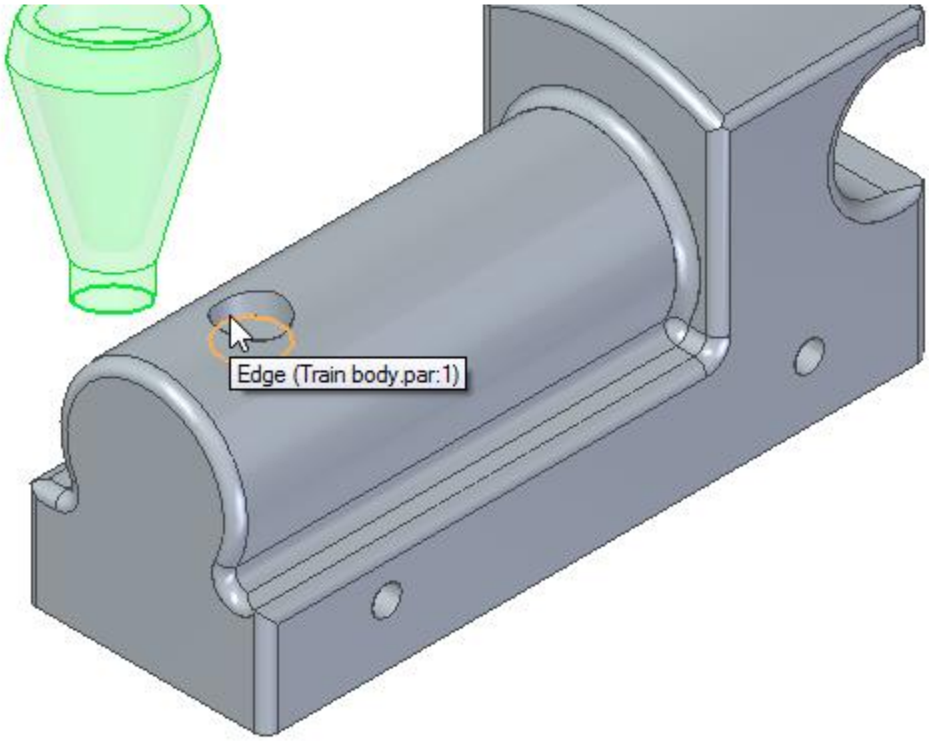
Now drag the stack out of the library and leave it a short distance from the engine body.



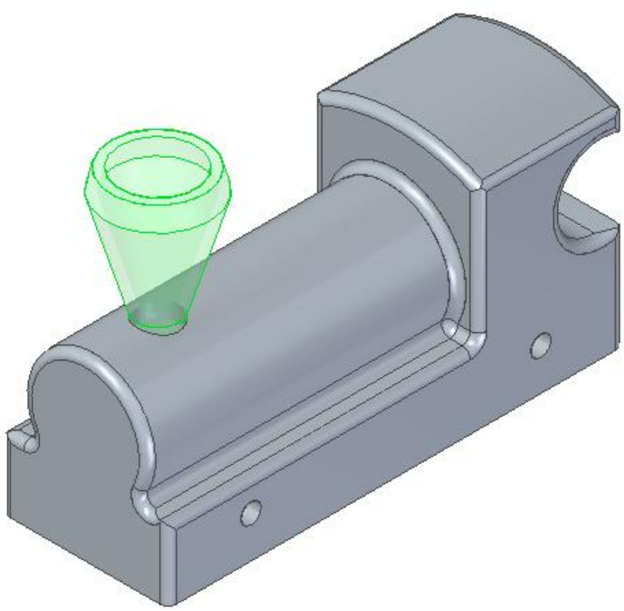
Select the bottom circle of the stack.



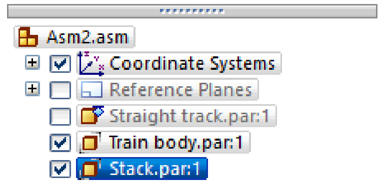
Select the bottom circle of the hole in the top of the engine.

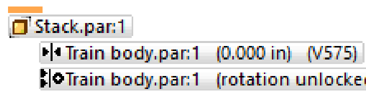


The software then figures out the relationship necessary. It decides the circles should share a center and they should touch.



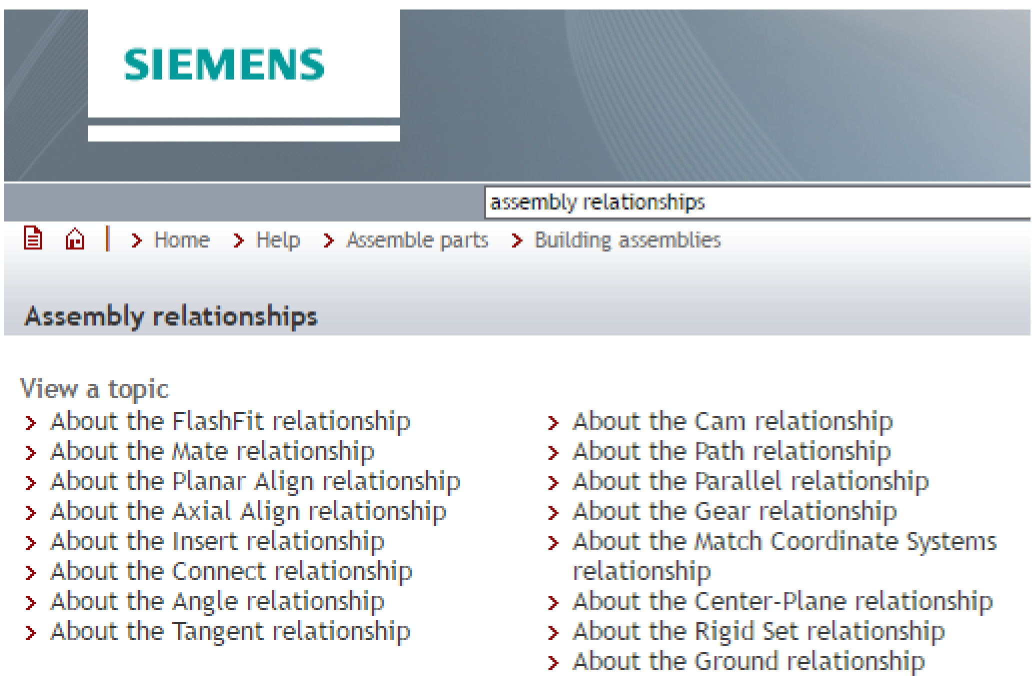
Hit the ESC key to exit the command. In the path finder highlight the stack and the geometric relationships will be applied.





Check the path finder often. When two parts will not connect because of conflicting relationships you can find the part in the path finder and highlight the offending relationship and delete it.

For more information about how components can be assembled, search help for “Assembly Relationships”.



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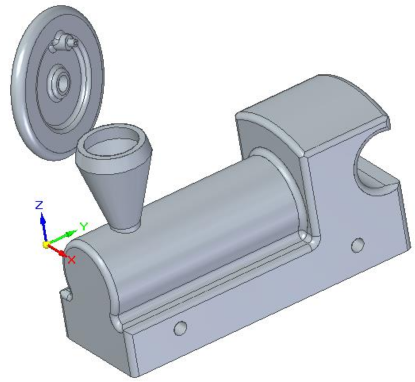
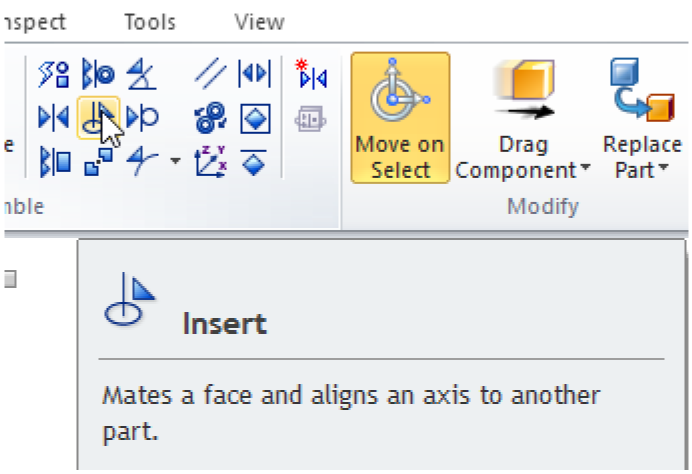
Insert Relationship

Drag a wheel from the library to the work area.

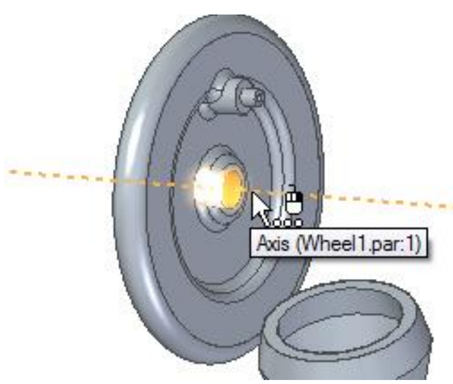


We can define exactly how components fit together by specifying the relationship between the parts. An Insert relationship will line up the axis and mate a face at the same time. Select F1 for more information about the command.

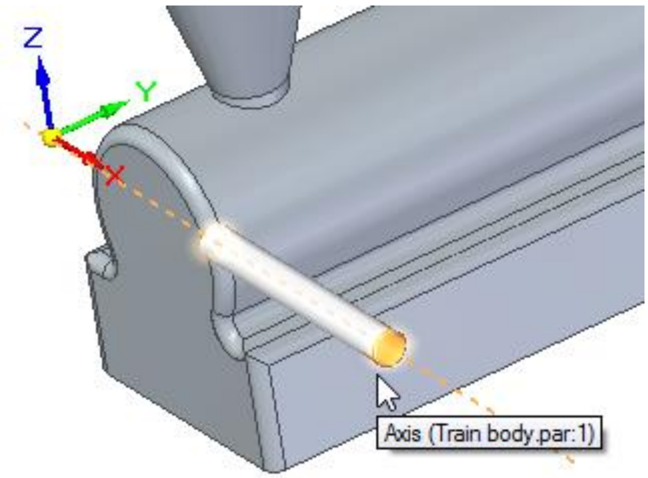
Select Insert from the assemble area of the ribbon.



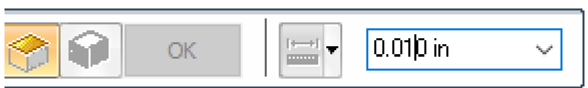
Hover over the wheel until the axis highlights.



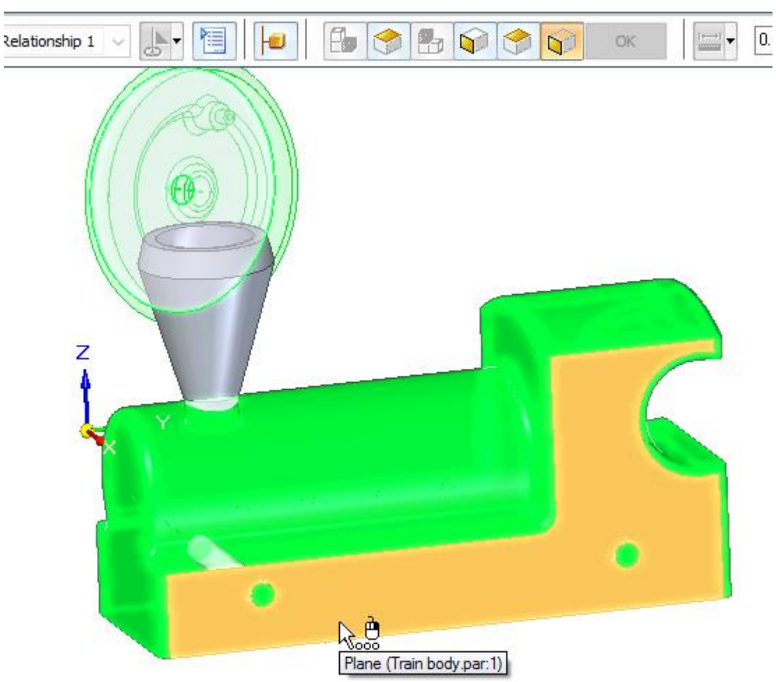
Click to accept. Then hover over the engine body where the hole goes through the body, click again.



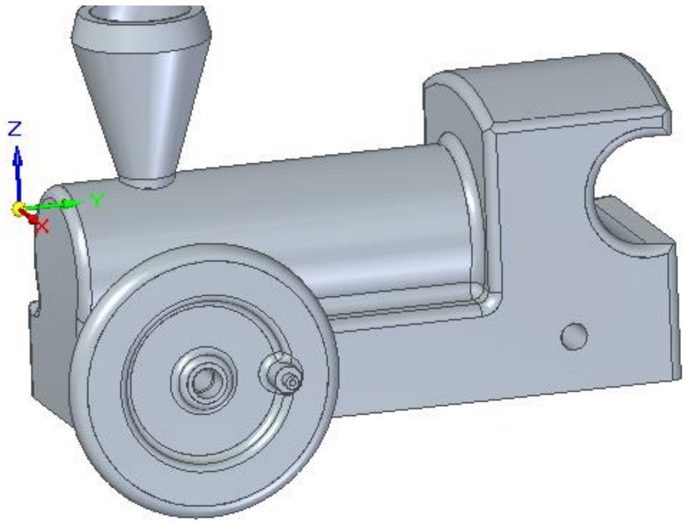
At the end of Assemble tool bar is a section for offset. Set the value there to .010



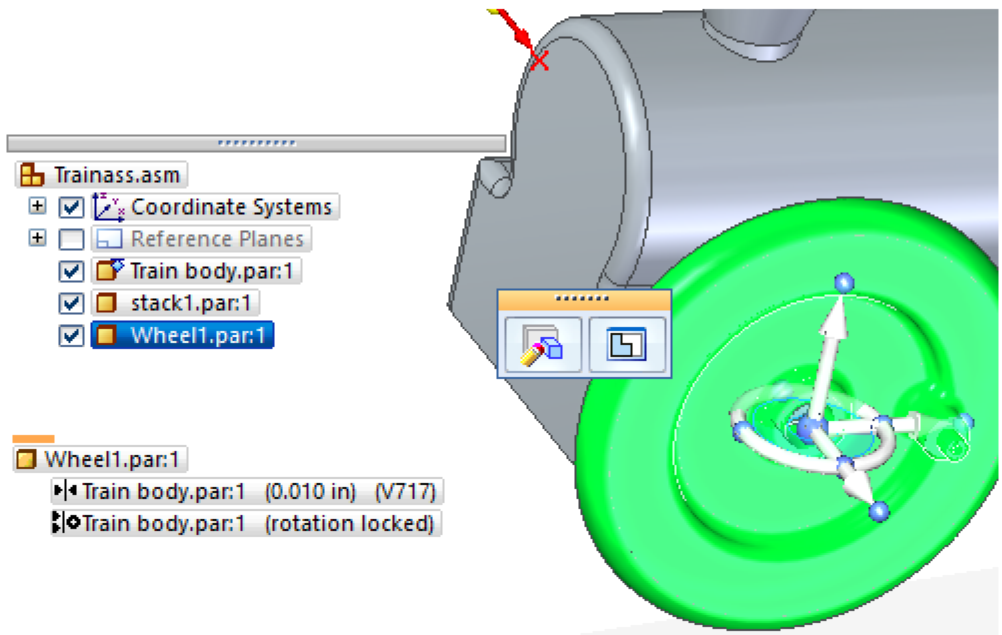
Select the flat side of the wheel and then the flat side of the engine body.



The wheel should now be in place and be set .010 out from the engine body. This will also allow the wheel to move.

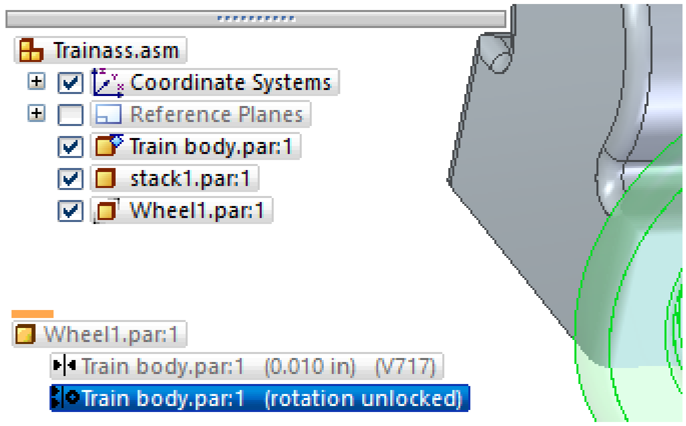


Hit the Esc key to exit the command. In the path finder highlight the wheel and you will see the relationships assigned. You will see the insert command has locked the rotation of the wheel. If we want the wheel to rotate we will need to unlock the wheel.



Right click on the relationship that ends with (rotation locked). Select edit definition from the options. This will open the tool bar. To unlock the wheel, click on the unlock rotation arrow on the right side of the tool bar.

When you check ok, the path finder will report your edit.



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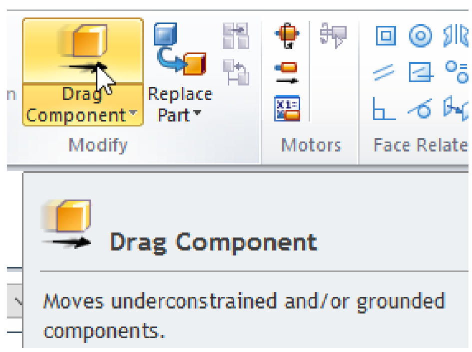
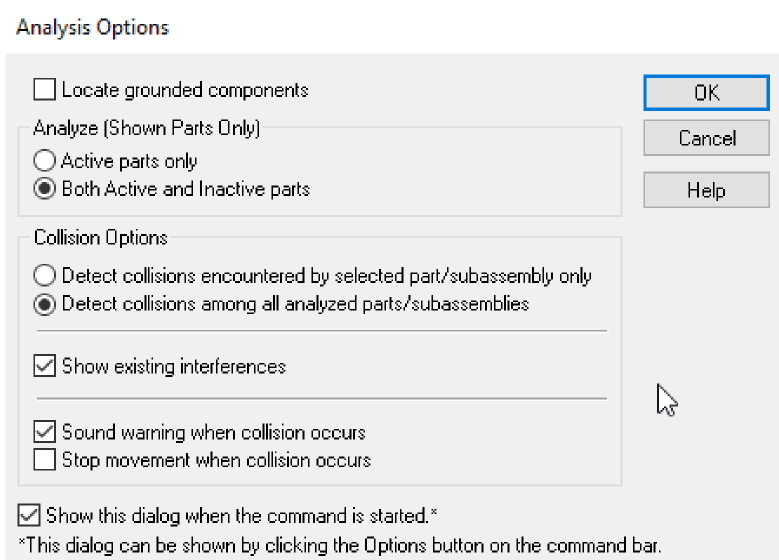
Drag Component

Hit Esc to exit that command. To see the results in real time, select Drag Component from the modify section of the ribbon.

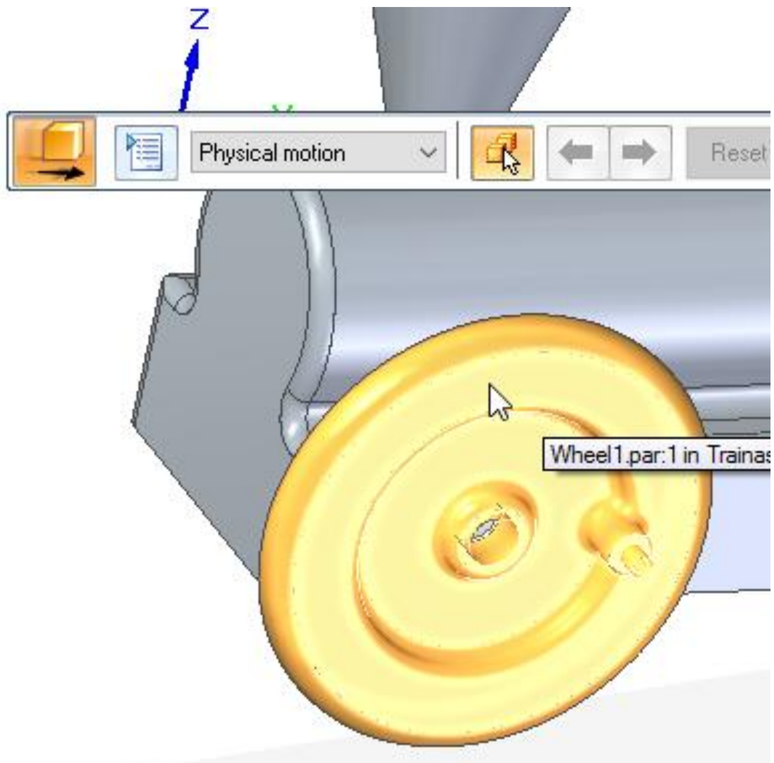


This will open a dialog box for analysis options. Select the options shown below and click ok.

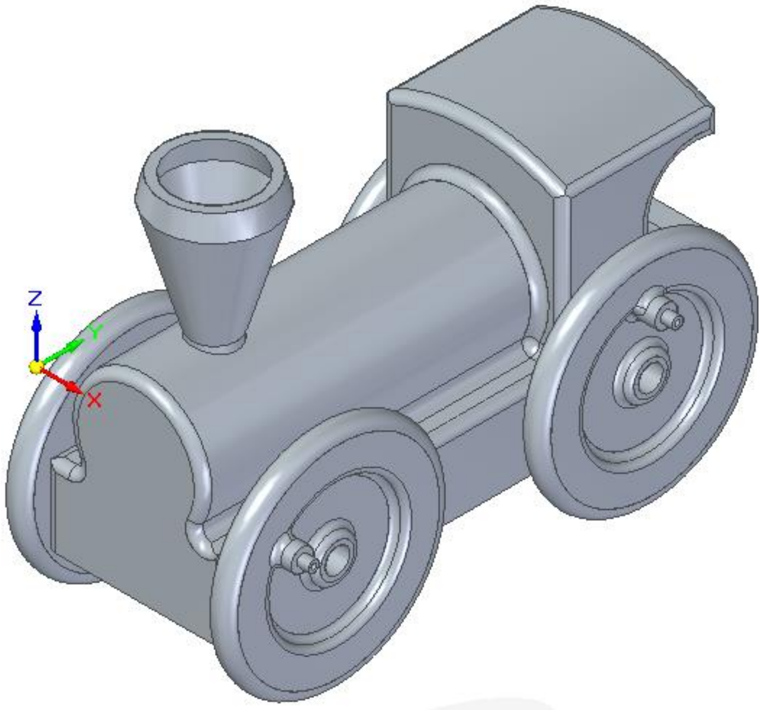


The toolbar opens. Set the motion analysis option to physical motion. Select rotation for the option.

Select the drag component option and then click on the wheel and hold the mouse button down. You should be able to rotate the wheel.



Place the other three wheels and apply the relationships so the wheels are in the proper place. Be sure they are unlocked.



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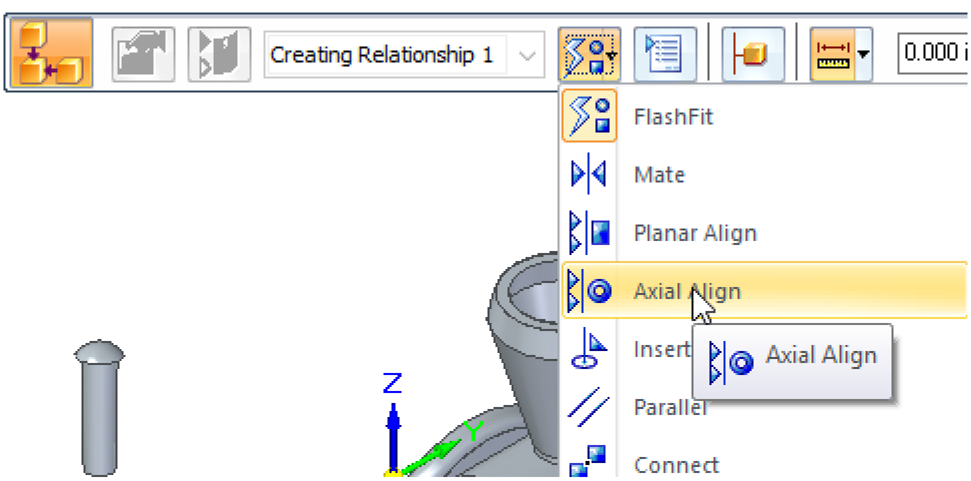
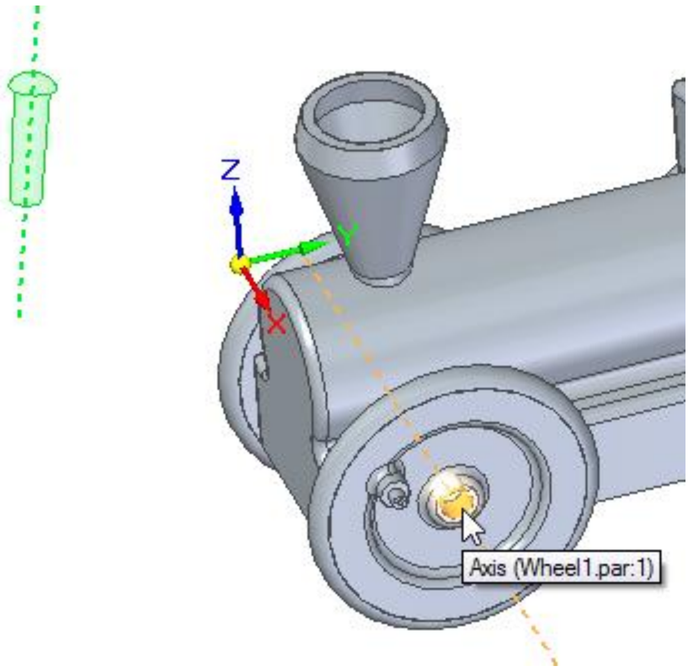
Axial Align

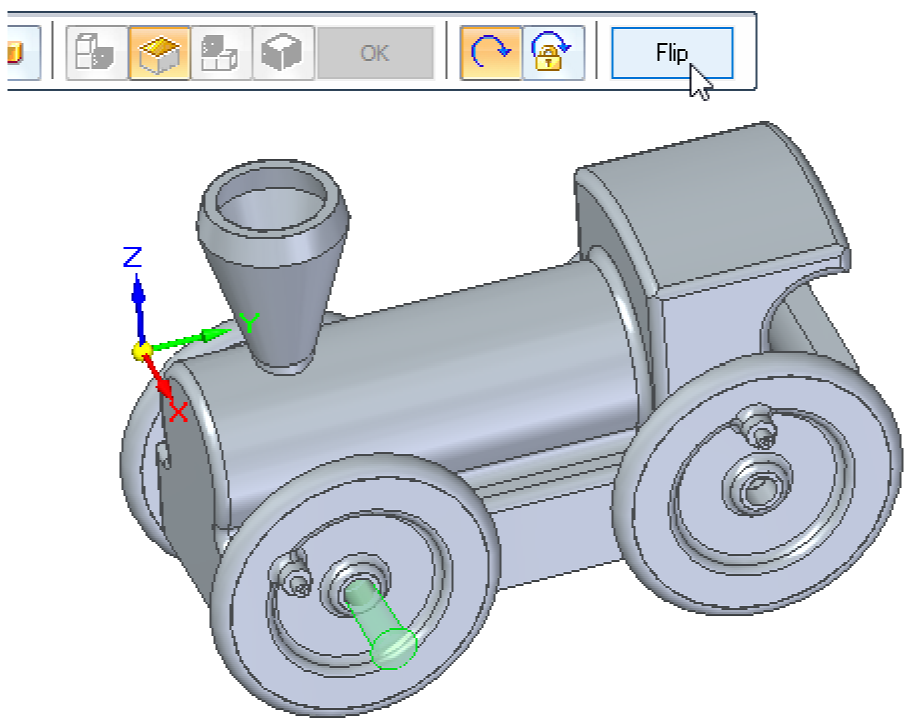
The geometric relationships hold the wheels in place, but in real life you will need to hold the wheel in place. Drag a peg onto the screen. You could use the insert command to place the peg but that will lock rotation keeping the wheel from turning. In this case, use two separate relationships to achieve the same thing. From the Assemble toolbar select Axial Align.



Select the axis of the peg and then the axis of the wheel.



When the peg moves into position, there are two possible ways the peg can position and fit the relationship. If looking at the wrong end of the peg, select the Flip button on the toolbar to reverse the alignment. Be sure it is unlocked.



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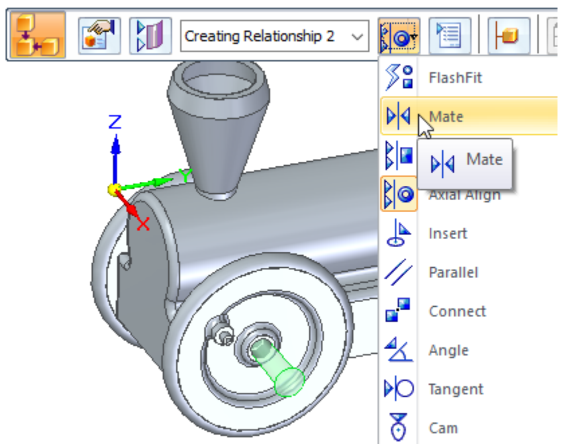
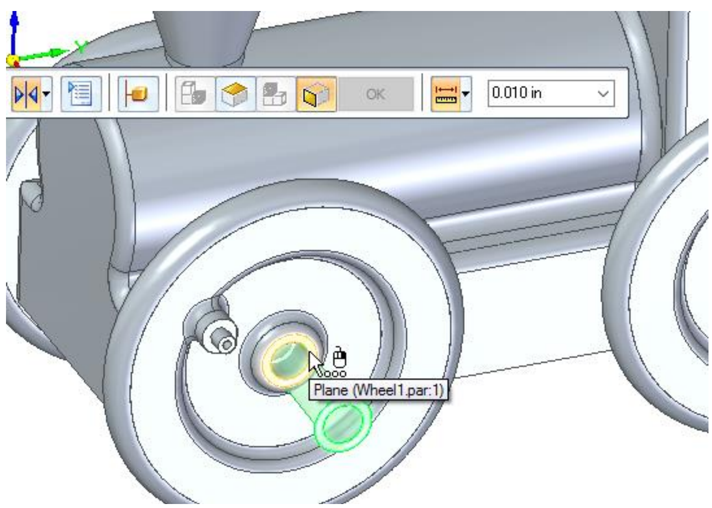
Mate:

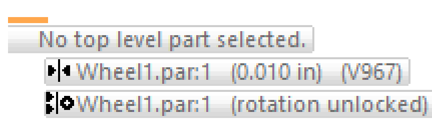
The mate relationship allows two surfaces to be in planer alignment. We can define an offset if desired. In this case, an offset of .010 will allow the wheel to rotate. Select Mate from the assemble toolbar.



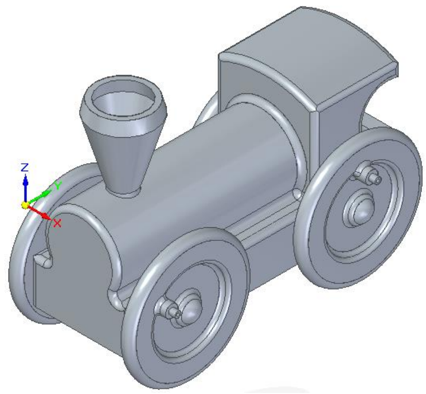
Select the underside of the head of the peg and then the raised boss of the wheel. The peg will slide into place.



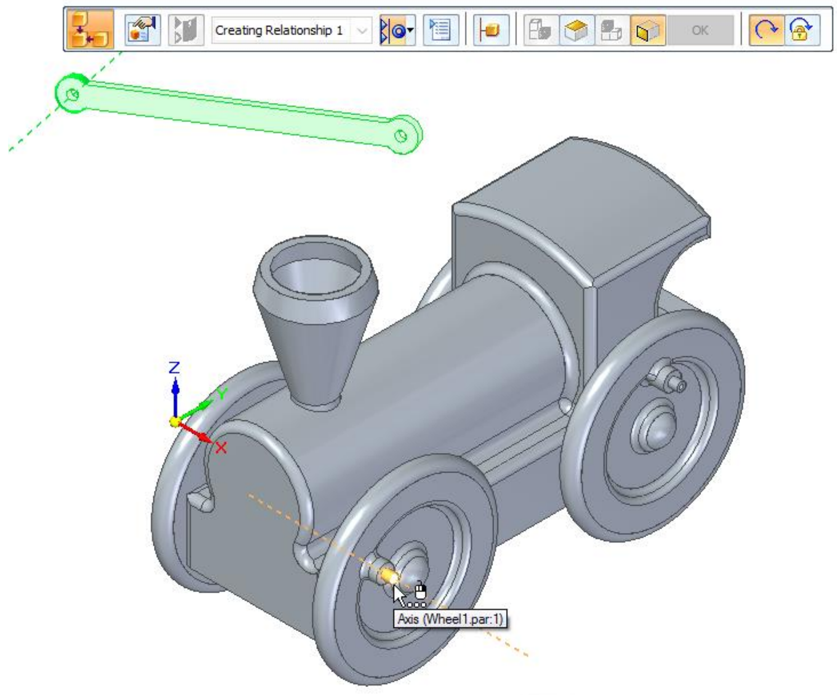
In the path finder you will see that the peg shows the mate with the offset of .010 and the axial alignment with the status of rotation unlocked.



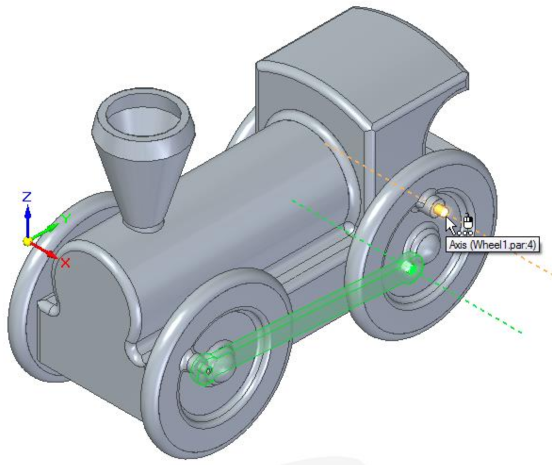
Place the other three pegs and add the appropriate relationships.



Drag the linkage arm onto the screen. Use the axial align relationship to locate the center of the hole with the linkage fitting on the wheel.



Use the axial align relationship to position the other end of the linkage arm.



Notice how the wheels moved to make the relationship possible. If you get an error message that is a sign that one of the wheels is not free to rotate. Find the locked component and edit the relationship so it is free to rotate.

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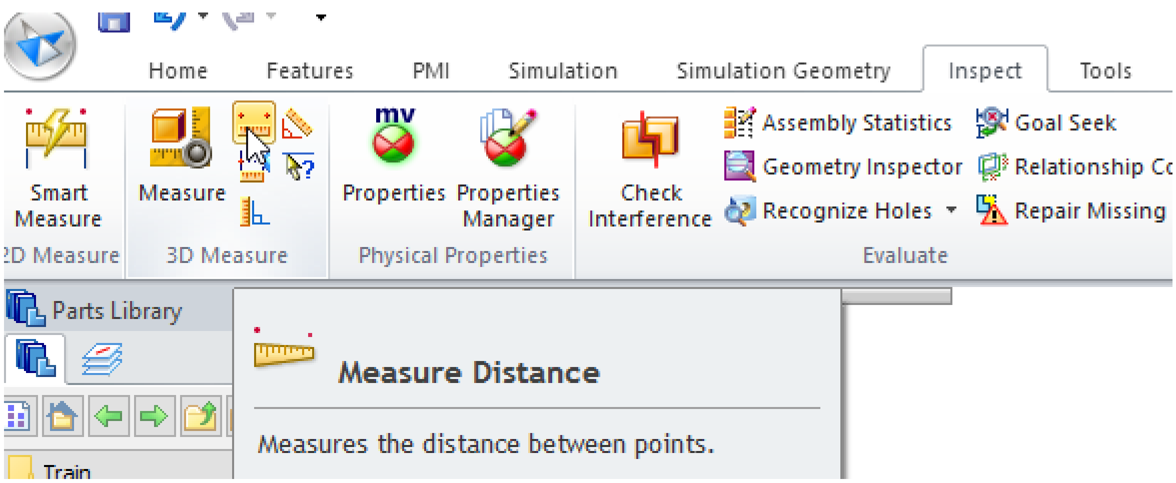
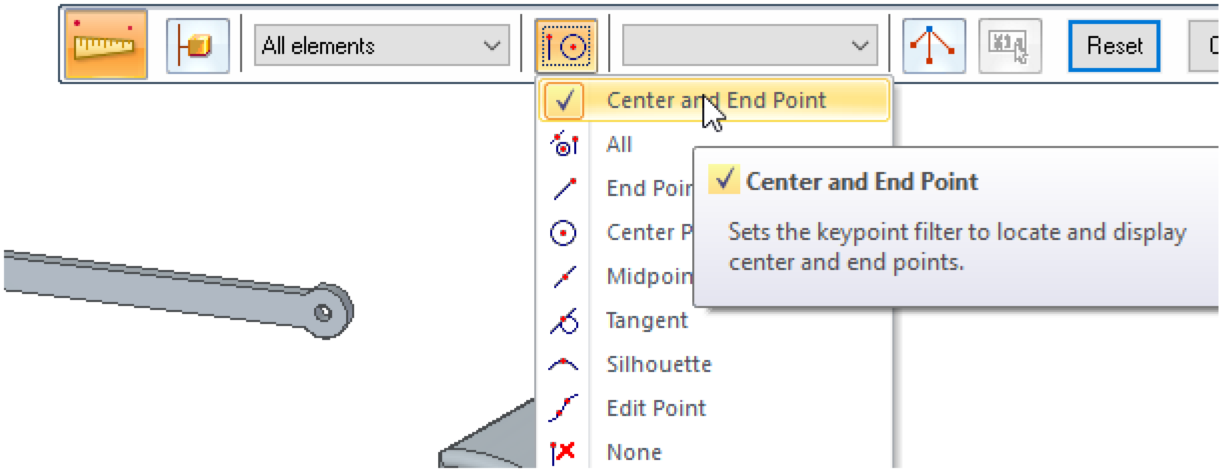
Inspect: Measure Distance

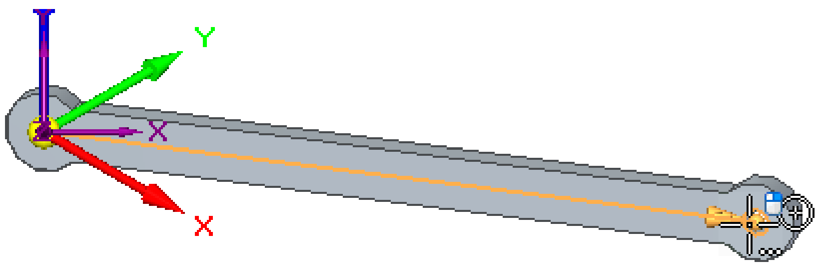
If you are still having trouble that is usually a sign that the distance between the wheels (3.5) is different from the length between the holes of the linkage arm. To check the dimension select the Inspect tab to see the Inspect ribbon. Select Measure.



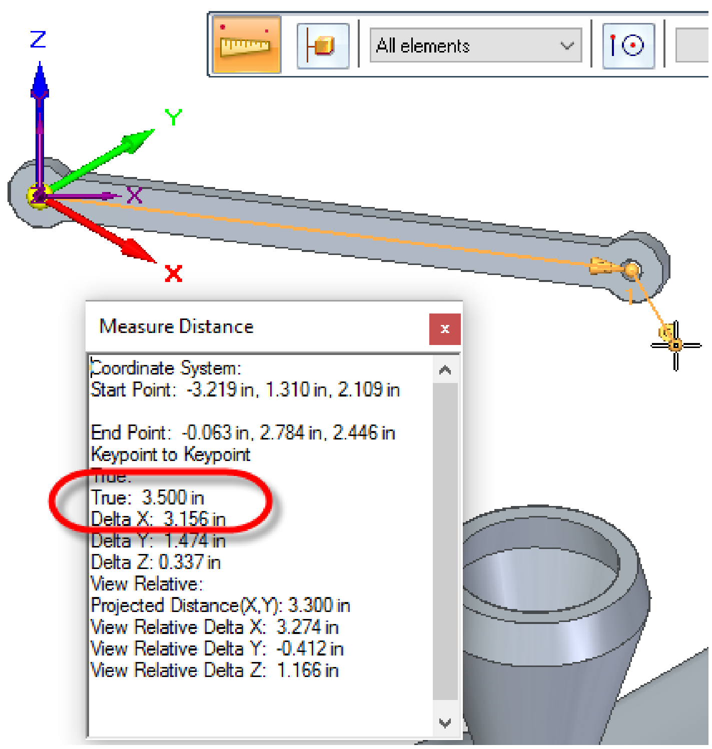
The measure distance tool bar will open. Set the parameters to center and end point.



Select the center of each of the holes.



The computer will determine the actual distance.



Edit the part if it is not correct.

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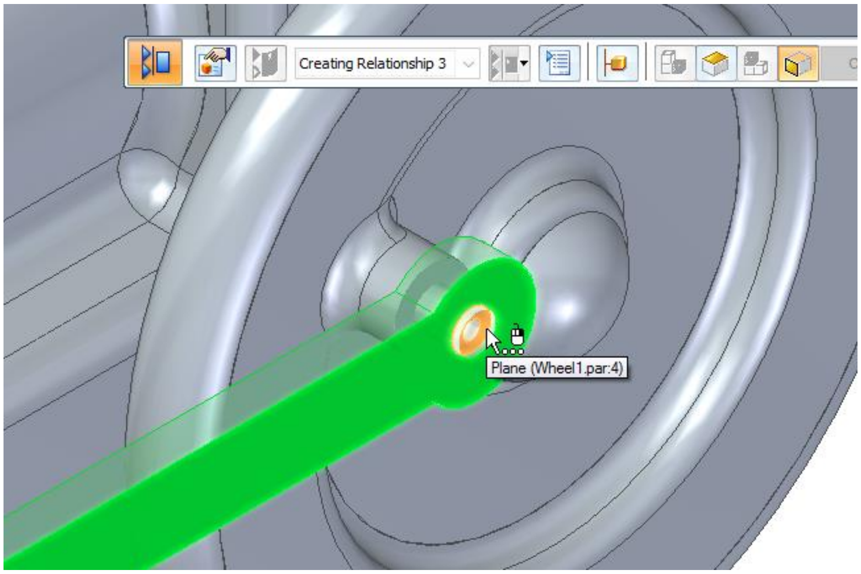
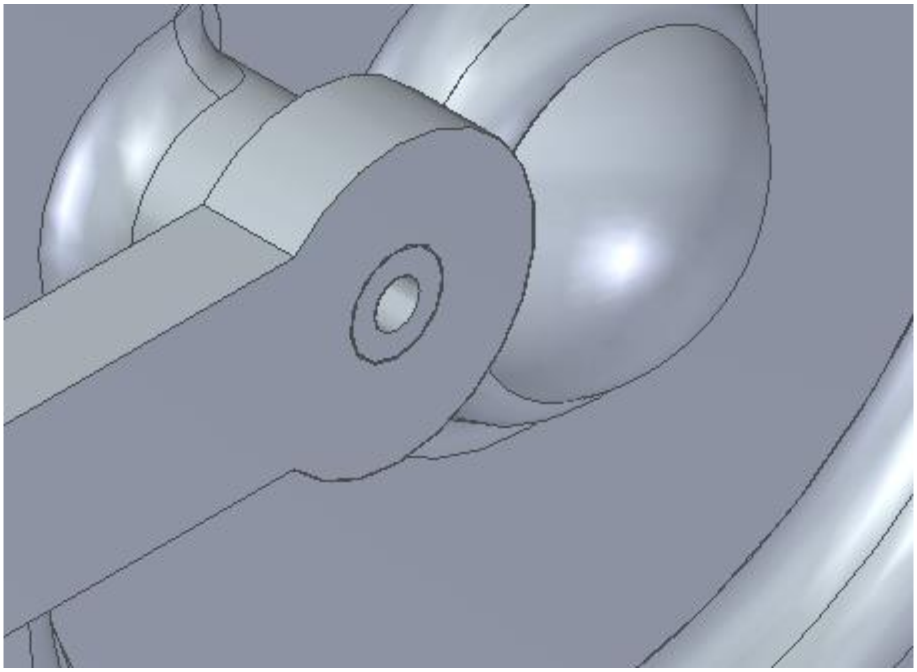
Planer Align

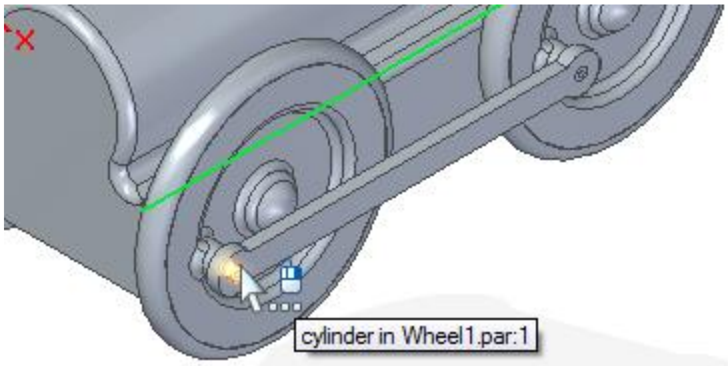
Planer align is a relationship that aligns the faces so they are parallel and facing in the same direction. Highlight the face of the linkage arm and then select the end of the wheel's linkage cylinder.



This aligns the face of linkage arm with the face of the wheel cylinder.



Use the drag component command with the rotate option to see how the parts now work together. Once you select the wheel if you select the cylinder on the wheel you will be able to drag the front wheel in a circle. How does that motion translate to the rear wheel?

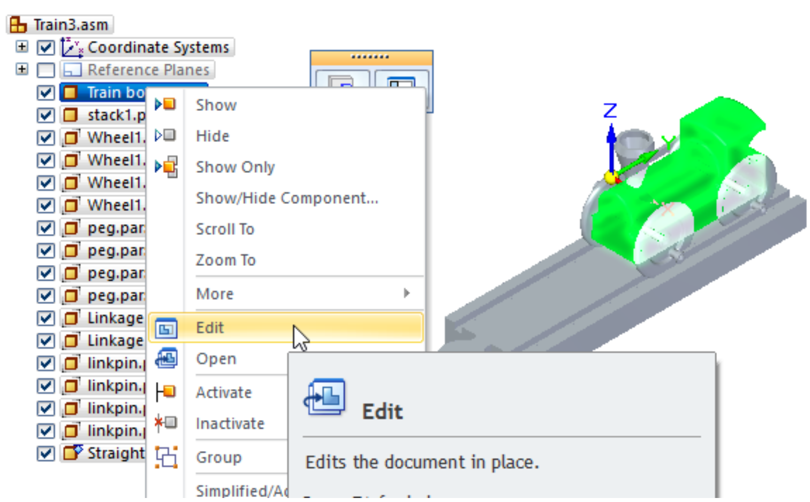


Apply the linkage bar to the other side of the engine.

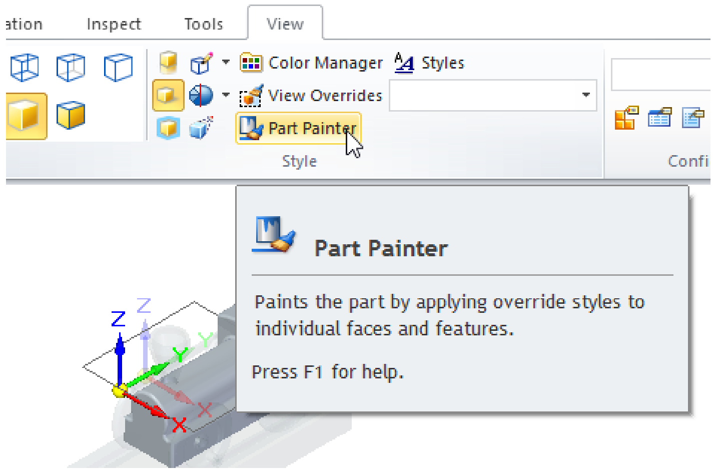
Drag a link pin onto the screen. Using similar relationships to the wheel pegs place the pins to secure the linkage arms to the wheel cylinders.

Color:

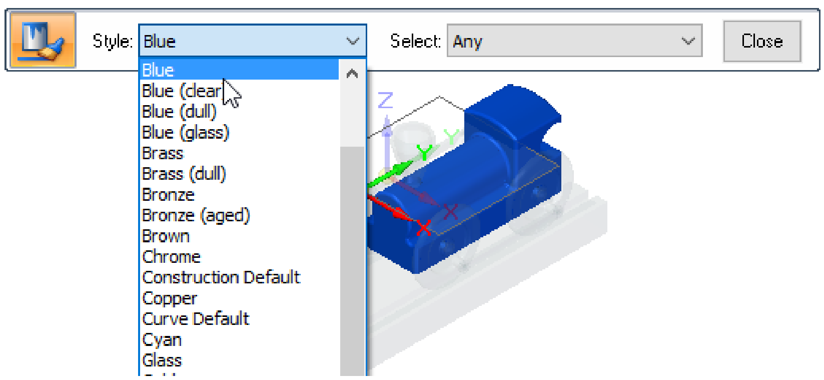
Parts are very generic in color and material. The first step in making an assembly easier to comprehend is the addition of color to the parts. To add detail to a part, right click on the part name in the path finder and select edit. Begin with the engine body. The part will highlight.



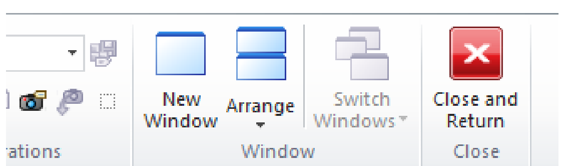
The rest of the parts are dim in the background and only the engine body is bright. Switch to the View tab and select the Part Painter icon from the ribbon.



Color options are available in the style section. Select colors that help people see the differences in the parts.



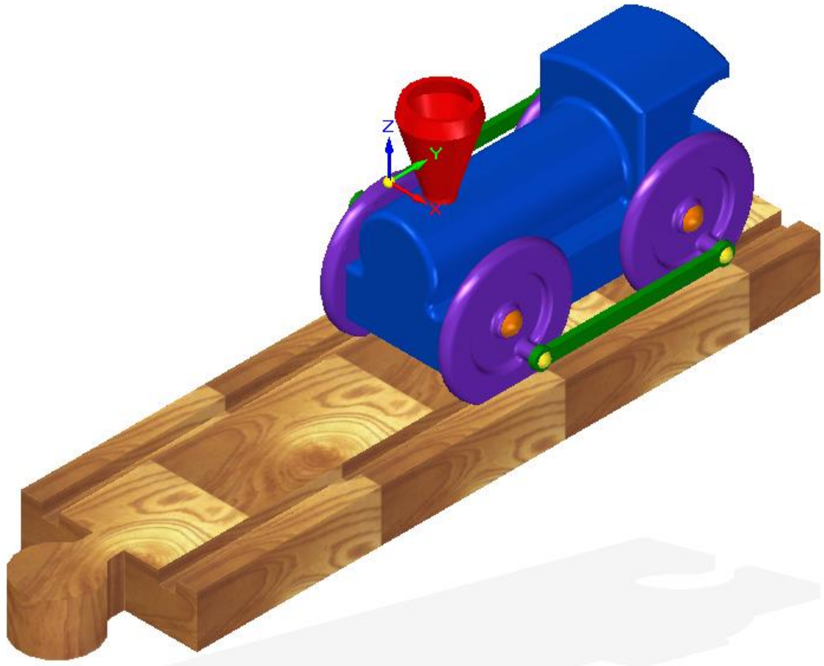
When completed, select Close and the color remains. From the ribbon select Close and Return to bring the assembly up again.



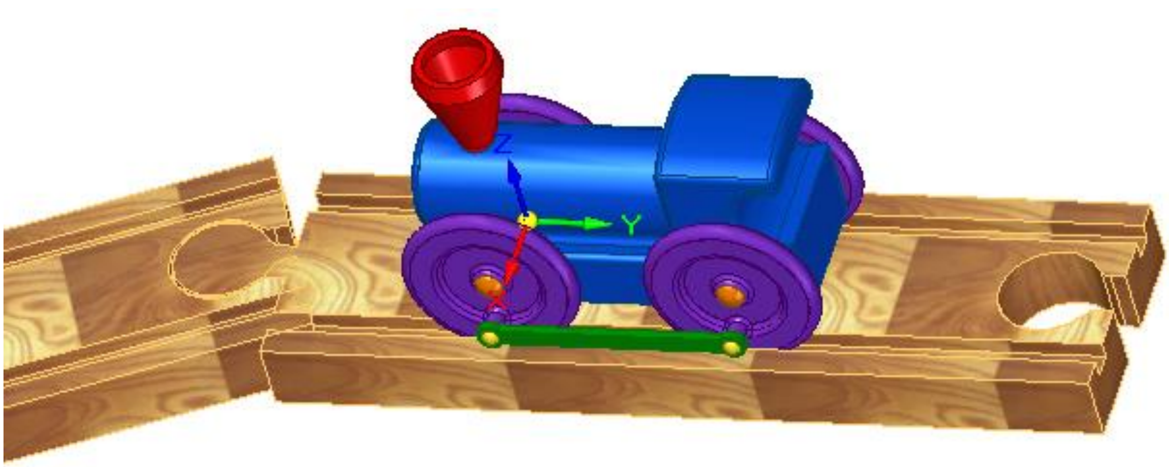
Make the track visible again by placing a check next to it in the path finder.

Add color to all the other components.

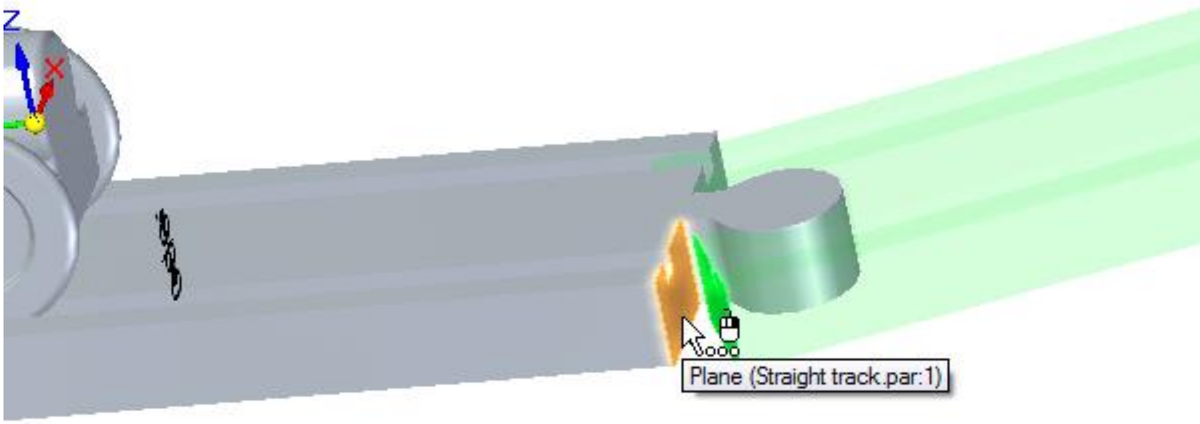
The assembly should now provide an idea of how the various components are located.



Add a second piece of track in front of the grounded one. Use the Planer Align to align the top of each piece of track. Us the Axial Align to line the peg with the slot.



Now use the mate relationship to line up the back of the track with the front of the grounded track.



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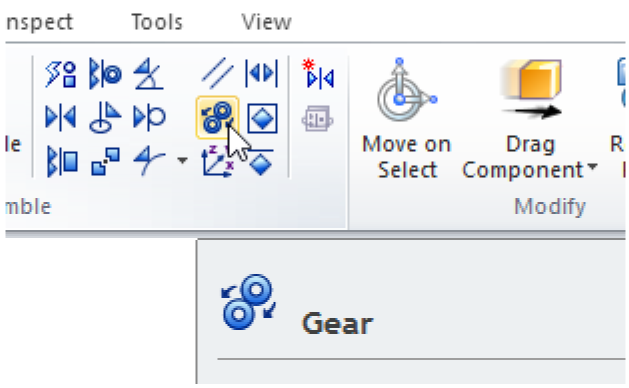
Gear Relationship

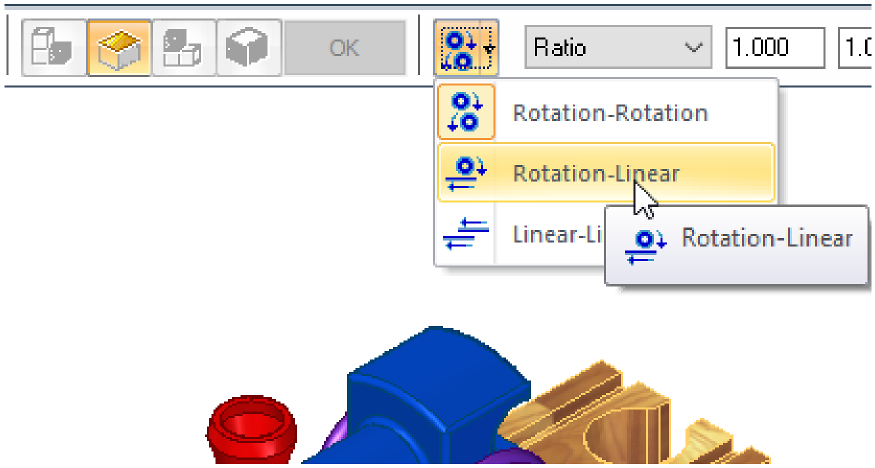
The Gear relationship defines how one part moves in relation to another. It supports rotational-rotational, rotational-linear, and linear-linear type movements.
The Gear relationship is useful when working with assemblies that contain gears, pulleys, parts that travel in grooves or slots, and hydraulic or pneumatic actuators. In the case of the engine we want the wheels on each side of the engine to move together. We also want the engine to move down the track.

The first thing to do is to establish how far the engine should move on one revolution of the wheel. The circumference of the wheel is found by the formula $\text{Circumference} = \pi D$. When we designed the wheel the diameter applied was 2.25 in. Multiplied by pi we find the circumference is equal to 7.0686 inches.

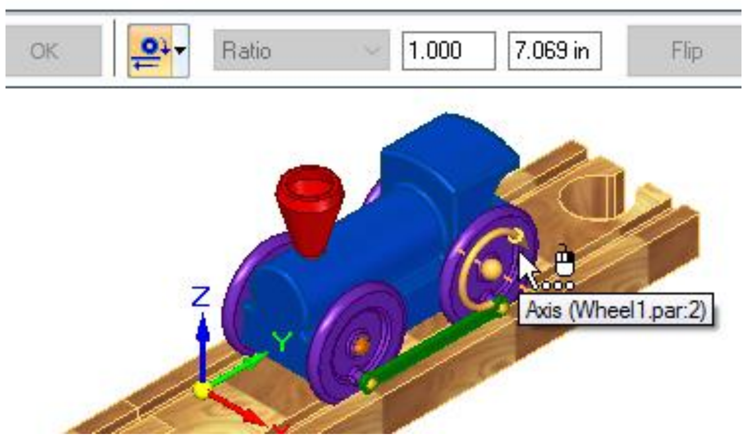
Select the Gear relationship from the Assemble section of the ribbon.



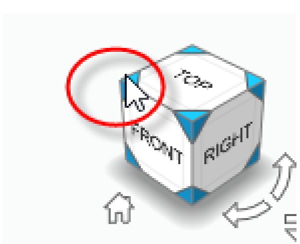
On the toolbar select the option for Rotation-linear.



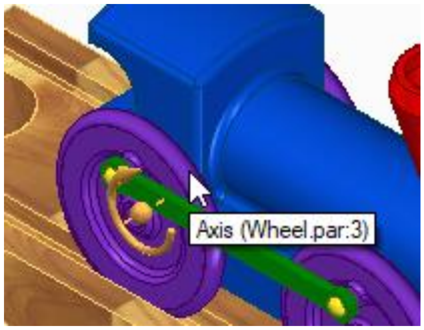
Enter in the distance per revolution ratio. Once the distance is entered select axis of the wheel. Be sure the indicator is reporting the Axis.



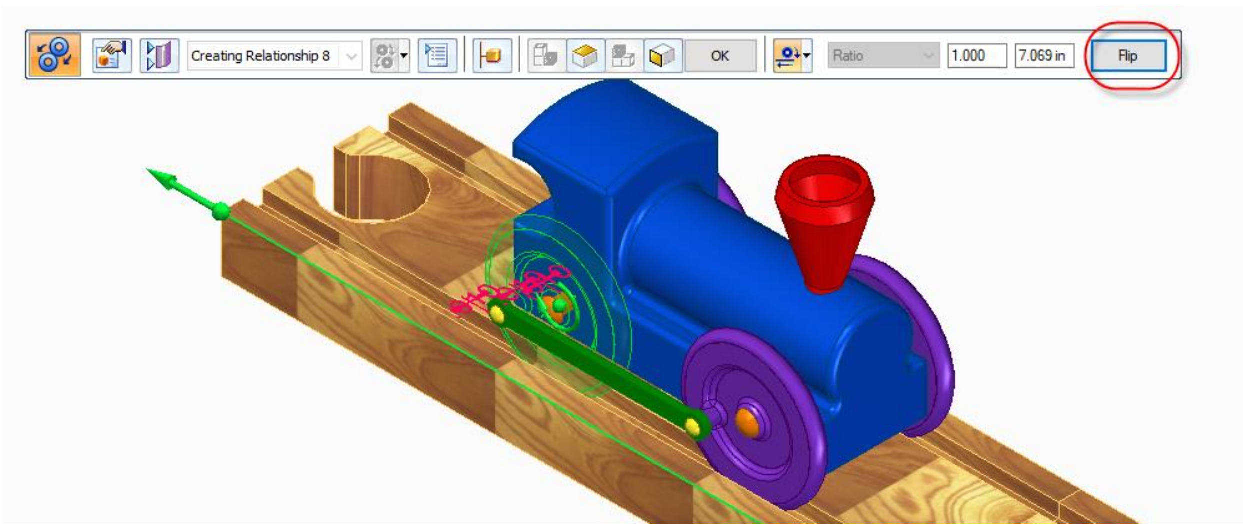
If the arrow is in the reverse direction as in the picture above hit the escape key. Change your view to the isometric from the other direction by selecting the appropriate spot on the view cube.



This will take you to the opposite side. Repeat the Gear Relationship command and the Rotation-Linear Option. Re-enter the 1 and 7.069 dimensions. Select the back wheel on that side.

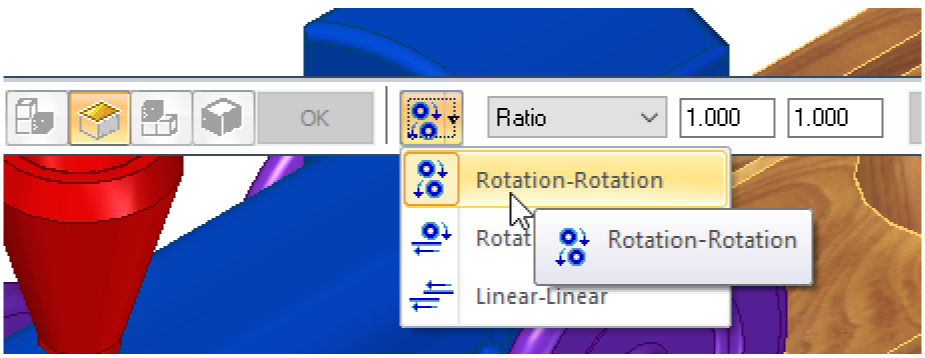


The arrow should point in the correct direction so the wheel will rotate correctly when animated.
Then select the edge of the track to select the direction.

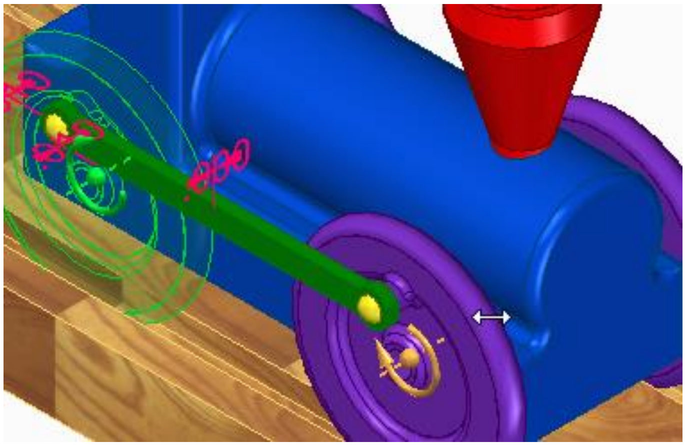


Select OK to apply the relationship. Hit the Esc key to exit the command.

Now work on the other wheels to rotate at the same time in the same direction. Select the gear icon from the assemble section of the ribbon again. This time use Rotation-rotation as the choice and 1.000:1.000 as the Ratio

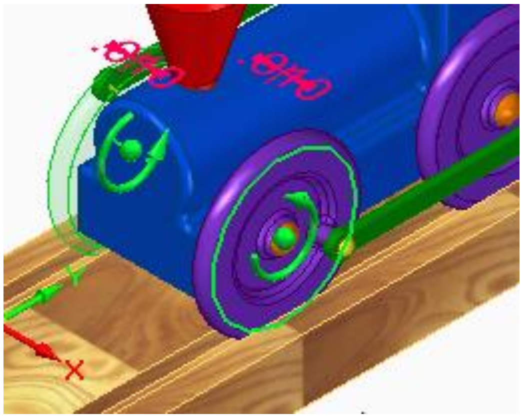


Select the back wheel axis and then the front wheel axis. Be sure the arrows point the same direction.



Select OK. To create movement on the other side of the engine, tie the front wheel on the other side of the engine to the front wheel for which the ratio was just applied.

Select the wheel on one side of the engine. Then select the wheel on the other side of the engine. If the rotation arrows do not agree, select Flip so they will both rotate the same direction. The ratio should be set 1:1 so they rotate at the same speed.



Working on the other side of the engine, apply the gear relationship to the two wheels on that side. This will keep all the wheels moving in the same direction together.

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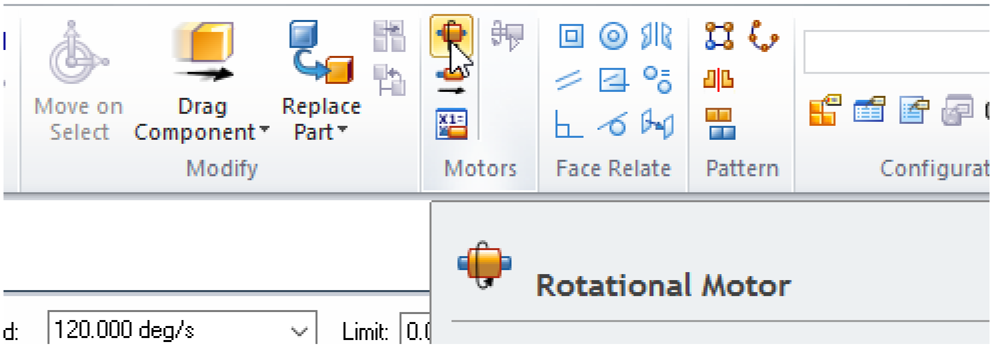
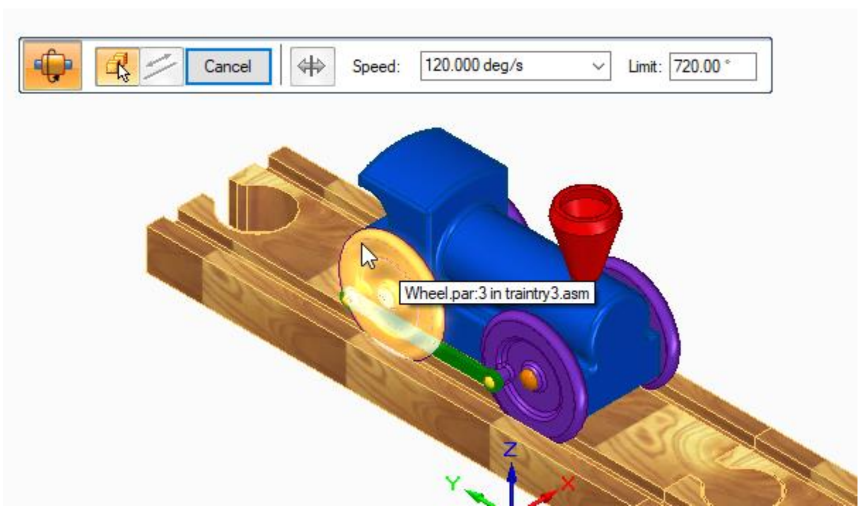
Motors:

Motors allow us to observe how a set of under-constrained parts will move relative to the part you define as a motor. This allows the design and simulation of complex mechanisms to observe the movement of a set of interrelated parts. The motor will cause movement in one part and we can observe how the system behaves.

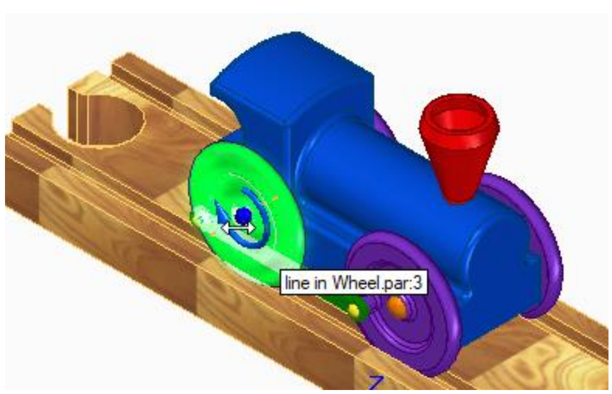
Select Rotational Motor from the Motors section of the main ribbon.



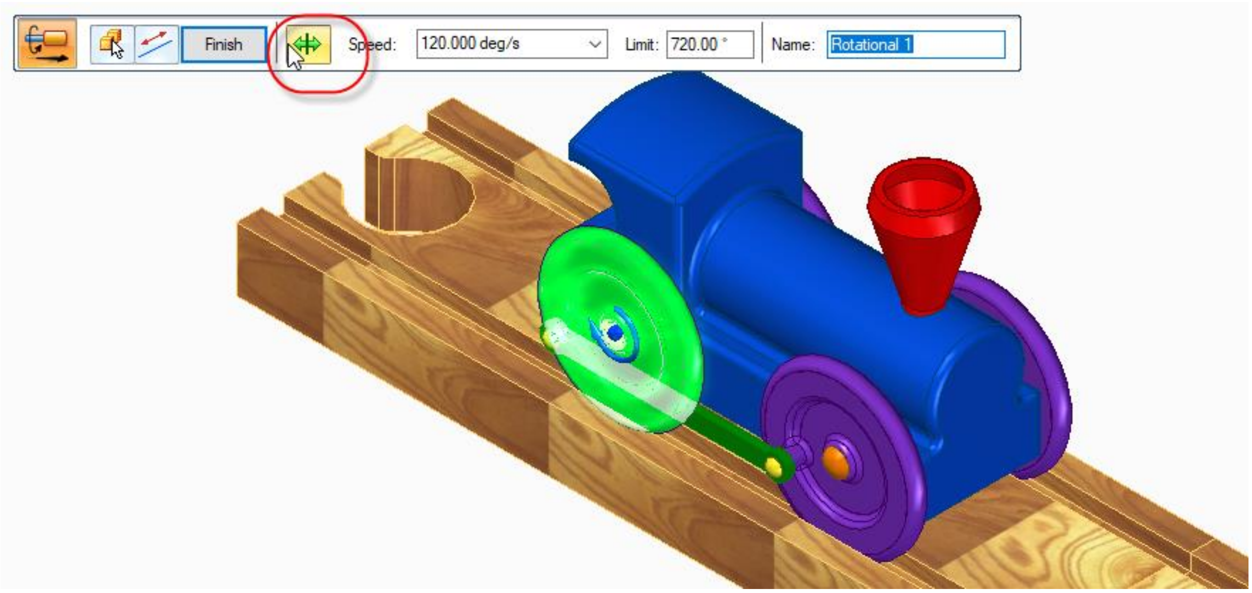
This will bring up the tool bar. Set the speed to 120 degrees per second. This means it will take 3 seconds for a revolution. Set the limit to 720 degrees which will limit the travel to two revolutions. Then select the rear wheel of the engine.



Then select the wheel axis for the axis of rotation.



Flip the arrow on the wheel if needed by selecting the Flip arrows on the tool bar. Select Finish. Click Esc to exit the command.



Save your file.

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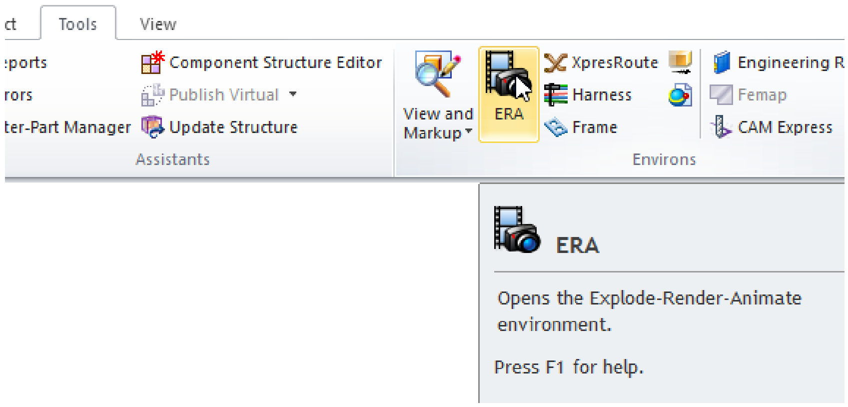
Exploding and Animation Of Assemblies

Assemblies show how the components go together. Many times it is difficult to see the order of assembly or how details of the assembly are accomplished. 3D solid modeling programs allow designers to show information about assemblies. The tool sets help communicate information by making it easier to understand.

Animating an Assembly

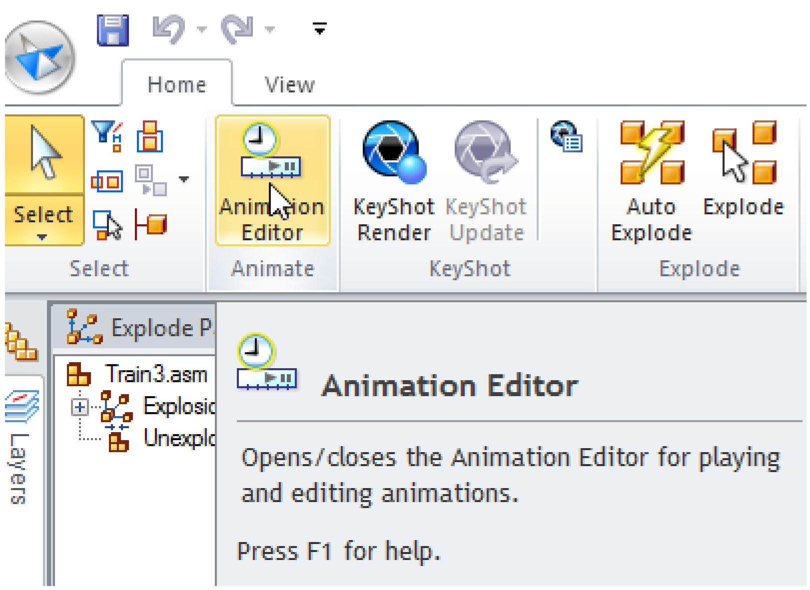
If you have properly set up your assembly you can see how the components will all work together. The animating process allows us to observe and analyze how parts work together or cause issues when in motion. We can also record what happens so we can watch later or use the animation as part of a presentation.

From the Tools ribbon select the ERA icon. This stands for Explode-Render-Animate. Select the F1 Key to see the help menu for this section.

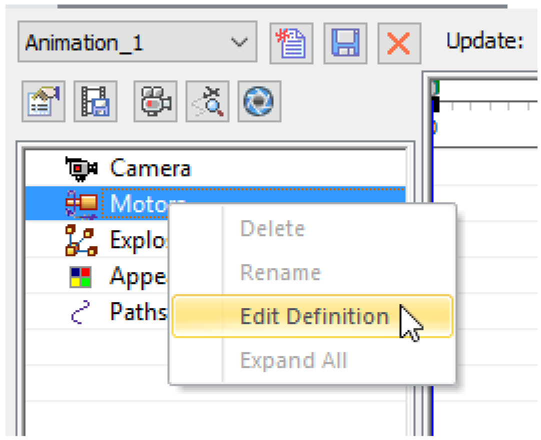


This will open up the ERA section of the program.

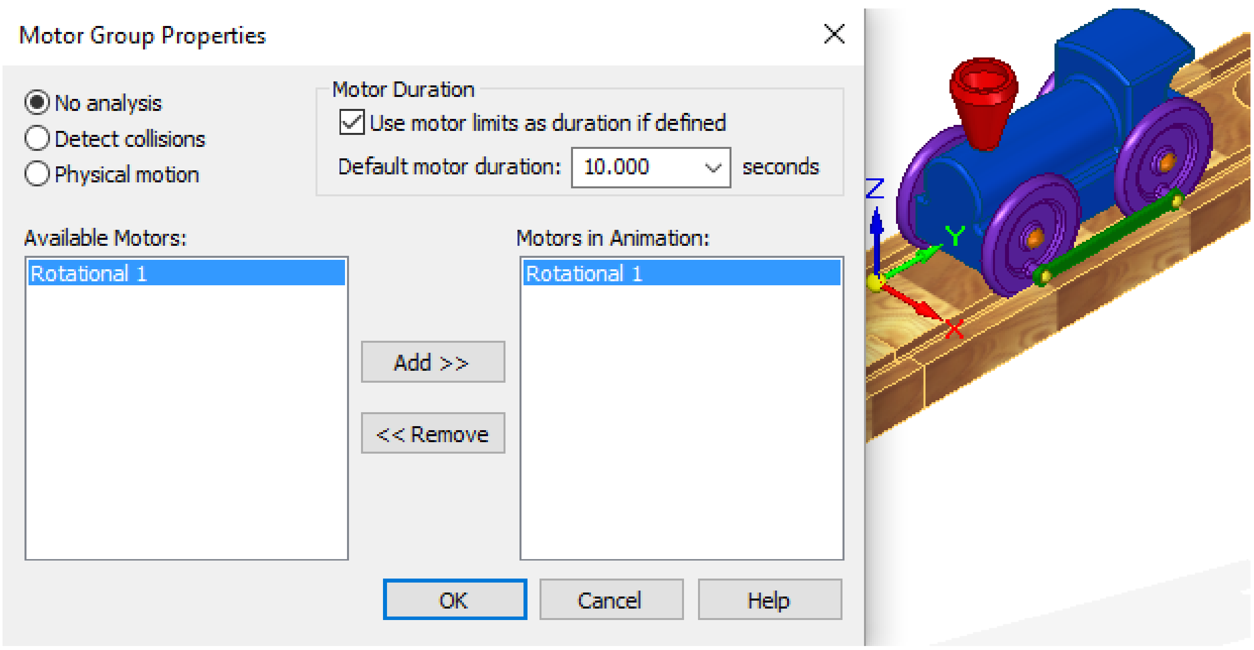
Select the icon for the Animation Editor from the Animate section of the ERA ribbon.



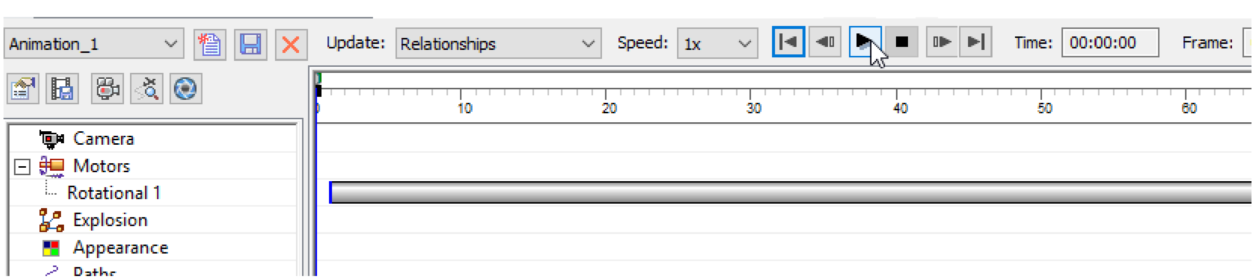
The Animation Editor appears on the screen. Right click on Motors and select Edit Definition.



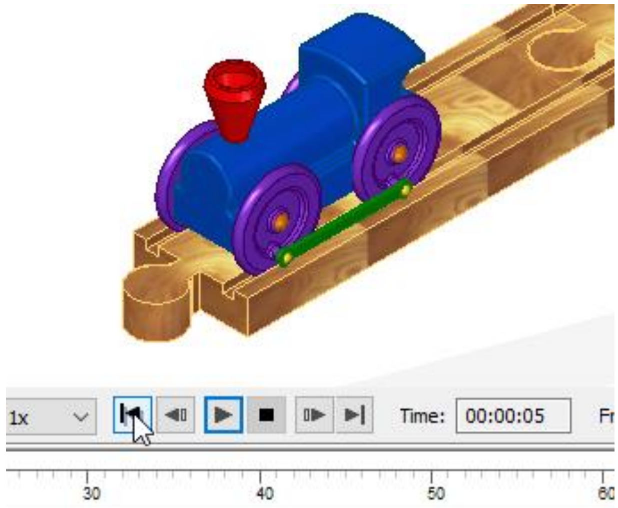
The Motor Group Properties dialog box opens. Since we placed only one motor,that is the only one that is visible. Be sure it shows on the right hand side so it will appear in the animation.



Select OK and see the Animation Window populate. Select Play and the engine should begin to move and the wheels turn.

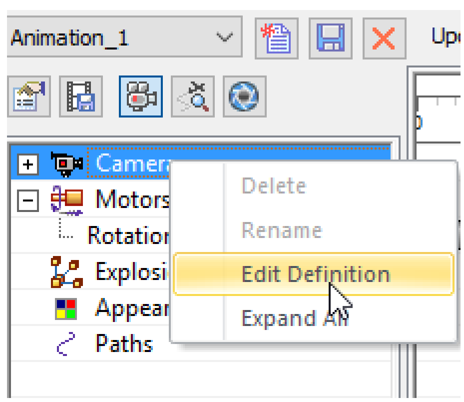


Click the Go to Start button and the engine will return to its original position.

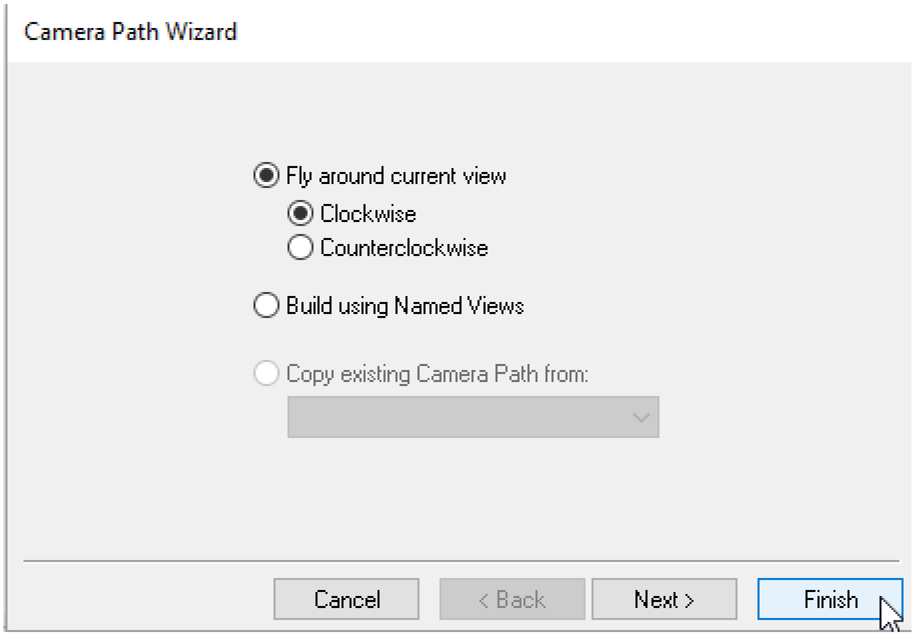


Now that you have seen the engine move, we can add a camera so we can watch from different angles.

In the Animation path finder right click on the Camera. Select Edit Definition.



In the Camera Path Wizard, select Fly around current view and Clockwise. Click finish.



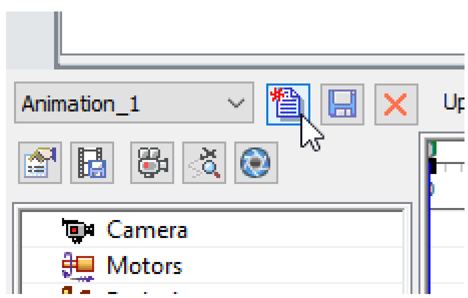
Play the time line again. You will see the animation and the camera flying around the track.

You can create custom paths or use known views when you create the path. For more information click on the camera and press F1.

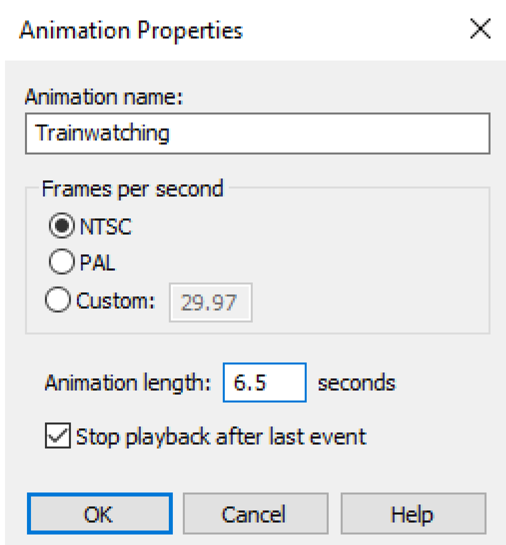
Back

Creating the Custom Animation Movie

Create a new animation by selecting the icon for New Animation on the toolbar.

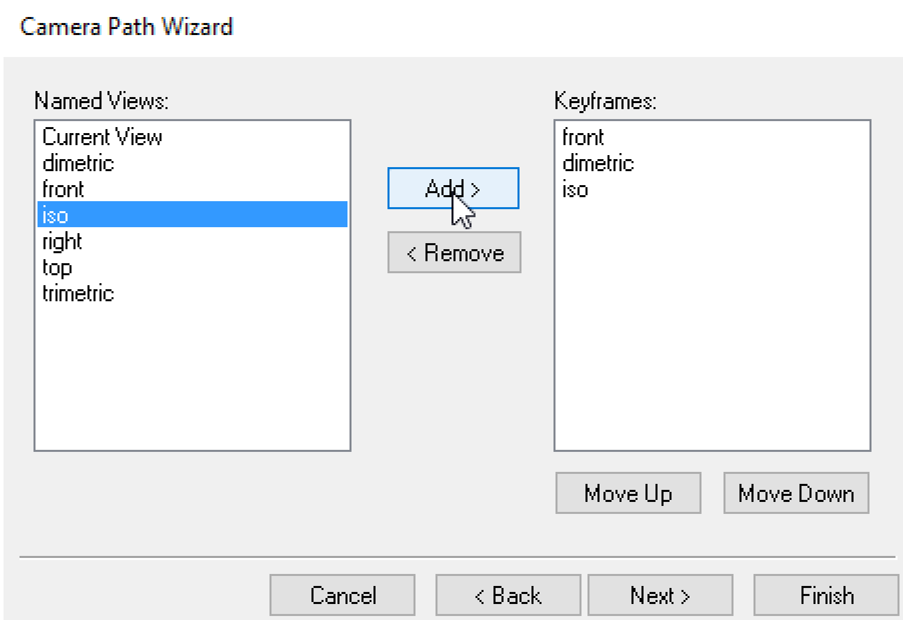


Since we want to make a video presentation of this we need to adjust the settings as well as giving our animation a name. In the Animation Properties dialog box give a name to your animation. Set the Frames per second to NTSC. This is a setting used in the US. Set the length to 6.5. We know the wheel will turn twice and it is moving at 120 degrees per second.

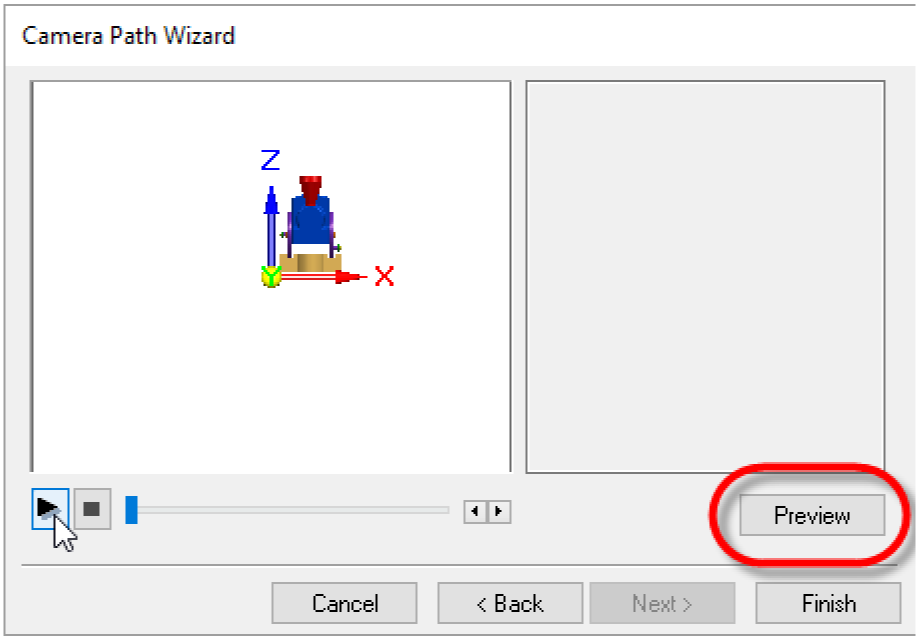


Click OK. Your name should now be in the animation window.

Right click on the Camera in the Animation Window path finder. Select Edit Definition. In the Path wizard select the option to Build using named views. Click next. In the Camera Path wizard add front “dimetric” and “iso” by highlighting them and selecting the Add button.



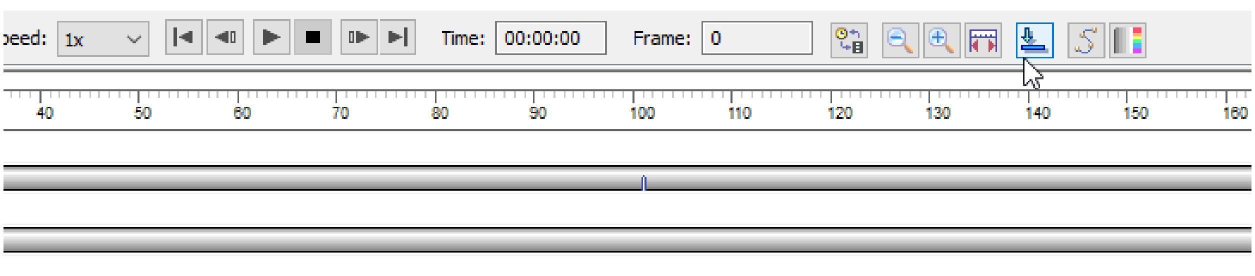
Select next. Click the Preview button. Then click the Play button and see the path the camera will take.



Click Finish. If you are satisfied, select Finish. If not, select back and edit the path.

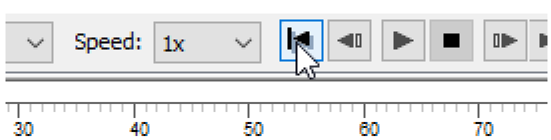
Right click on the Motors in the path finder and select Edit Definition and add the Rotational Motor.

Click on the Toggle button to minimize the Animation Editor.

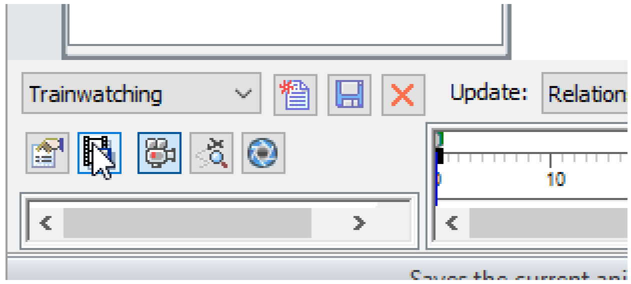


Play the animation and be sure it is what you want.

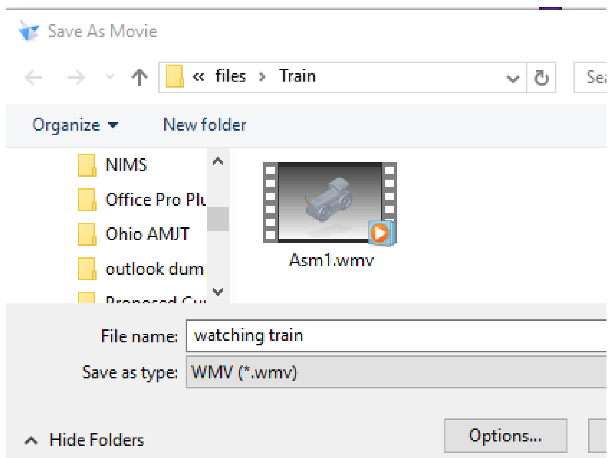
Click the Go to Start button.



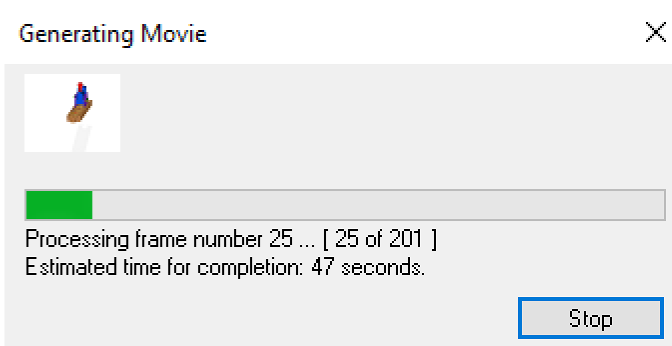
Select the icon for Save as Movie. This saves the current animation in a format that can be played back, uploaded to the cloud, or saved as part of a presentation.



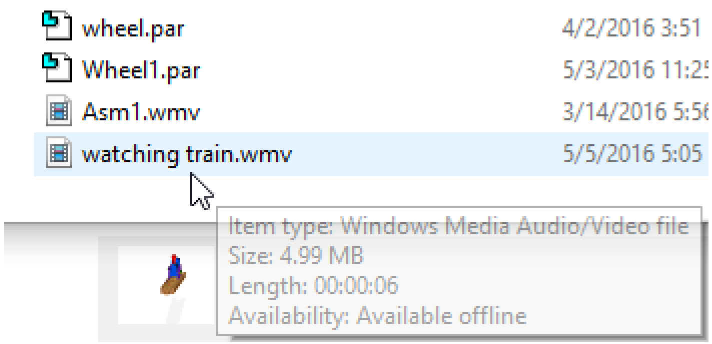
In the dialog box select where you would like to save the movie and provide a name.

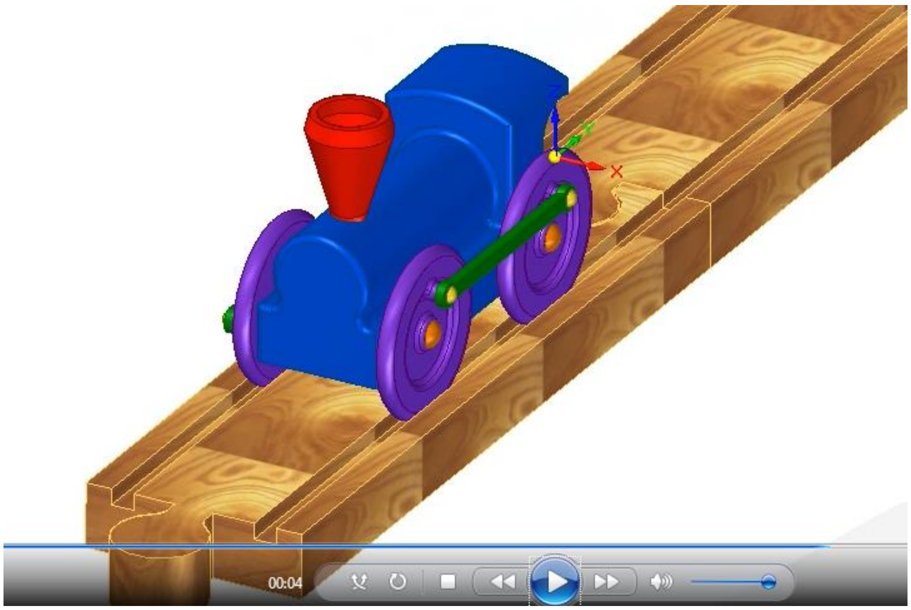


When you are ready, select Save. See the generating movie dialog box and watch the progress.



When done, browse to the folder where the movie is saved and be sure you can open it.





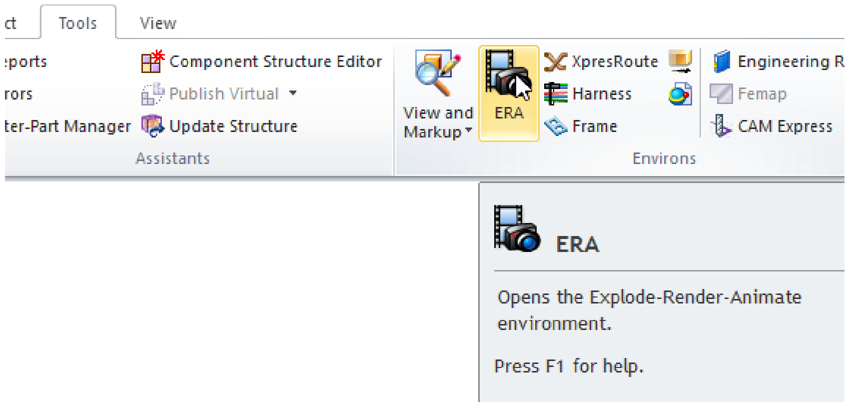
Save your file and exit the Animation Editor and the ERA.

Back

Exploding the Assembly

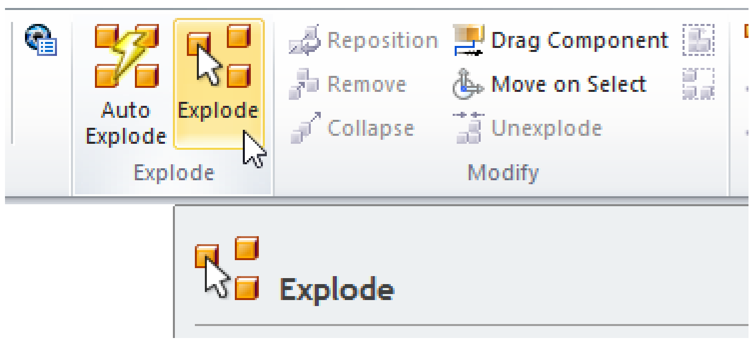
Another way to see how parts go together is to take them apart and leave a trail the parts will follow. This allows the viewer to see the relationships between the parts and also see the order in the assembly process.

From the Tools ribbon select the ERA icon. This stands for Explode-Render-Animate. Select the F1 Key to see the Help menu for this section.

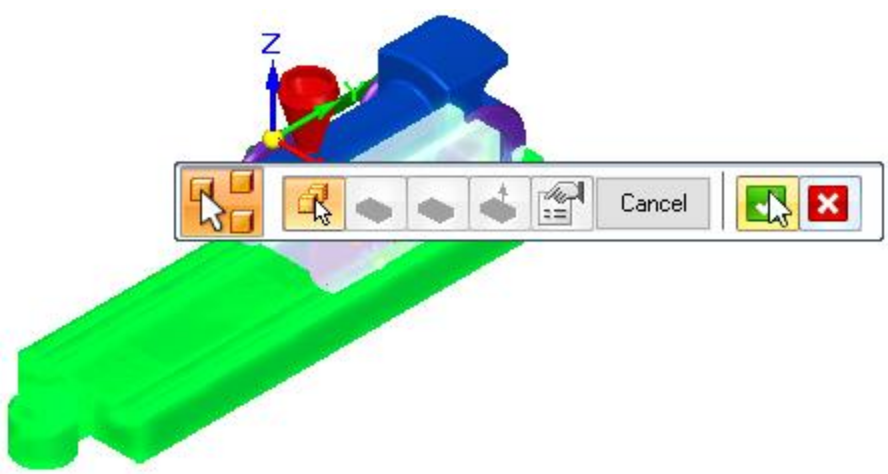


This will open up the ERA section of the program.

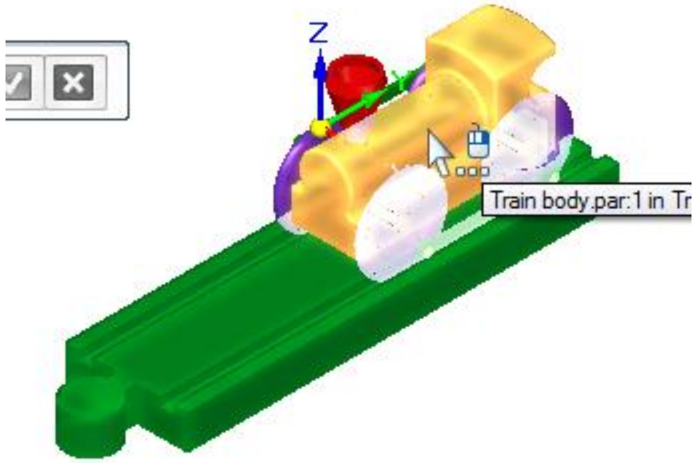
From the ribbon select the icon for Explode.



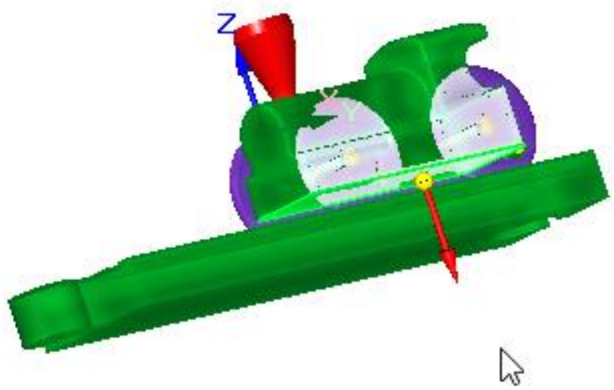
The Explode dialog box will open. Select the track. It will highlight.



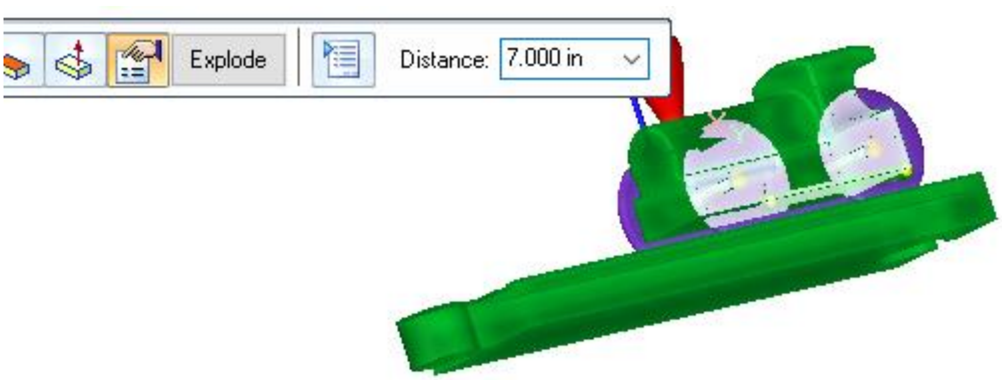
Select the green check to let the program know you are done with the selection process. The prompt is asking for the part that will remain stationary. Select the engine body.



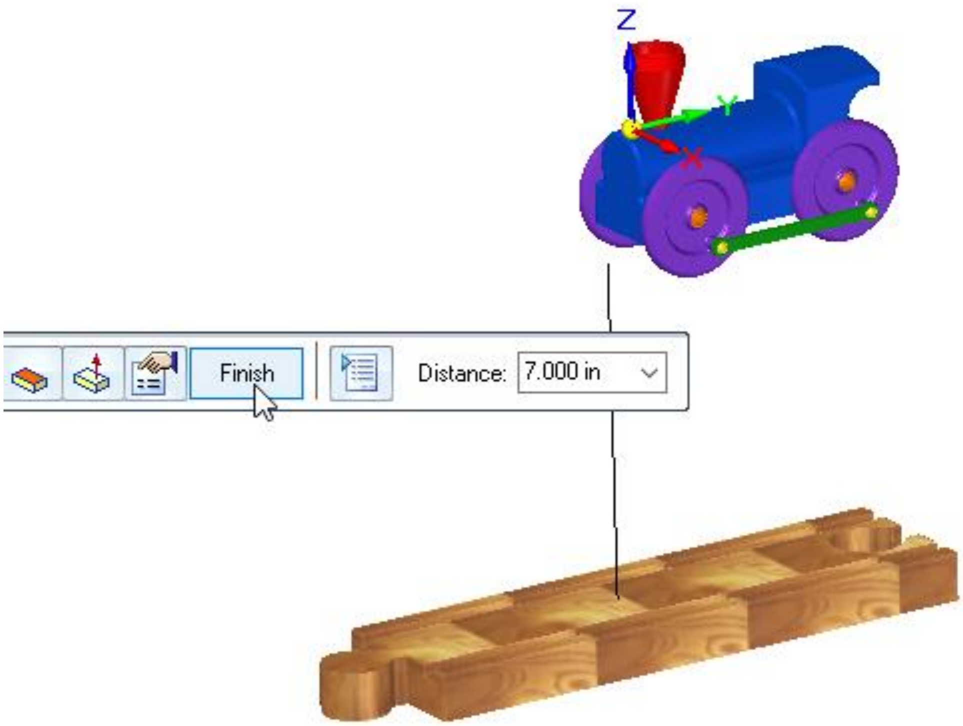
The prompt then asks what surface represents the plane. Rotate the view so you can select the bottom of the engine body.



The direction arrow will appear. Move the mouse below the track and click. This selects the direction the track will move. Enter 7 for the distance.

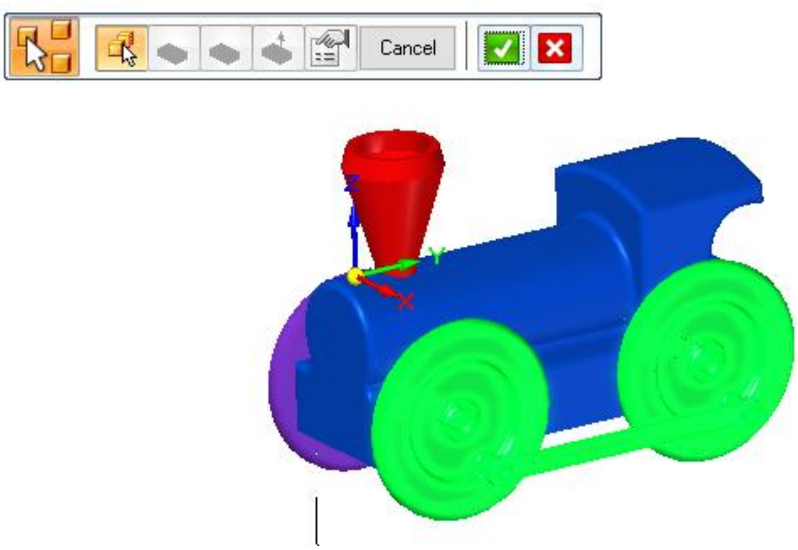


Select the Finish icon on the dialog box.

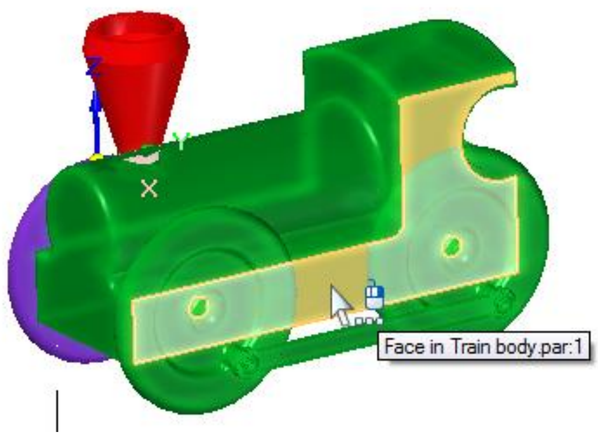


Select the Cancel on the tool bar to exit the explode command.

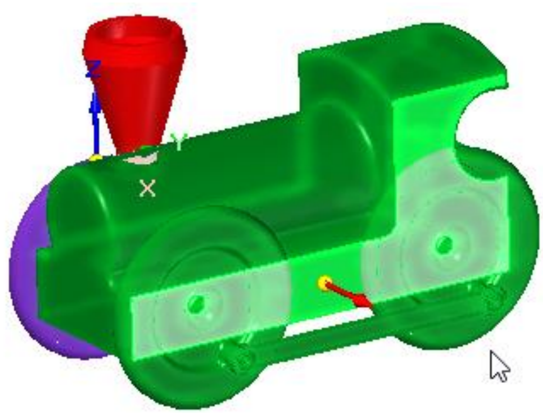
Zoom in so you can see the wheels of the engine. Select the Explode icon again. This time click on each wheel on one side along with the pegs, linkage arm and link pins. All should highlight.



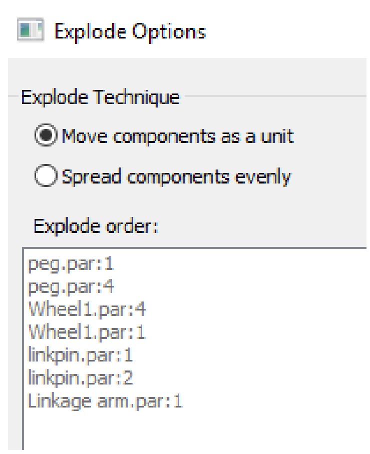
Accept the selection with the green check mark. Pick the engine body for the stationary part. Then select the side of the engine body to be the face from which to explode.



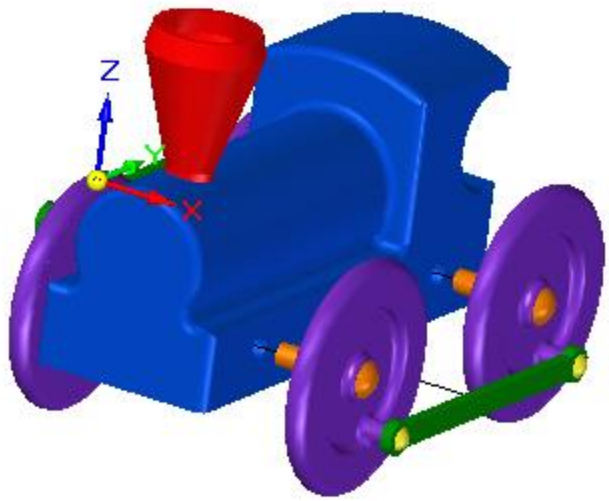
Click on the blank area to select the direction of the explosion.



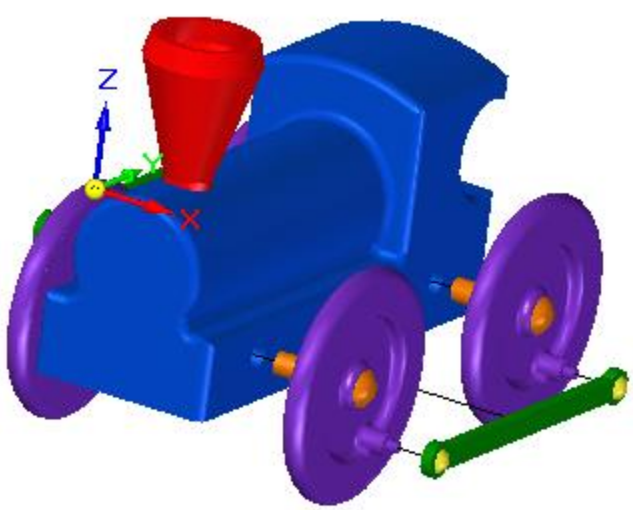
A dialog box will ask what to do with all the parts. Select Move components as a unit. Select OK.



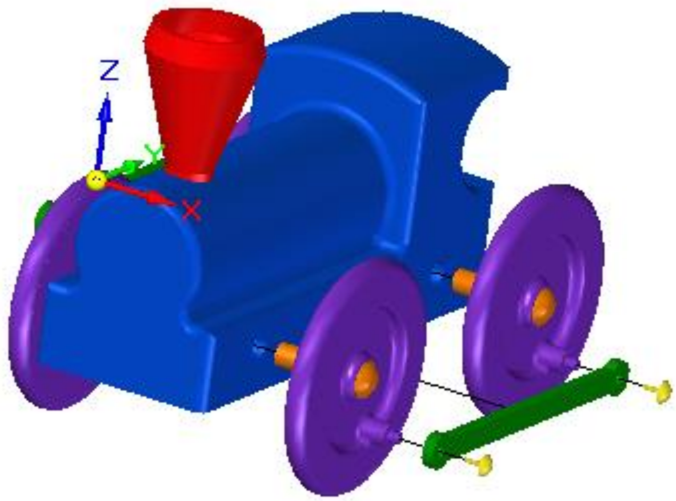
Enter 1 for the distance. Select Explode. Then select Finish.



Select cCancel to exit the command. Select Explode. This time select the Linkage Rod and Link pins. Follow the process and send them out from the face of the engine body 1.5

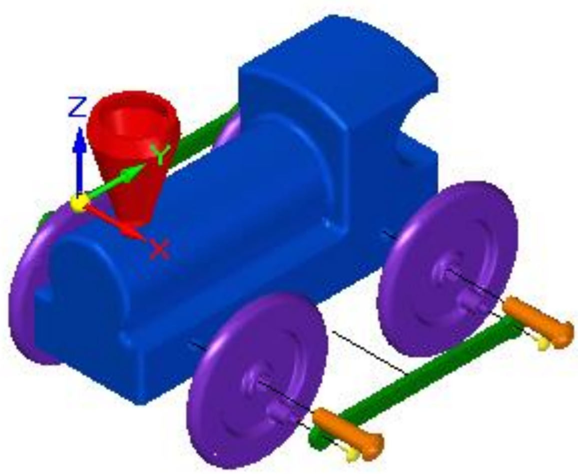


Select Finish and then cancel. Use the Explode command to move just the link pins. Set those 2.0 from the face of the engine.

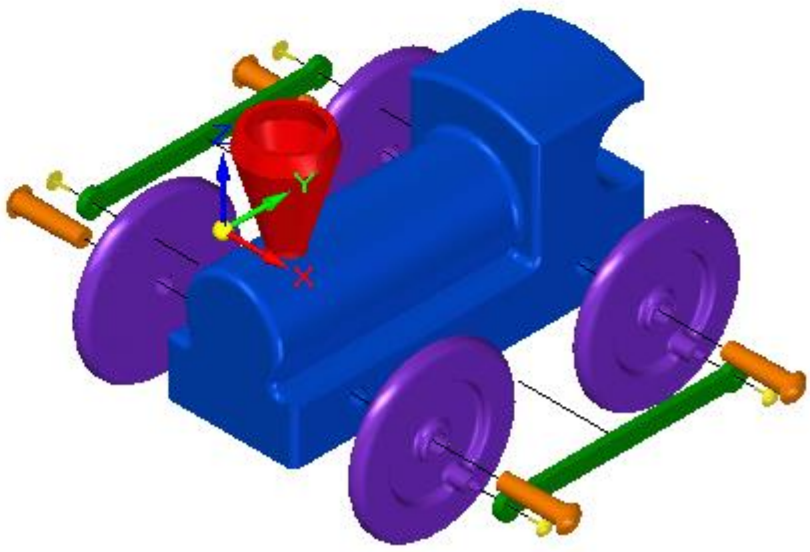


Select Finish and then Cancel.

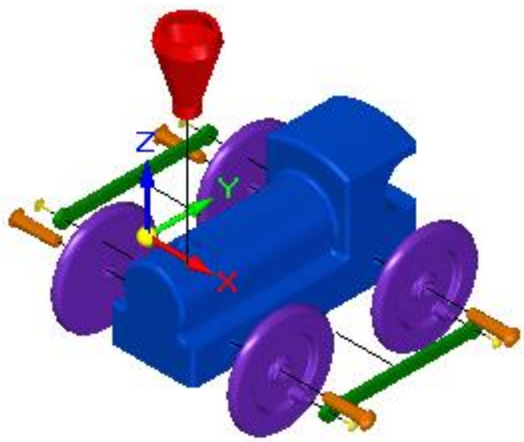
Select Explode and then select the Wheel Pegs. Move them 3” from the engine body.



Spin the assembly around and repeat the same process on the other side.

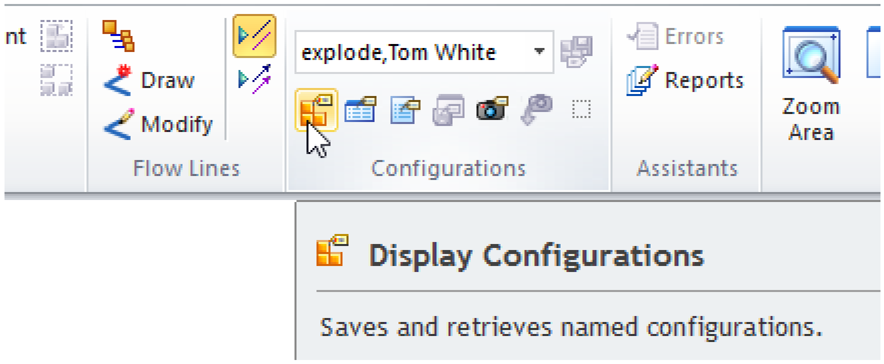


Now select the stack. Use the top face of the track as the face to control the Explode command. Use a distance of 10.

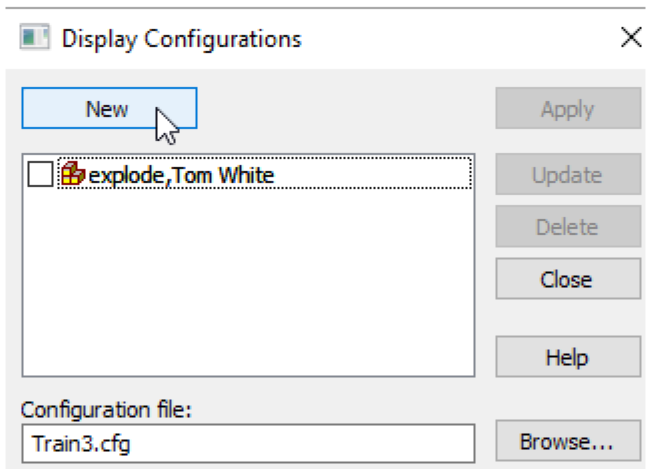


Now that the assembly is exploded save the configuration. This way it will be available for future use.

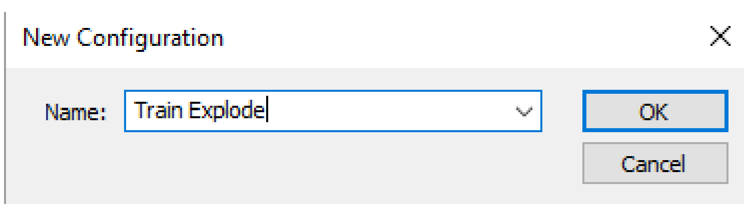
Select the Display Configuration icon from the ribbon.



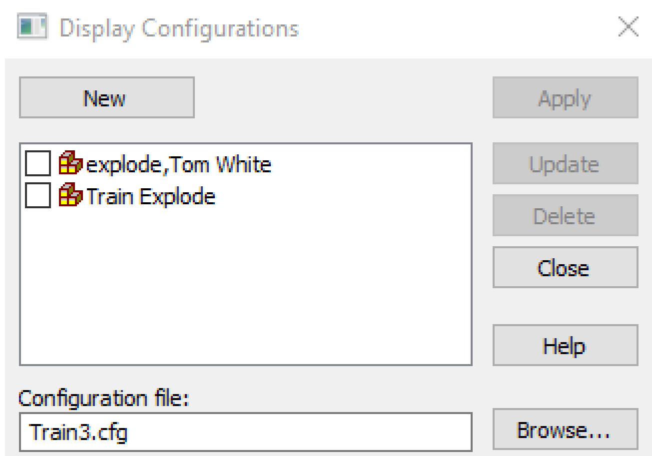
In the dialog box select New.



Type a unique name for the explosion.



Select OK. It will appear in the Display Configurations dialog box.



Select Close.

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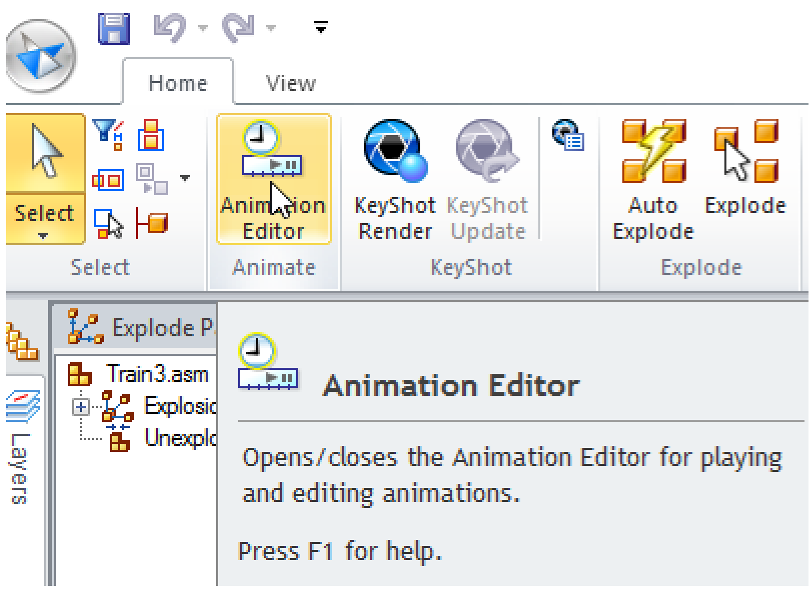
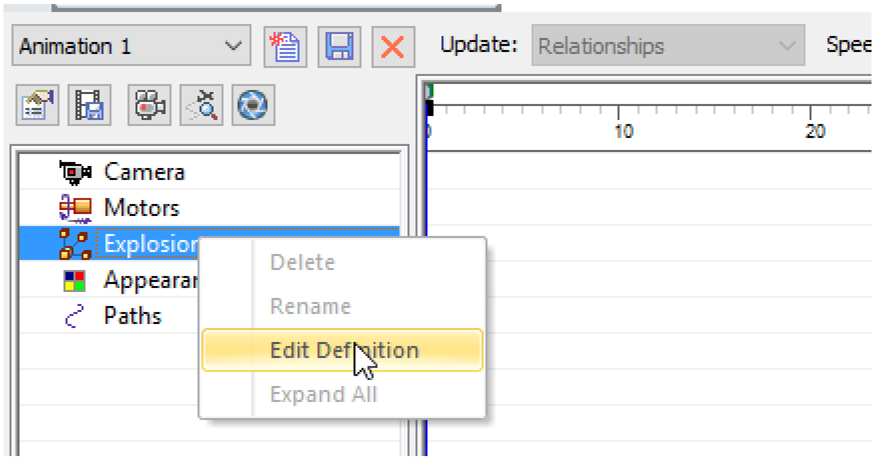
Animating the Explosion

Animation is a useful tool to display information to others. Select the icon for the Animation Editor from the Animate section of the ERA ribbon.

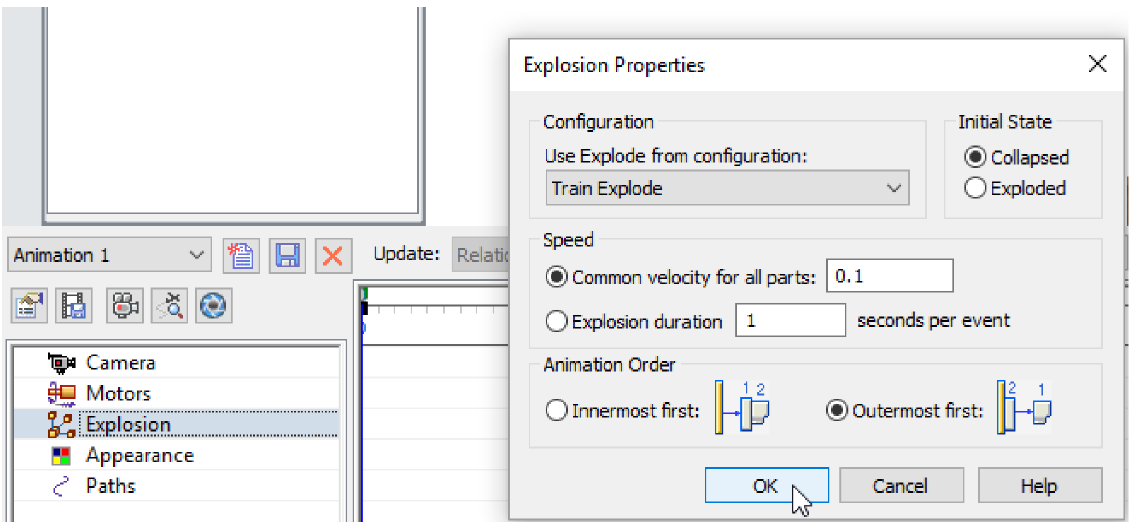


The Animation Editor appears on the screen. We will animate the explosion.

Right click on the Explosion in the path finder. Select Edit Definition.

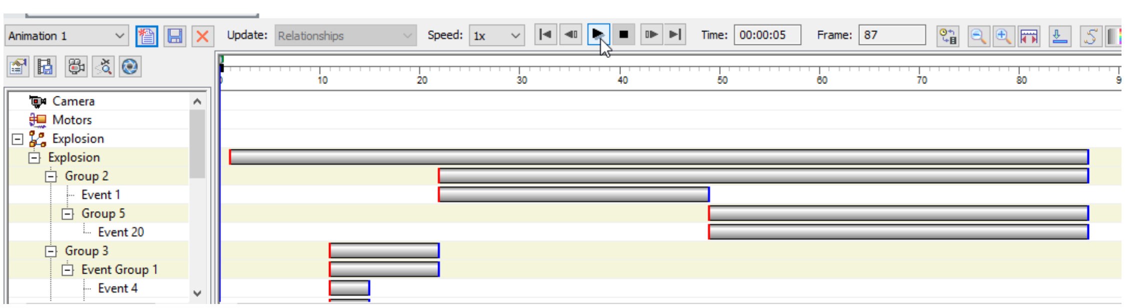


Select the name of the saved configuration. In this case we will watch the explosion happen from the assembly so set the initial state to Collapsed. Select the Outermost first.



Select OK.

In the Animation Editor select Play. Watch the explosion animation.



Close the ERA. Save the assembly.

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Exploded Views

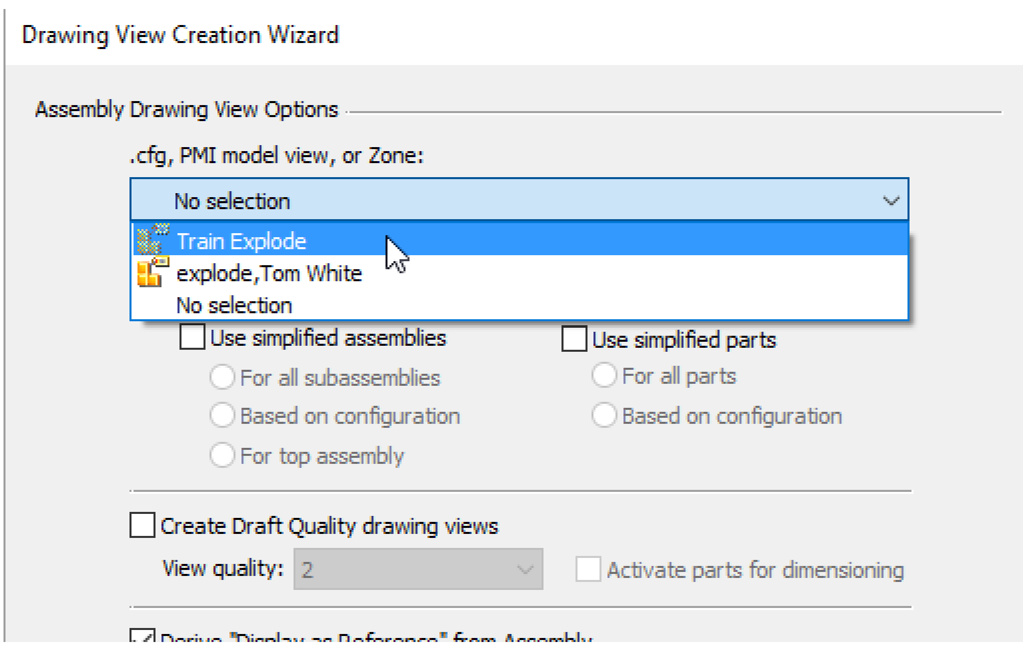
Exploded views are an important part of a set of working drawings. This drawing shows all the components that make up an assembly and how they go together. These drawings are also used in brochures showing all the parts in a parts list and the order in which they should be assembled.

Create a new sheet in your engine working drawings set. Apply the background you designed.

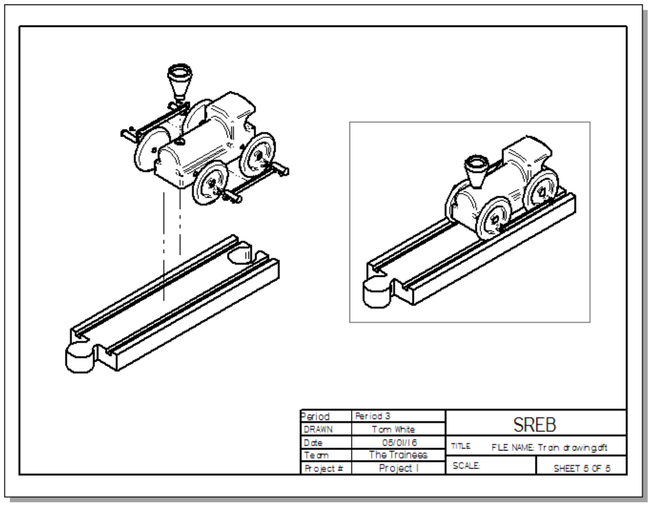
Drag a copy of your assembly from the library to the sheet.

Change the Scale to 1:4 and then select the Drawing View Creation wizard. This will allow us to configure how you want to see the assembly.

In the wizard click the down arrow next to the window that asks for .cfg, PMI model view, or Zone. Select the configuration saved when exploding the assembly.



Select OK at the bottom of the dialog box.


Period
Period 3
DRAWN
Tom White
Date
05/01/16
Team
The Trainees
Project #
Project 1
SREB
TITLE
FILE NAME: Train drawing.dft
SCALE:
SHEET 5 OF 5

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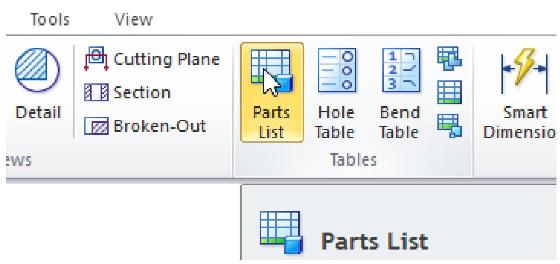
Bill of Materials/Parts List

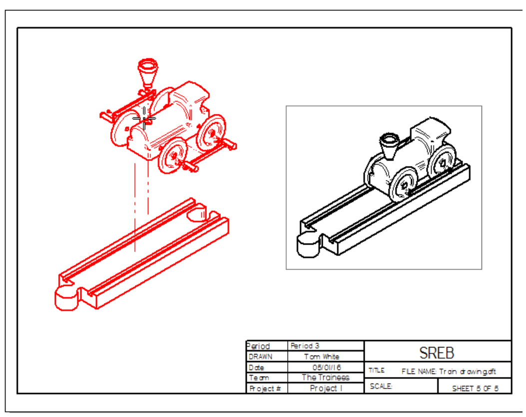
People will look at a drawing and can identify the component they are looking for. They might need to know what the name of the part is or what the material is. The bill of materials allows the user to access data that you determine necessary.

Select Parts List from the tables section of the home ribbon.

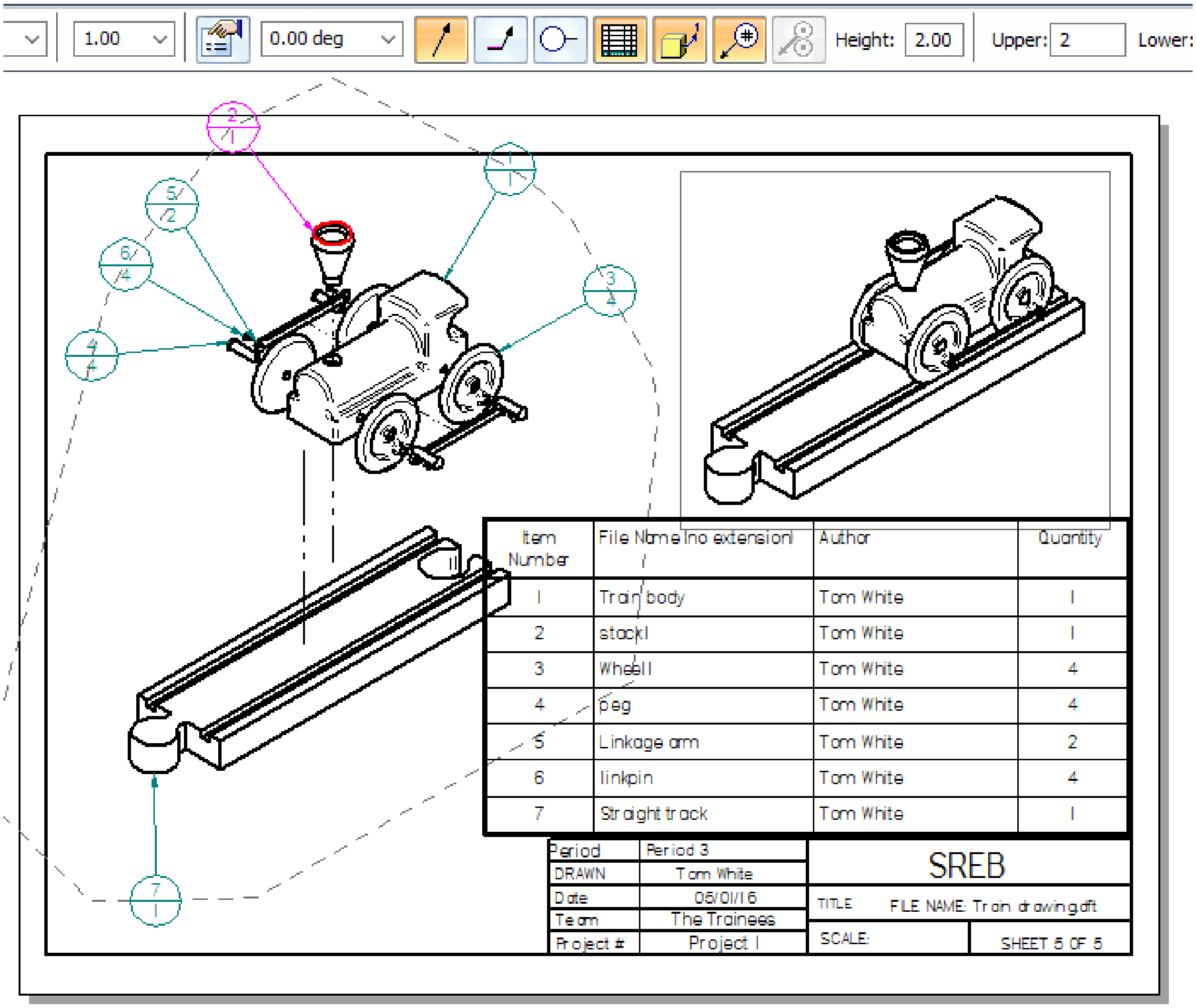


This will create the table from the components in the assembly and apply a balloon to the pieces for easy identification.

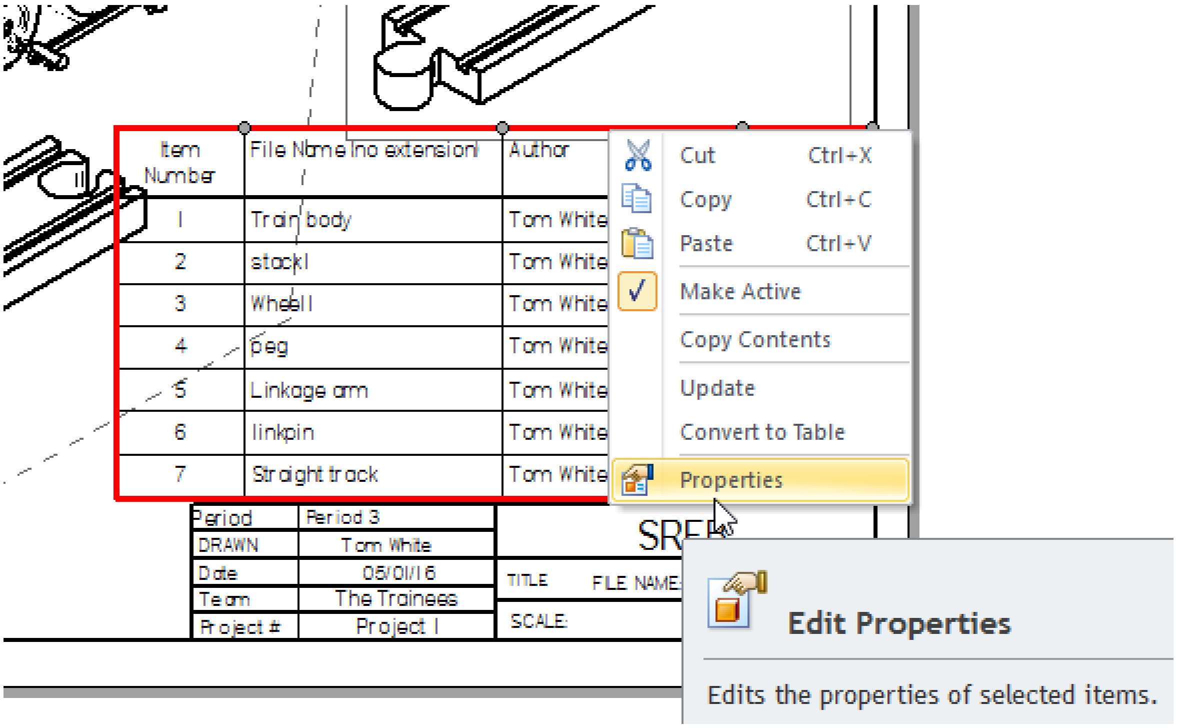
Click on the Drawing View you would like to use.



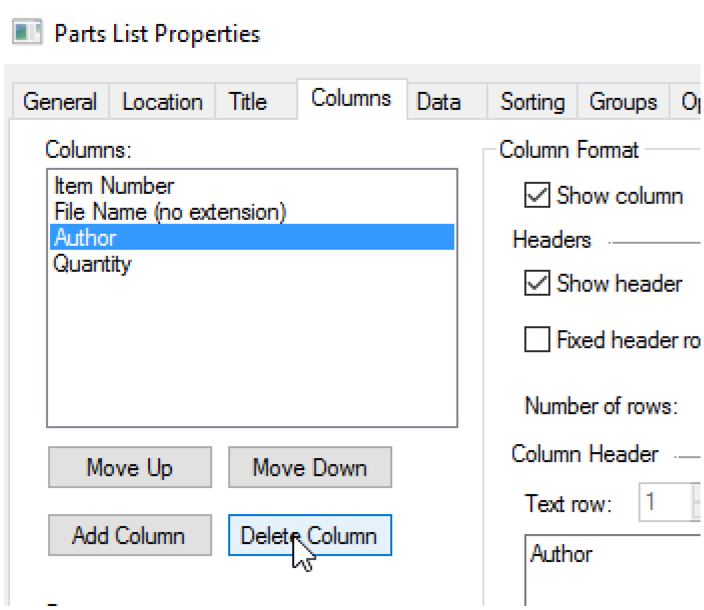
The list will appear as a square. Move the square to an open space on the drawing view.


1.00
0.00 deg
Height: 2.00
Upper: 2
Lower:
Item Number
File Name (no extension)
Author
Quantity
1 Train body Tom White 1
2 stack1 Tom White 1
3 Wheel1 Tom White 4
4 peg Tom White 4
5 Linkage arm Tom White 2
6 linkpin Tom White 4
7 Straight track Tom White 1
Period
Period 3
DRAWN
Tom White
Date
05/01/16
Team
The Trainees
Project #
Project 1
SREB
TITLE
FILE NAME: Train drawing.dft
SCALE:
SHEET 5 OF 5

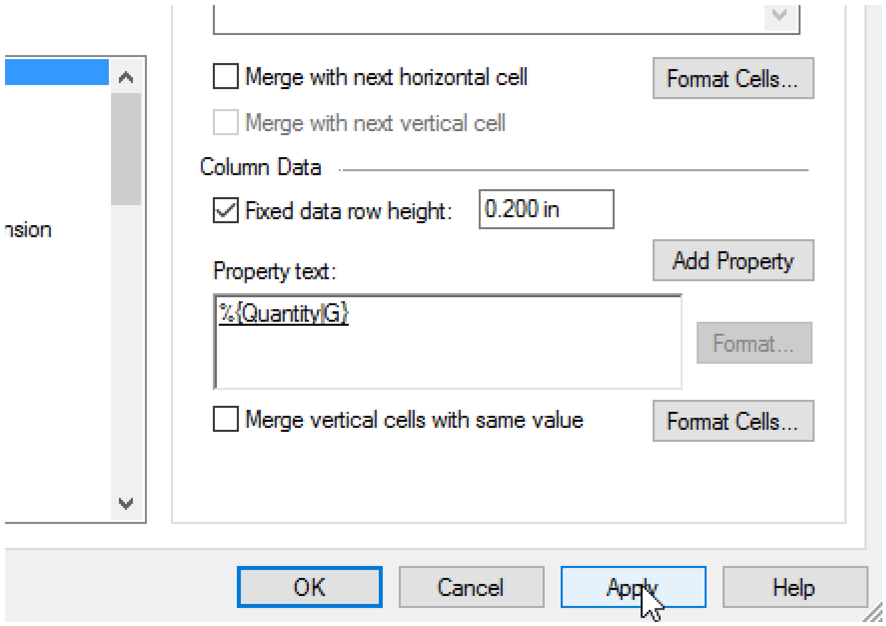
Things are having trouble fitting on the page. Left click on the table to highlight it. Right click on the border and select properties.



In the dialog box select the tab for columns. Since we do not need to see the author displayed remove it from the columns by highlighting it and selecting delete column.

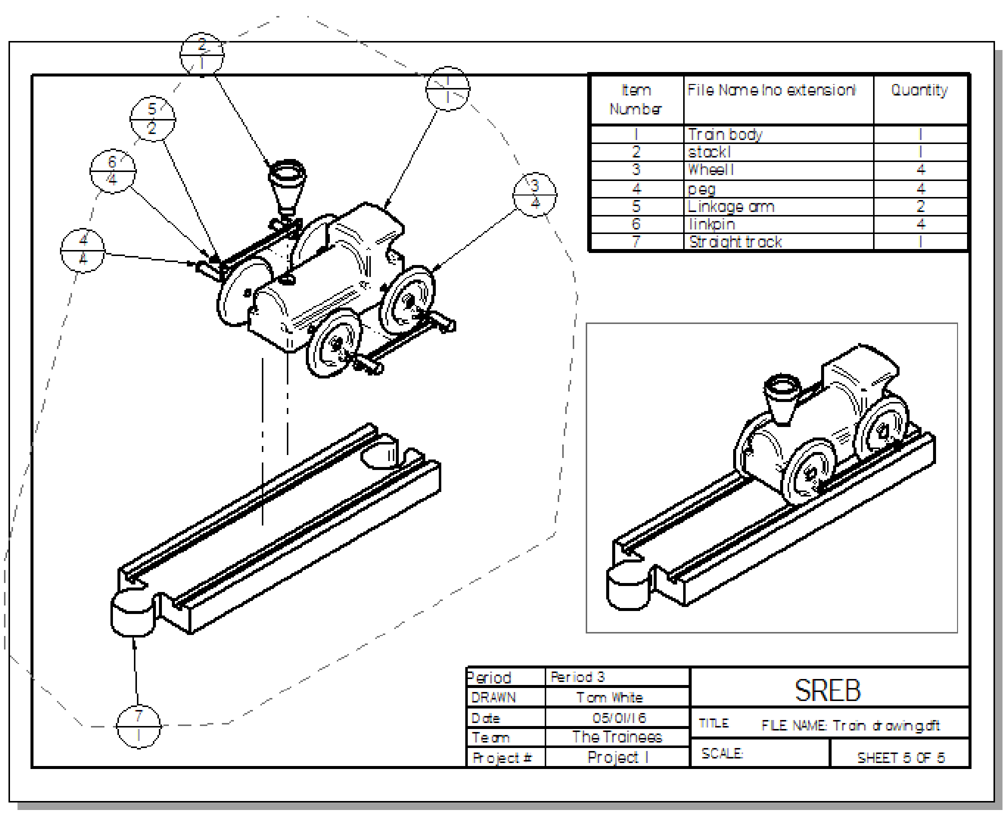


In the lower left hand corner of the columns tab find a section for column data. Place a check in the Fixed data row height and set the value to .200.

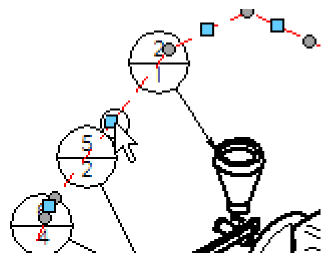


Select Apply.

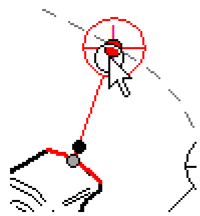
Move the table to a location where it is out of the way.



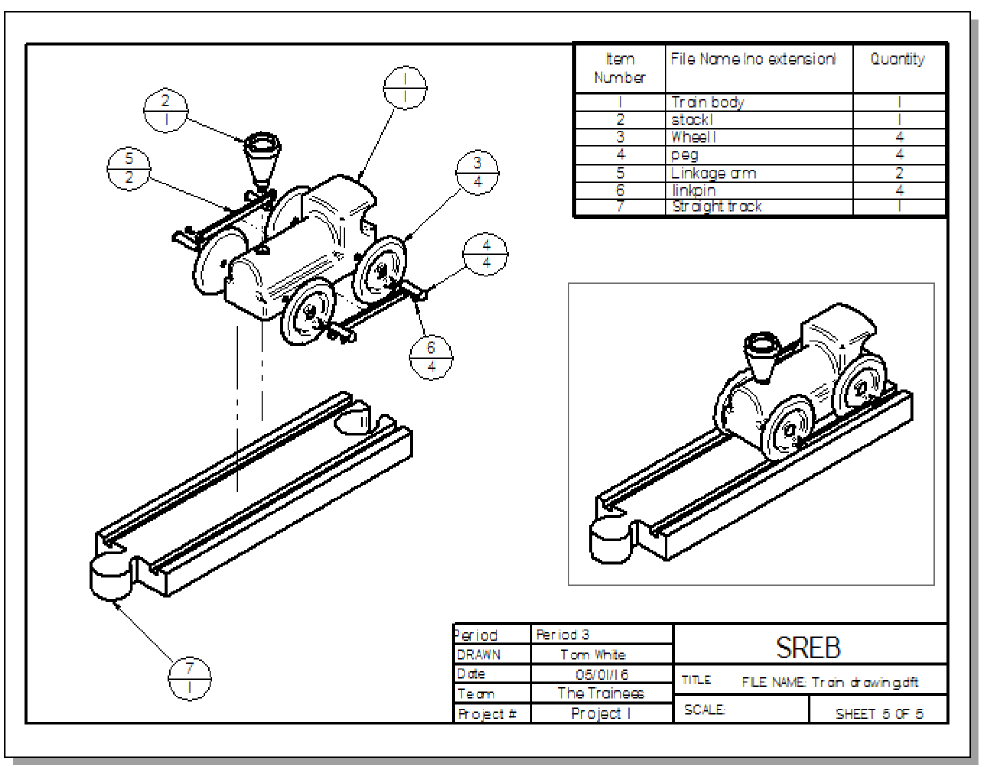
As shown, some of the balloons are not in the paper space. There is a dotted line that controls where the balloons appear. Click on the dotted line and you will observe blue grip points. Clicking on a blue dot will allow you to reset the position of the dotted line.



Clicking on the center of a balloon will allow you to drag just the one balloon along the dotted line.



Move things around the drawing to make them easy to read. Save your work.



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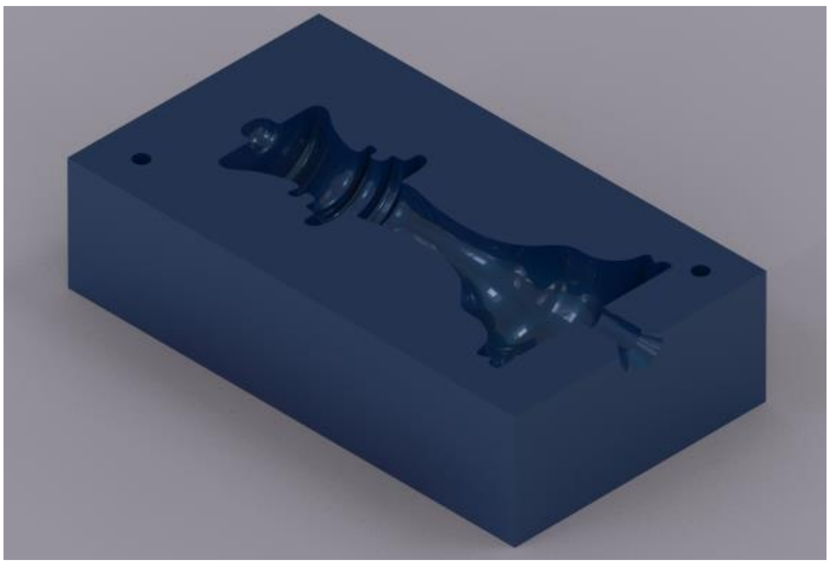
Working with Bodies

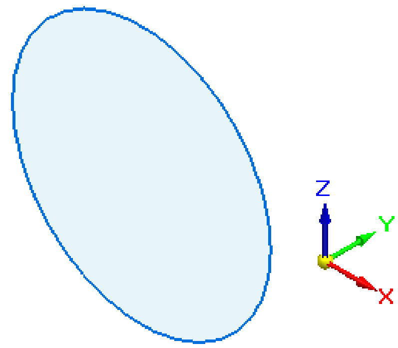


A normal part file only contains a single solid body. Most of the time if you want multiple parts an assembly is used. There are times when a second body is used to make changes to a part. For example, if you wanted to create a solid with a particular shape removed, the second part would be added to the file and then a Boolean function would be used to remove it. You will see this in molds for example. The same idea holds true if you had an existing part and wanted to add features from another part. If you had an existing part design and wanted to add a base from a Lego™ block, the part could then be utilized to connect different building sets.

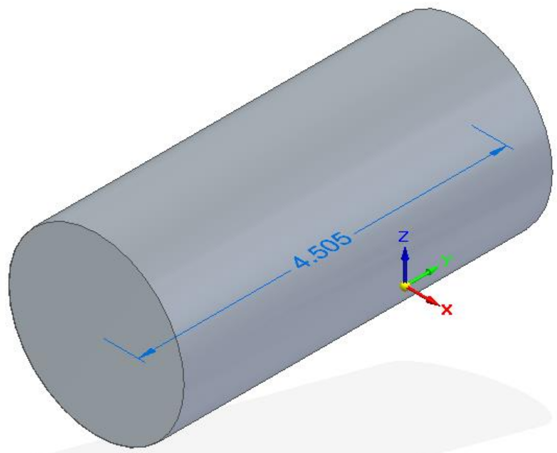
There are some basic skill sets that make this process easier. This exercise is designed to introduce some of the ways bodies can be utilized. The Path Finder is indispensable for following what is going on with your various drawings.

Begin a new part file. This is an exercise where the size and positioning of the shapes is not important.

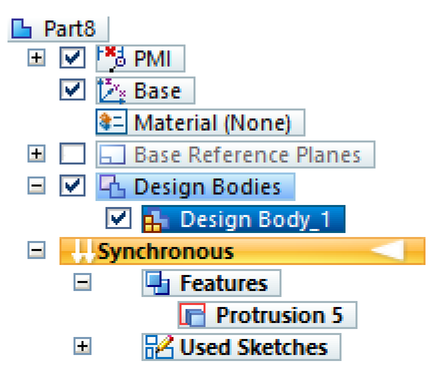
Draw a circle on the XZ plane



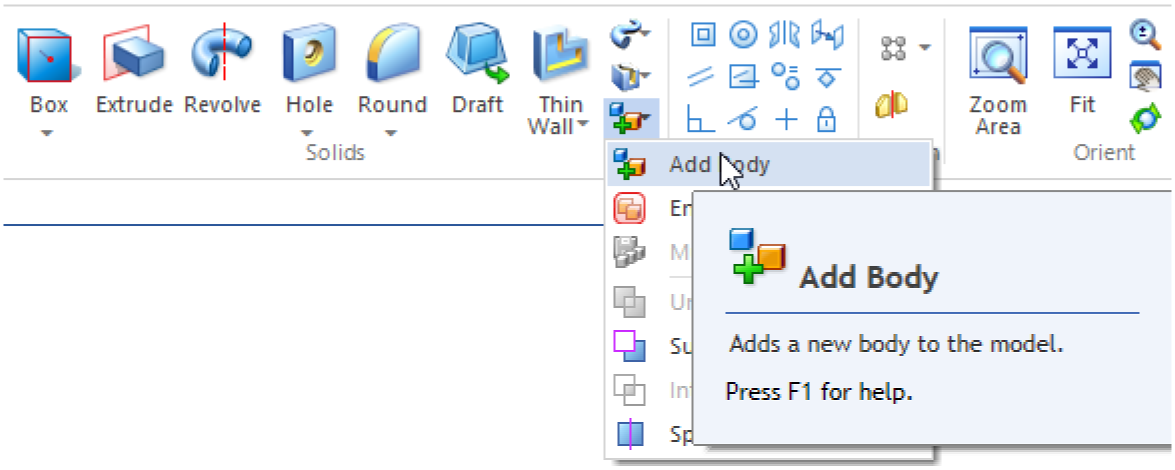
Extrude the circle into a cylinder.



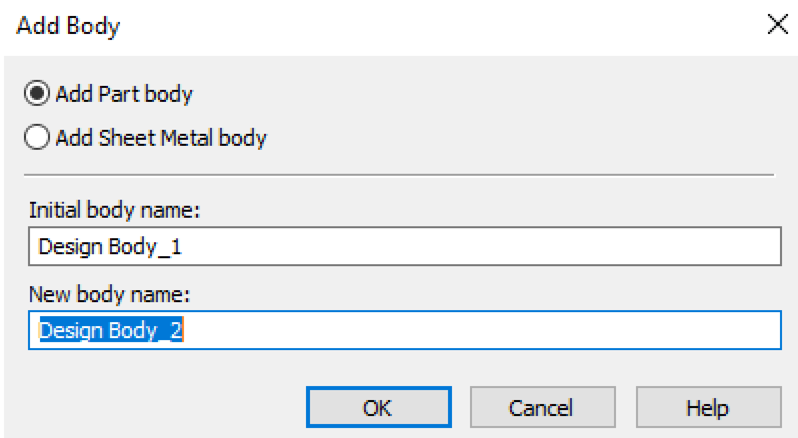
Check in the Path Finder. Under Design Bodies there will be a listing for Design Body_1. This is a default name for the first body in a part.



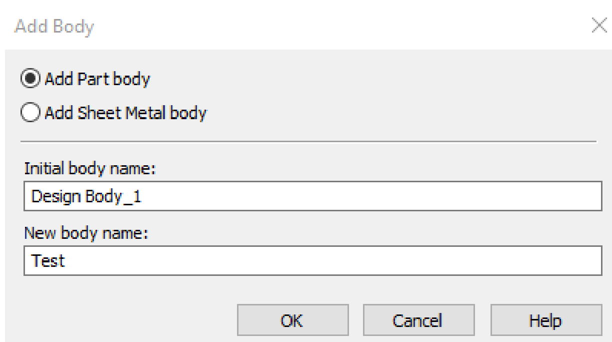
On the Home ribbon, in the solids section, select the Add Body command from the Bodies menu.



The dialog box opens and the new body name has the name of Design Body_2.



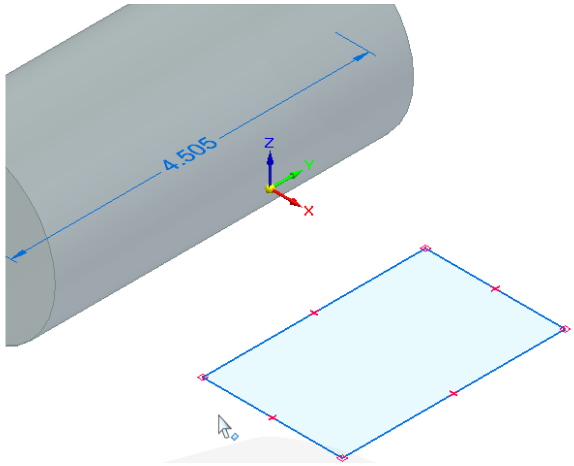
Rename the design body if you wish. In this example it is renamed Test.



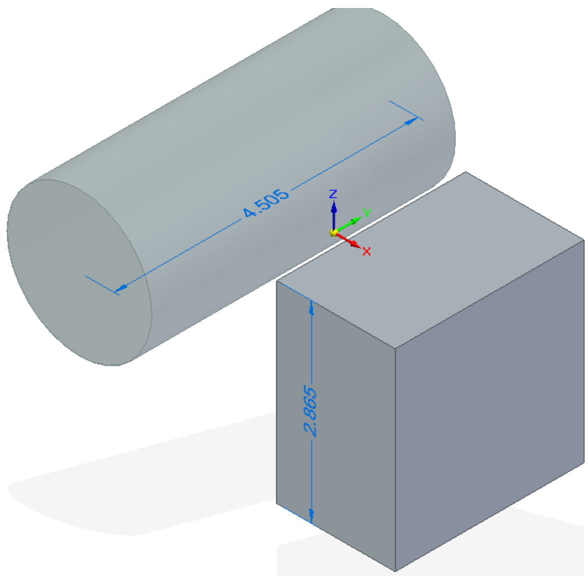
Select OK.

Nothing appears to happen but anything drawn now becomes part of the new design body.

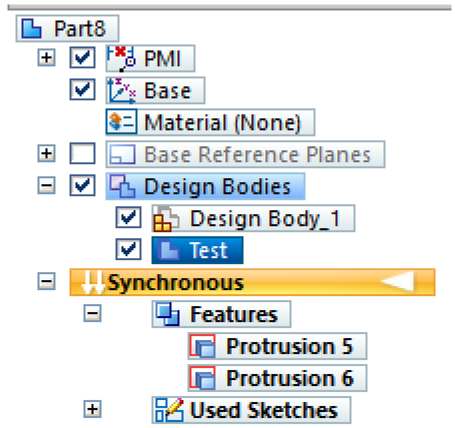
After selecting the Add Body command draw a rectangle on the XY plane.



Extrude the rectangle.



Checking the Path Finder reveals the second design body has been added using the name assigned.



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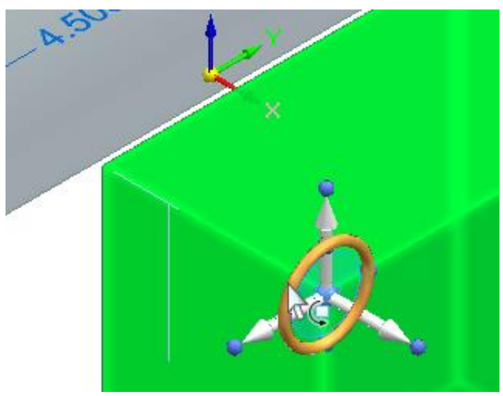
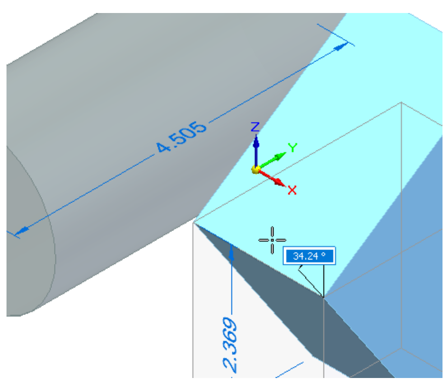
Moving Parts

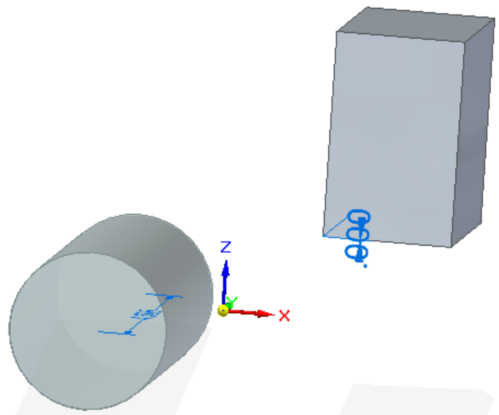
By highlighting one of the design bodies in the Path Finder, the part will highlight the Design Intent window and the steering wheel appears on the part. Uncheck everything on the Design Intent. We can now move and reposition the parts. Select the steering wheel similar to the picture below.



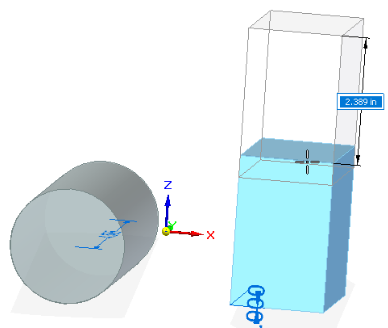
This will allow rotation of the part in relationship to the other part.



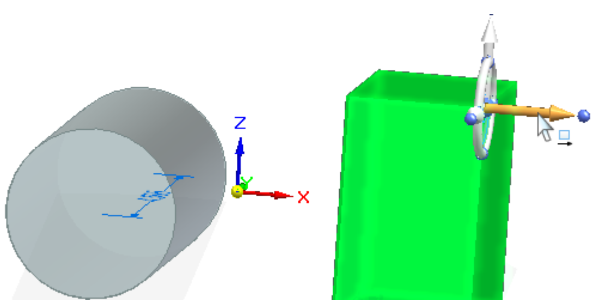
Enter 90 which will rotate the part counter-clockwise 90 degrees.



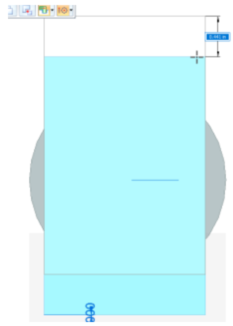
Highlight the part in the Path Finder. Click the X, Y, or Z arrow to select the desired direction. Drag the arrow to move the part to a new location in reference to the other part. The goal in this example is to place one part inside the other.



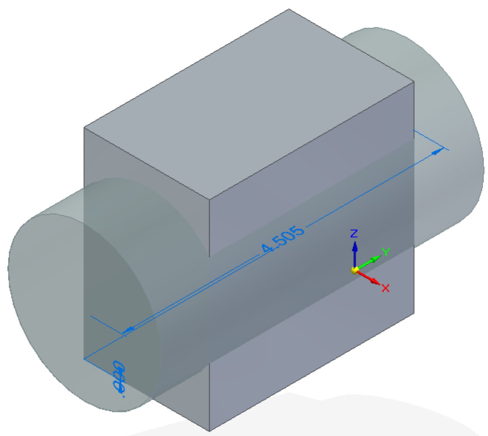
Moving with or against the arrow will take the body different directions. Entering Distances will allow the objects to move a specific amount.



Center the cylinder in the rectangular prism.



Your screen should resemble the one below.



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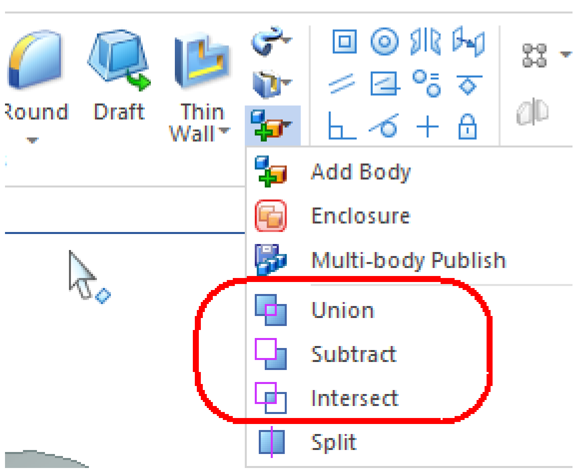
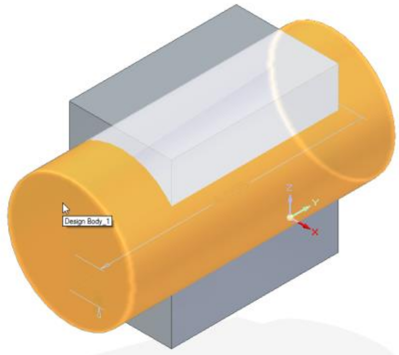
Boolean Operations

There are three main Boolean operations available; Union, Subtract and Intersect.



This section of the exercise will show how the functions work.

Select Union first. Highlight one of the bodies. The target is the first one you select and the one you want the changes to show.

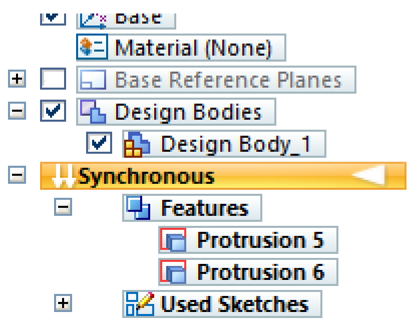


Right click to accept your choice.

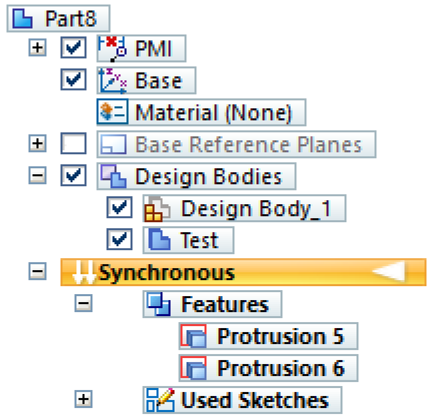
Now select the other part. This is known as the tool.

The green check shows up. Check the green check box.

Checking the path finder will show that the two parts have been combined into one.

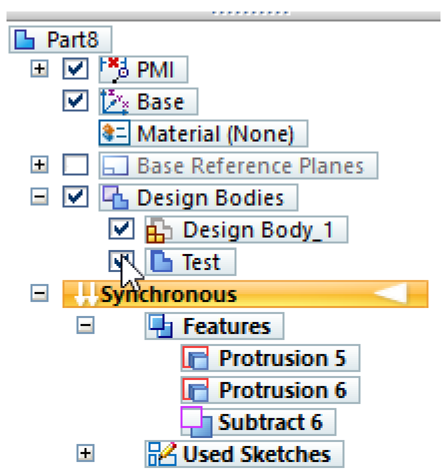


Undo the previous step and you should see the two design bodies again.

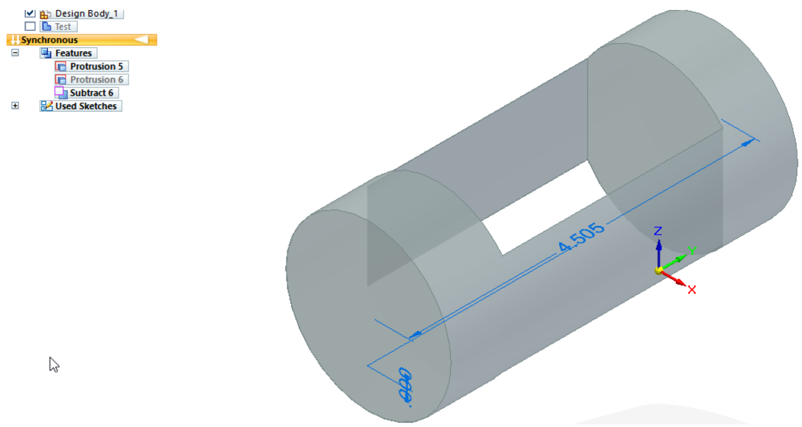


Now select Subtract from the options on the bodies pull down menu. Select the cylinder as the target body. Right click to accept. Then select the rectangular prism as the tool body. Check the green check mark on the subtract tool.

Go to the Path Finder and uncheck the box for Test which was the name of the part we used as the tool body.

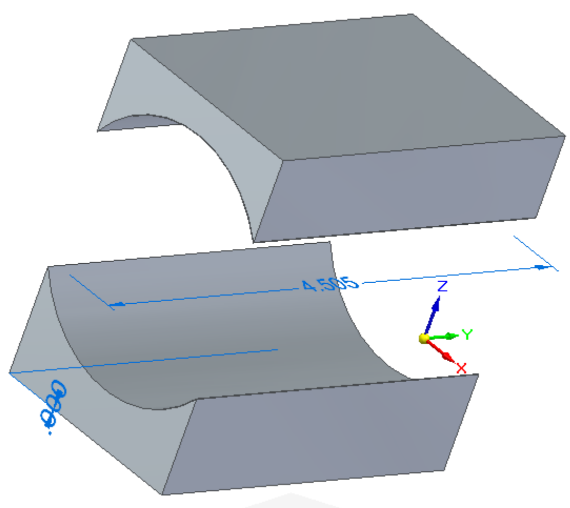


You can then see the results of the subtraction.



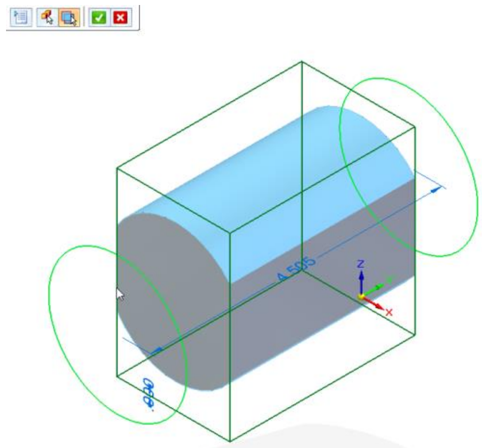
Undo the action. Recheck the second design body so they both show. Now do the subtraction, selecting the parts in a different order. Select the rectangular prism as the target body and the cylinder as the tool. When you are done uncheck the first design body. Yours should look similar to the picture below.

You will see the cylinder has cut the rectangular prism.



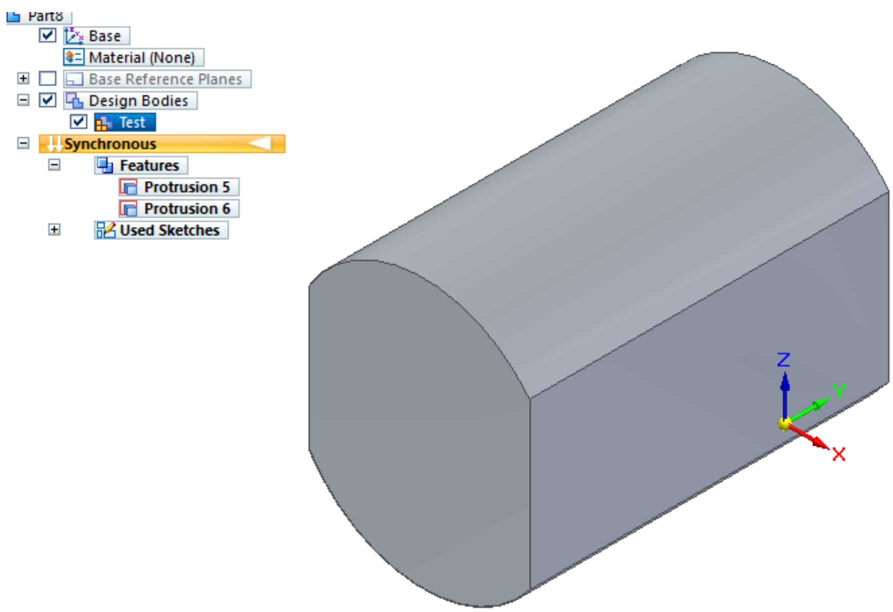
Undo this command

Select the Intersect Boolean tool from the Bodies menu. Highlight one of the shapes. Right click and then highlight the other shape.



Select the green check box.

You will see the results and the design body will be named the first one selected.



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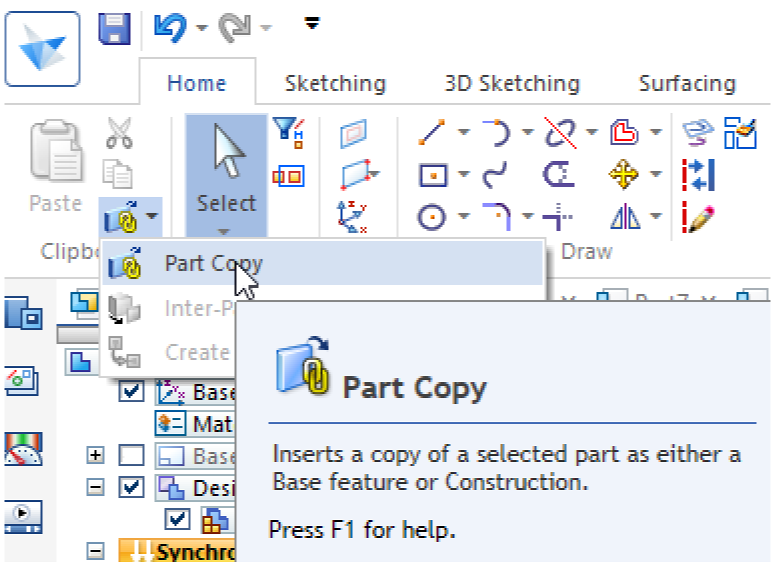
Creating a Two Part Mold

We can use the body tools to create a complex mold from a selected part. In this case we will be using a chess piece created in an earlier project.

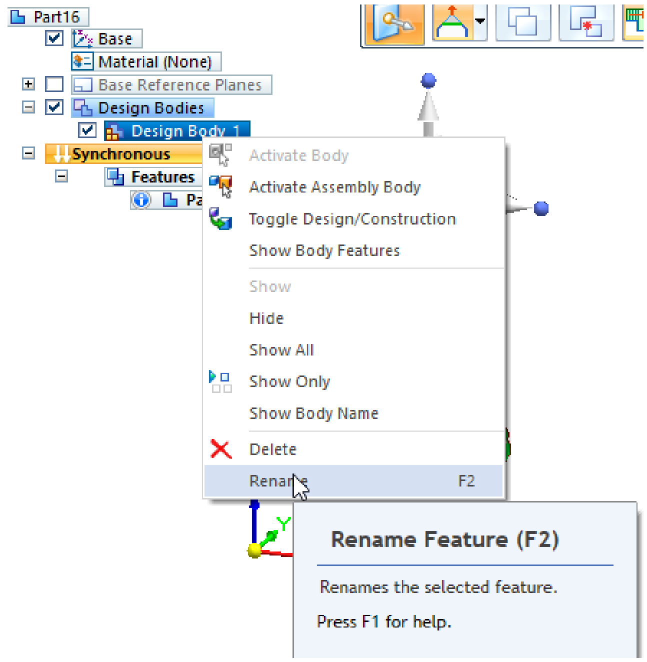
Begin a new part file.

On the home ribbon select the Part Copy command from the clipboard. At the Browse window navigate to the directory where your chess piece is saved. It will appear on the screen.

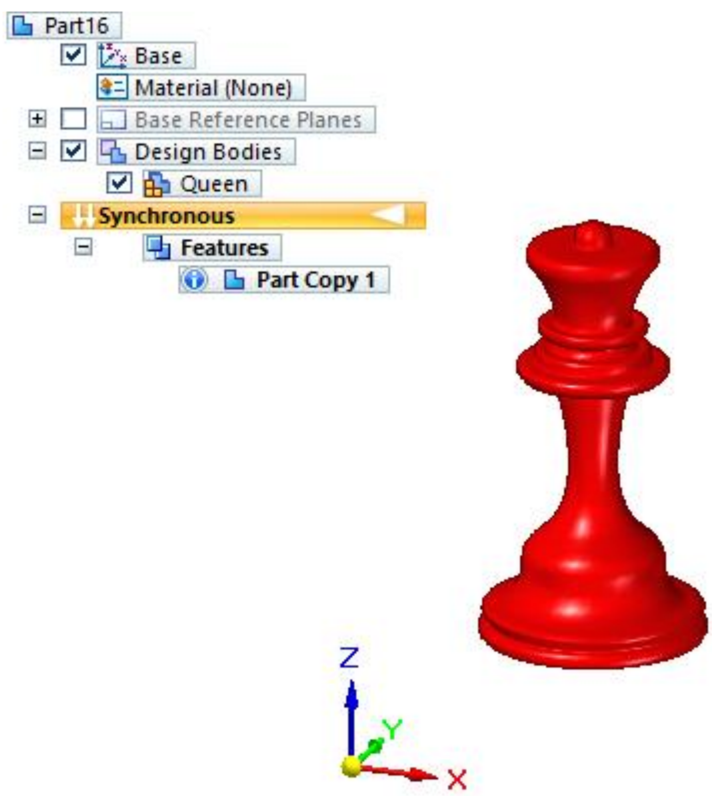


Select finish.

The chess piece appears on the screen and the Path Finder shows a design Body. If you right click on this you can select the option to rename the design body.

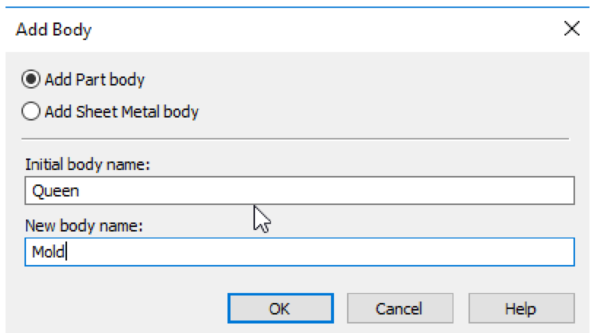


This will be easier to see and find later.

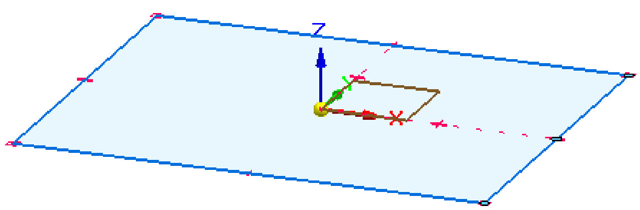


From the bodies menu in the solids section select add body.

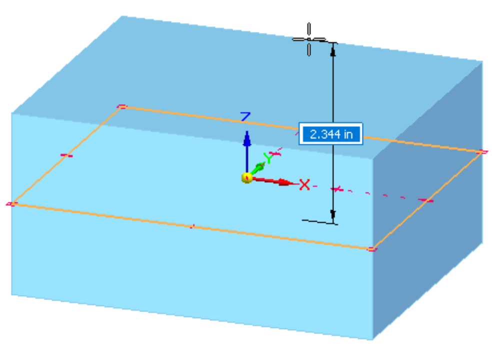
Give the new body a name. In this example Mold is used.



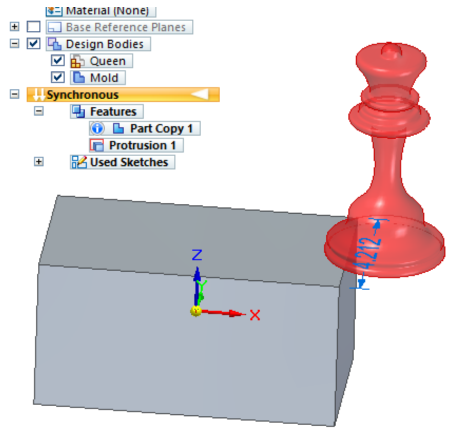
Draw a rectangle whose center is at the origin in the XY plane.



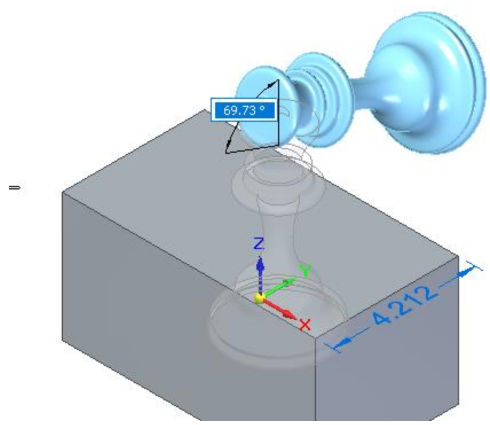
Extrude the rectangle symmetrically so the middle of the plane is on the XY plane.



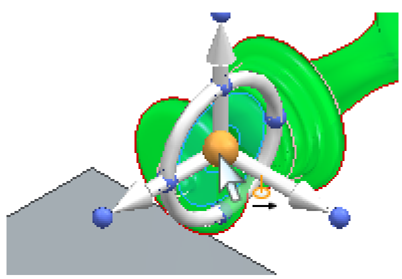
The queen and mold are now in the Path Finder.



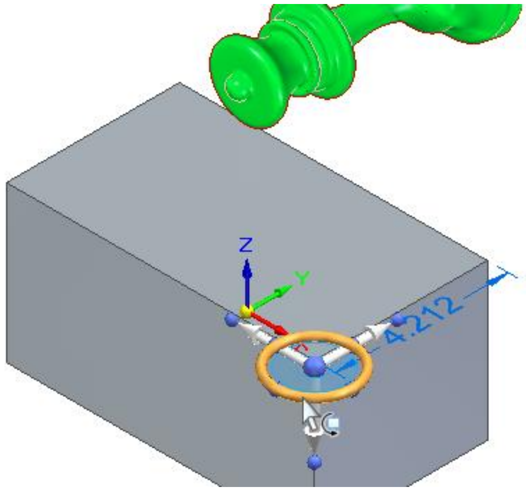
We can change the orientation and move the part to the middle of your block. Highlight the queen in the Path Finder and use the steering wheel torus and arrows to move the queen into the block. By selecting the torus on the steering wheel we can change the angular position of the piece.



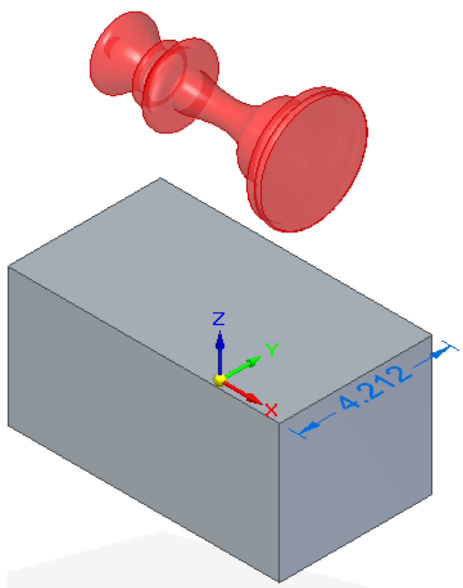
By clicking on the ball in the center of the wheel, you can control the orientation of the steering wheel by selecting other geometry.



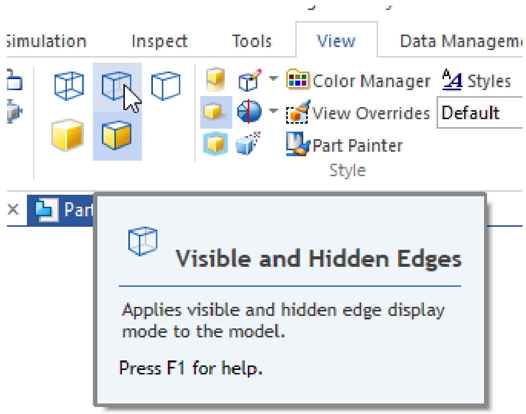
In this example a vertical line on the mold is chosen to position the steering wheel.



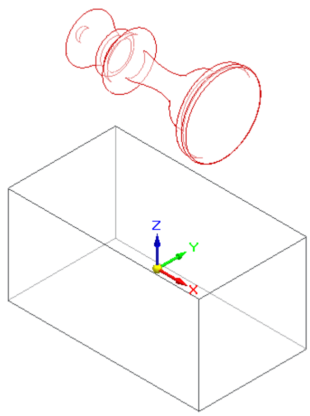
We can then use the steering wheel torus to reorient the chess piece to the mold.



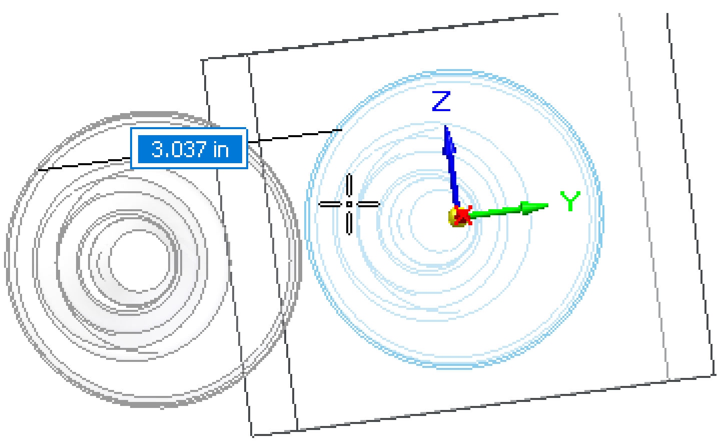
It is now possible to move your piece to the center of the mold. It may be necessary to adjust what shows on the screen to see what you are doing. Go to the View tab and select Visible and Hidden Edges.



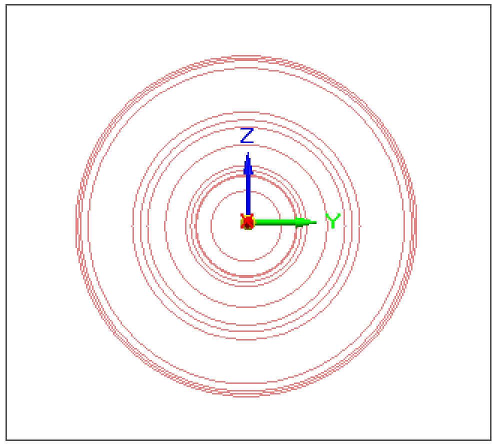
While not perfect, this might be easier.



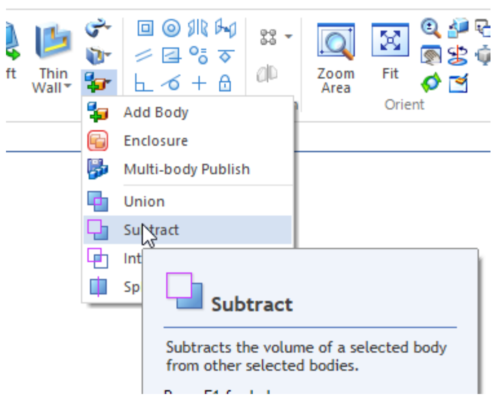
You will have to change views several times to see what is happening.



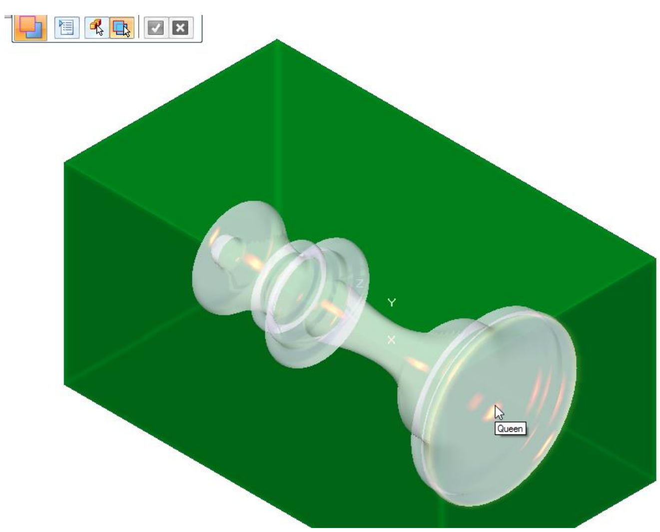
Spend time until the Queen is centered in the mold.



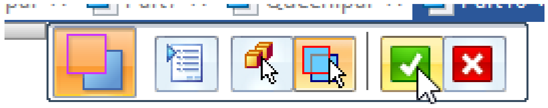
From the Bodies menu select Subtract for the Boolean option.



Select the mold for the target body. Right click and then select the queen for the tool.



Click the green check to accept.



Since we drew the mold block right on the origin we can use the origin plane to split the part.

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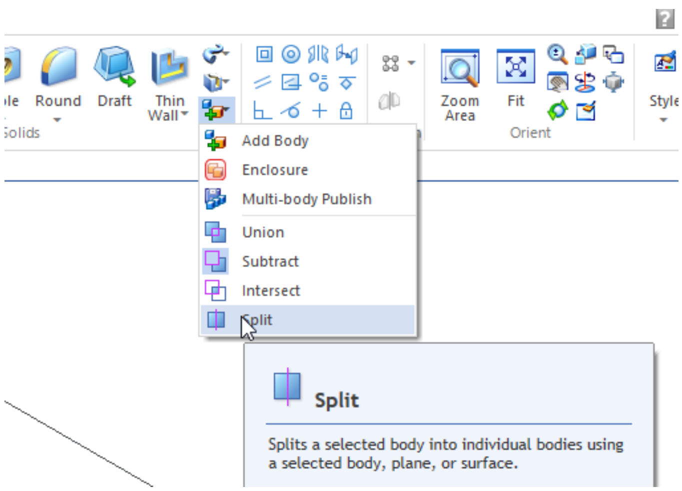
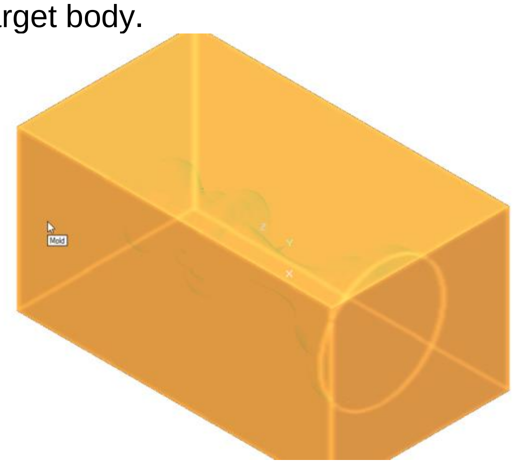
Splitting the Part

Select split from the bodies menu.

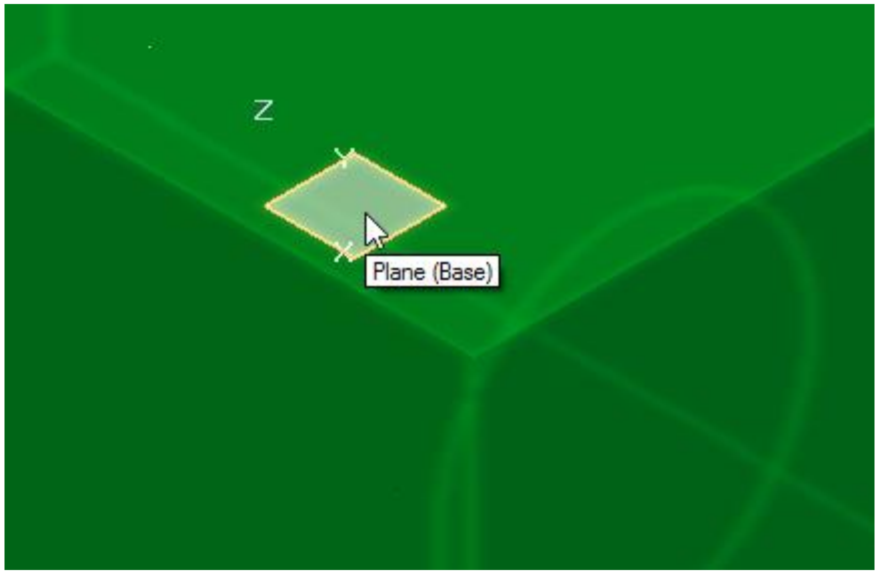


Select the mold for the target body.

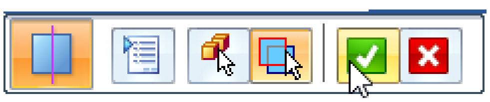


Right click to accept.

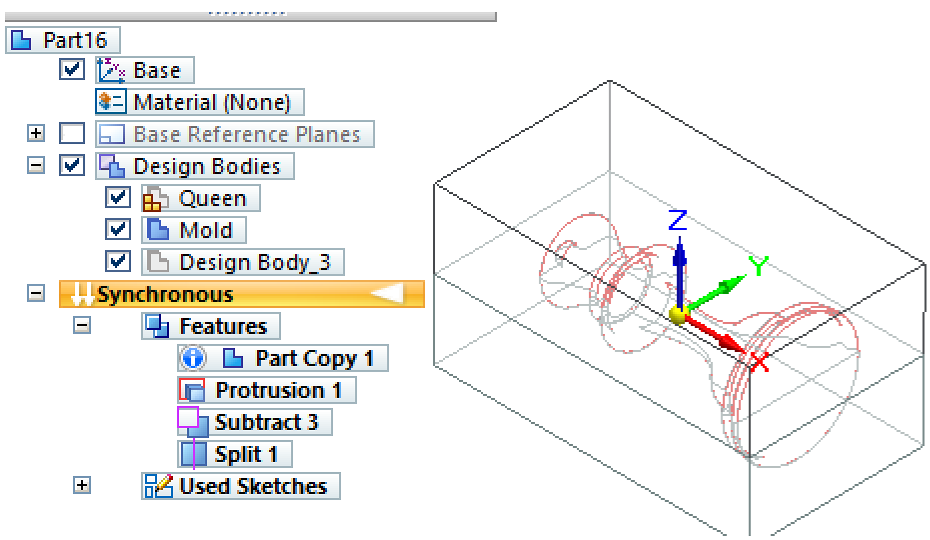
For the tool move the cursor to the origin and select the XY plane.



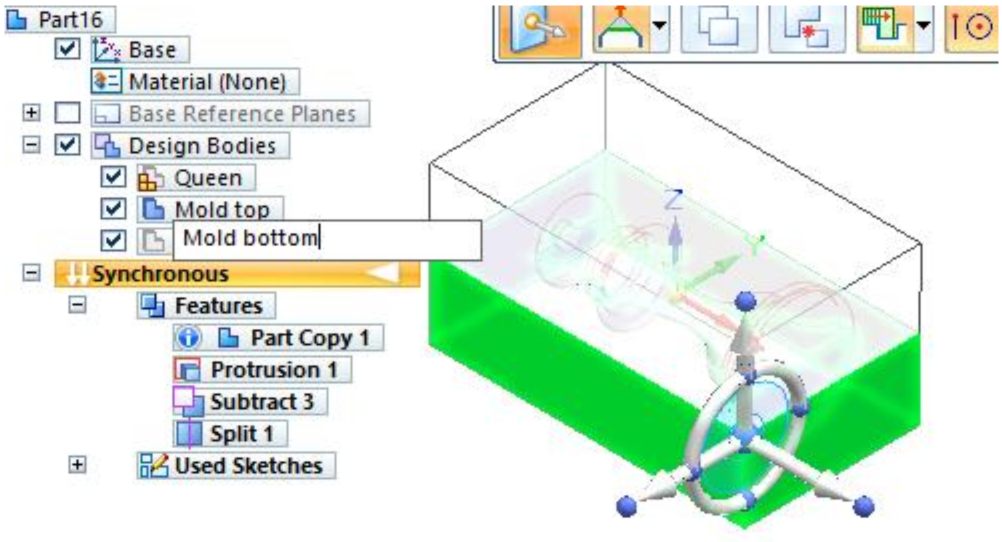
Select the green checkmark.



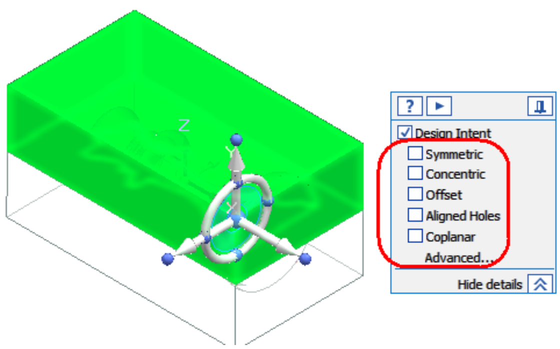
There should be a line around the mold and an additional entity in the Path Finder.



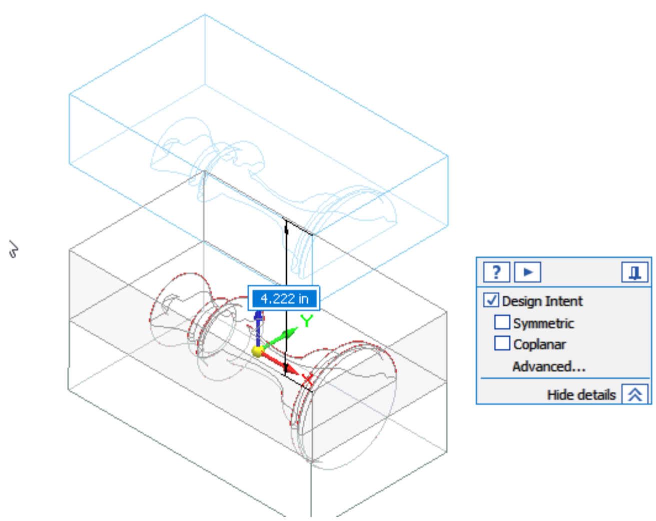
Rename the mold pieces to Mold top and Mold bottom.



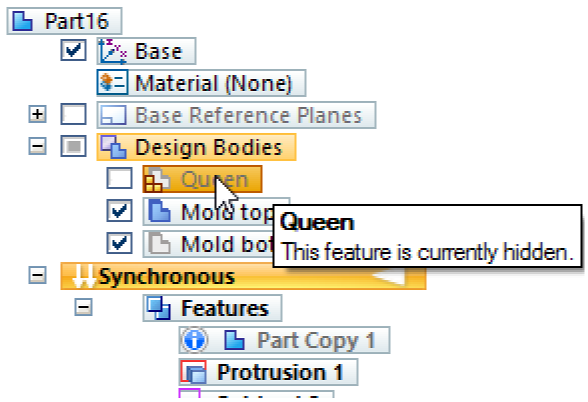
Highlight the mold top in the Path Finder. You will see the Design Intent appear. Uncheck the boxes.



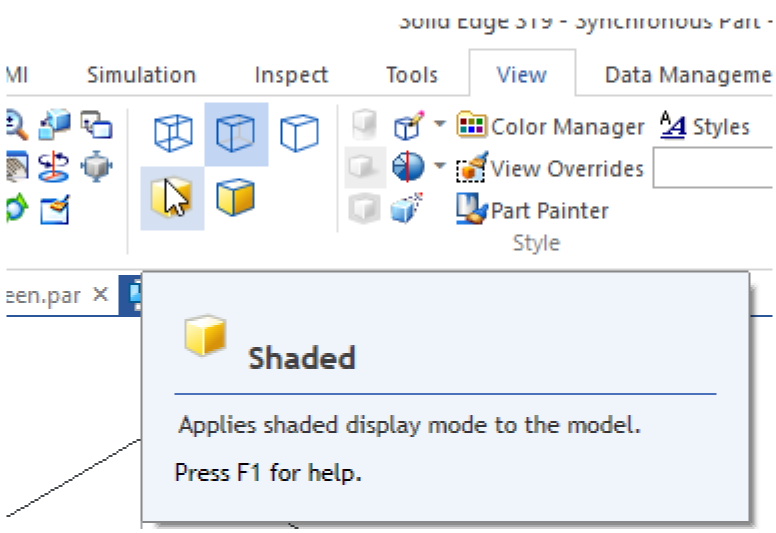
Grab the upper arrow and move the top of the mold in the upper direction.

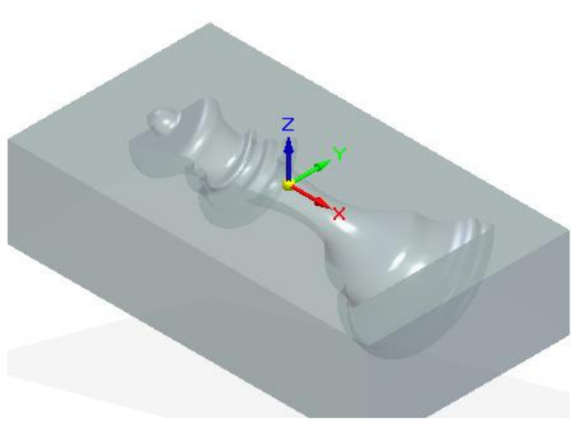


Uncheck the queen in the path finder.

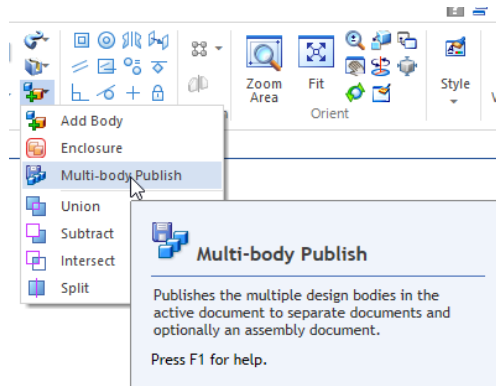


Return to the view tab and change the view back to shaded.

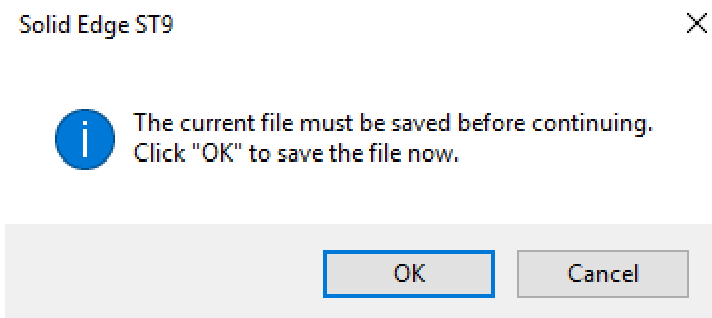




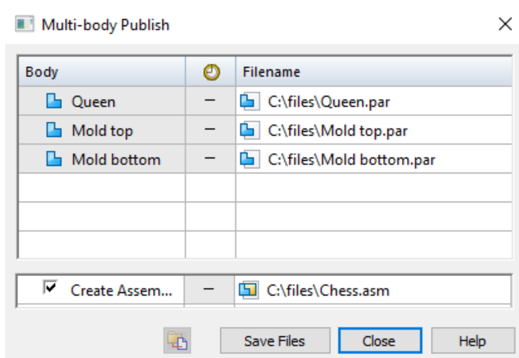
From the Bodies pull down menu, select the option for Multi-body Publish. This will save the mold pieces separately so they can be used in assemblies.



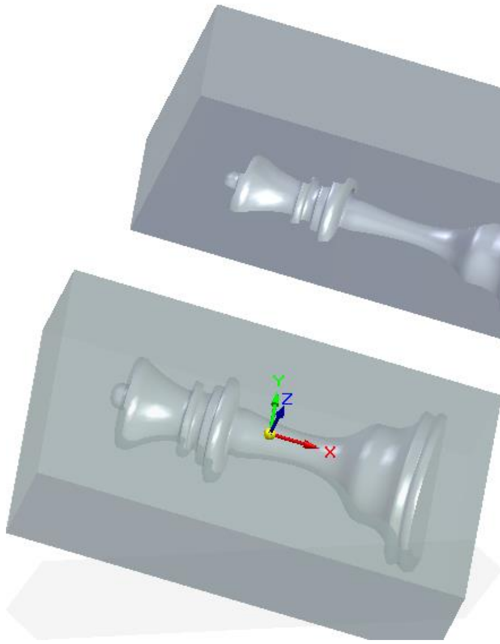
If you haven't saved the part yet you will see a warning. Select OK.



This will bring up the dialog box. Select where to save the files.



Select the save files button. Select close.



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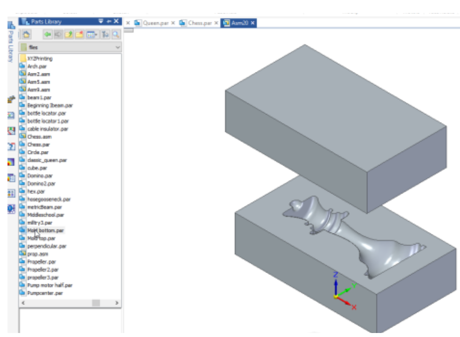
Finishing the Mold

Begin a new assembly.

From the Library, pull your mold top and mold bottom to the screen.

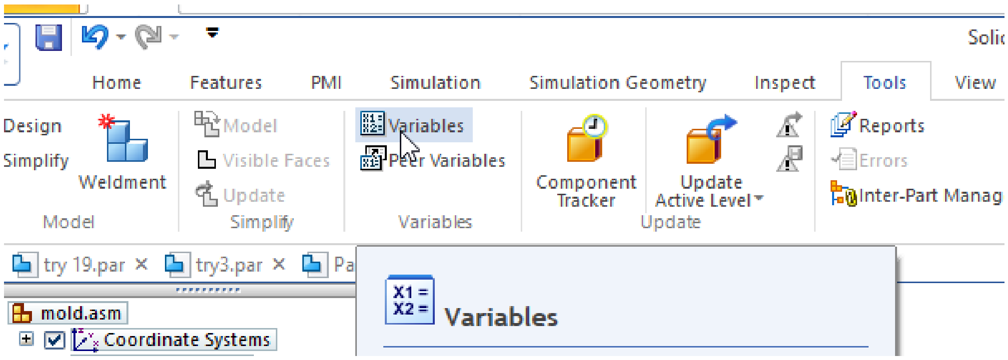


Back

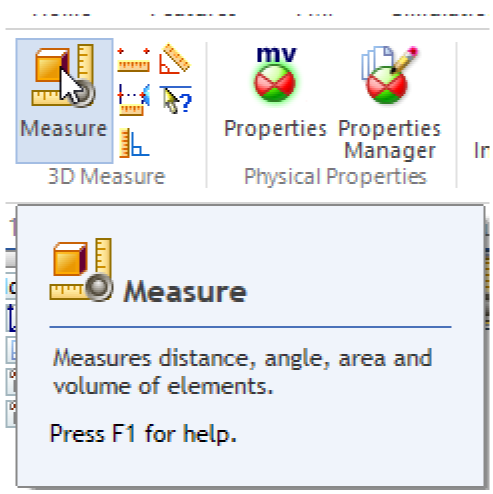
Using the Inspect Tools

You will need to know some basic information about the parts.

From the Tools menu select the Variables command. Leave the Variables window open.

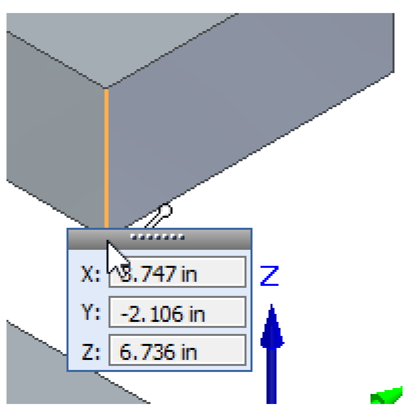


From the Inspect tab on the 3D measure section of the ribbon select Measure.

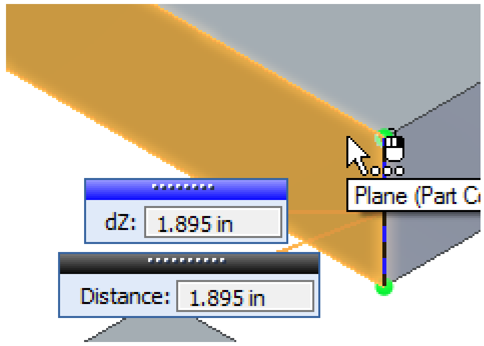


Measure the thickness of each part of the mold. Record your data in your engineering notebook.

Select the endpoint of one of the mold pieces.

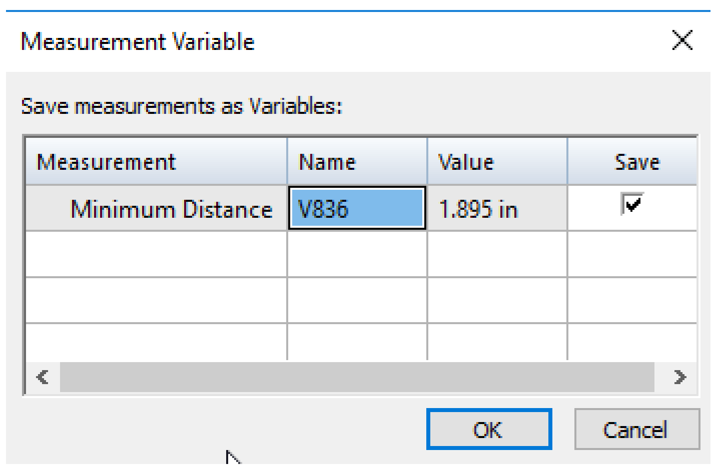


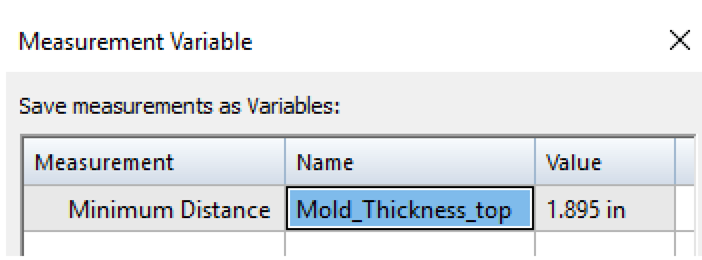
Select the point above the first.



You now know exactly the thickness.
On the measurement select the element for create a variable

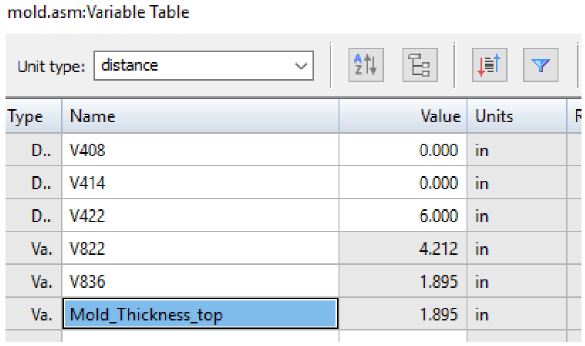
The dialog box appears. Change the name of your variable to something like mold thickness so you can find it again if you need.





Select OK.

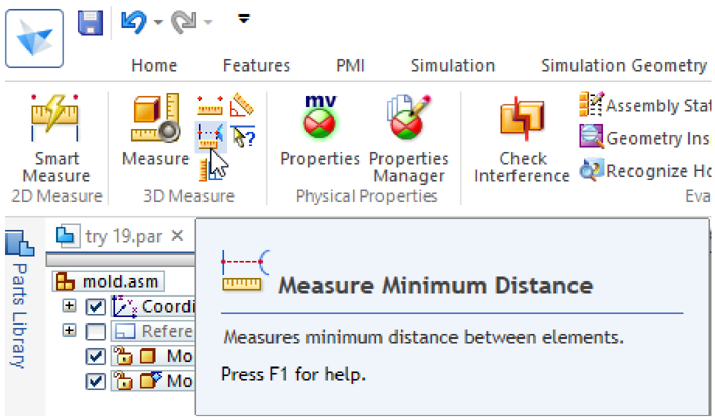
Check the Variable table to see that the measurement is there.


mold.asm:Variable Table

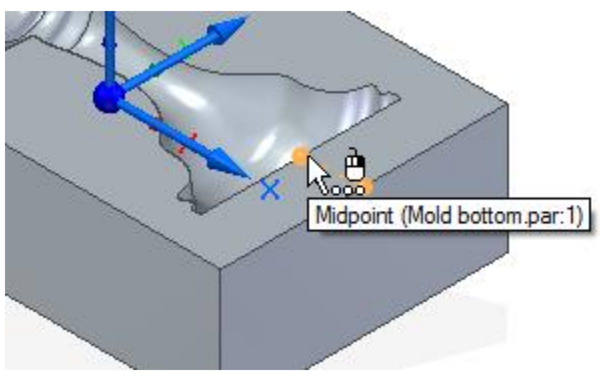
Unit type: distance

Type	Name	Value	Units
D..	V408	0.000	in
D..	V414	0.000	in
D..	V422	6.000	in
Va.	V822	4.212	in
Va.	V836	1.895	in
Va.	Mold_Thickness_top	1.895	in

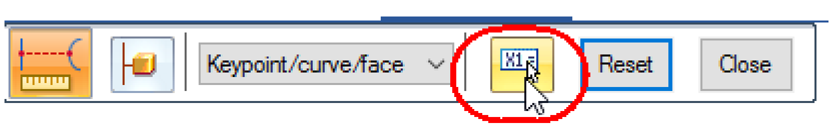
Check the distance from the edge of the mold to the base of your chess piece. In this case we will select Measure Minimum Distance.



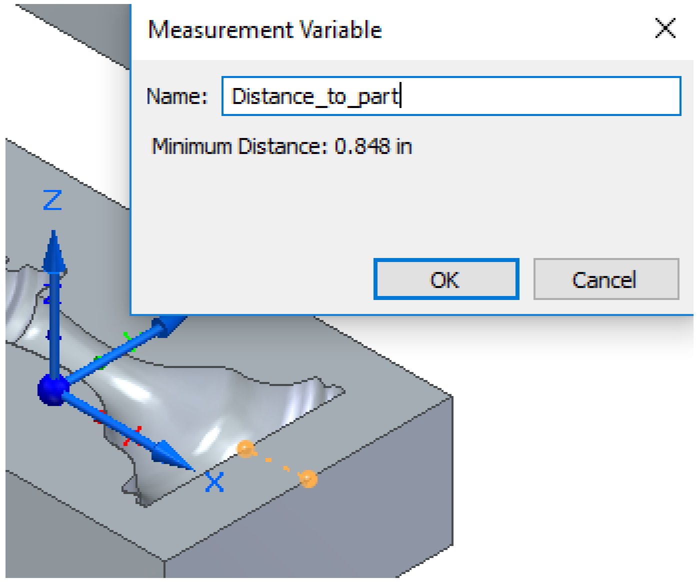
Click around the middle of the bottom line and then the middle of the chess piece line.



Once both spots appear, select the Create Variable button.



When the measurement variable box appears, rename the variable and select ok.



Again the variable table holds the information for future use if needed.

Va.	Mold_Thickness_top	1.895	in		
Va.	Distance_to_part	0.848	in		

Gather any other measurements you might need.

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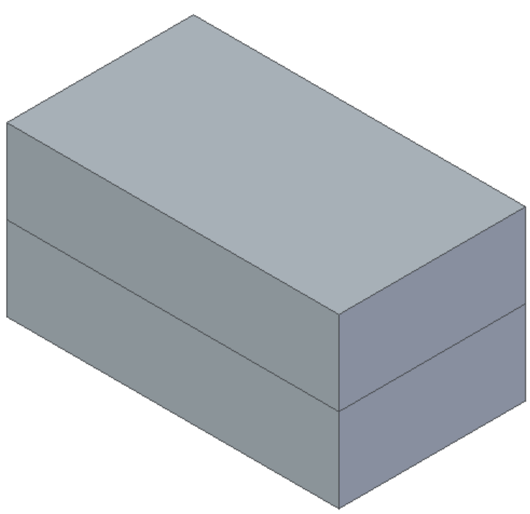
Assembling the Mold

Use Planer Align Relationship to align the mold components.

Then use a Mate relationship to put the mold together.

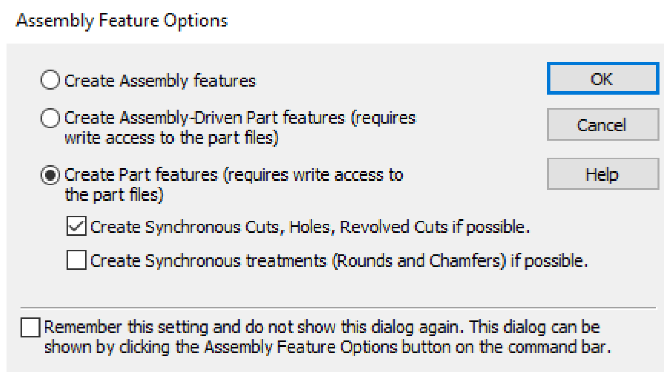


Adding Features

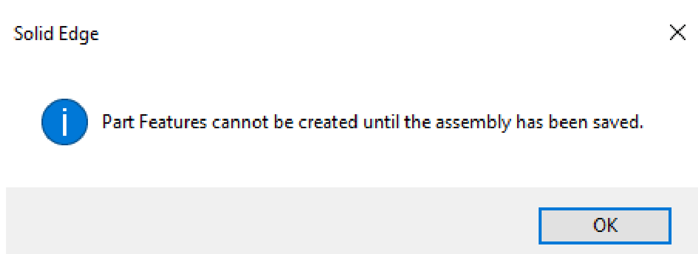
To complete the mold, it is necessary to add a way to inject the desired material into the mold.

On the features tab select Hole from the assembly features.

A dialog box appears about Assembly feature options. Check the one for Create Part features and check the box for Synchronous Cuts, Holes etc.

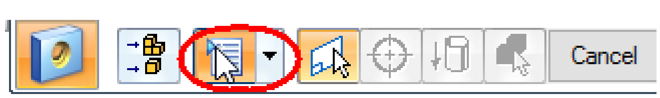


Select OK. A warning may appear stating that “part features cannot be created until the assembly has been saved”. If you see the warning, save the assembly files to a known location.

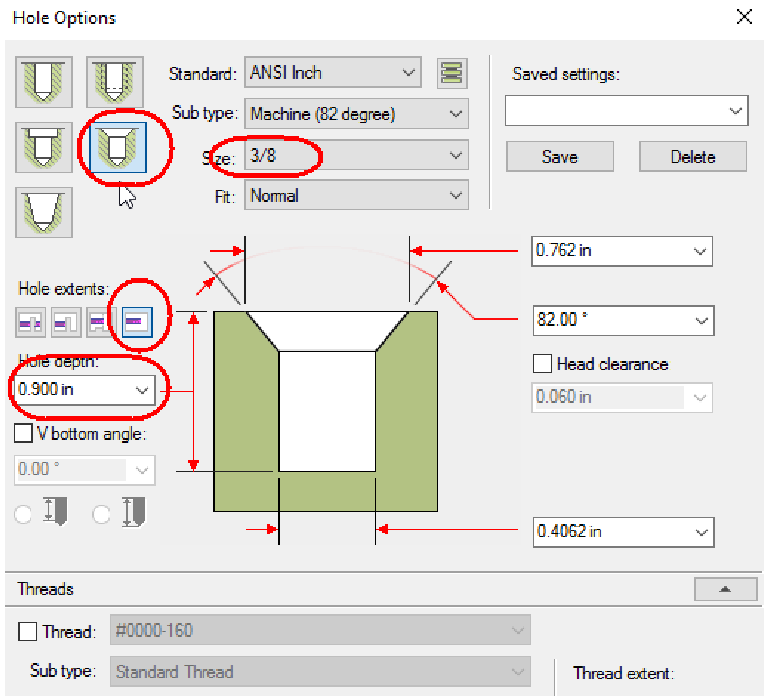


If a warning appears, save the flies and then select the Hole feature again.

Click on the Hole options link.

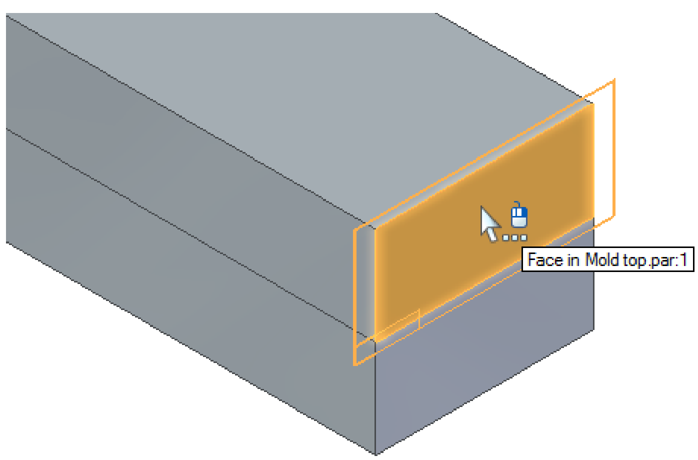


In the dialog box, select the option for Counter Sink. Set the size to 3/8. Set the depth to Finite and select a distance long enough to make it through to your mold cavity. Be sure Thread is unchecked.

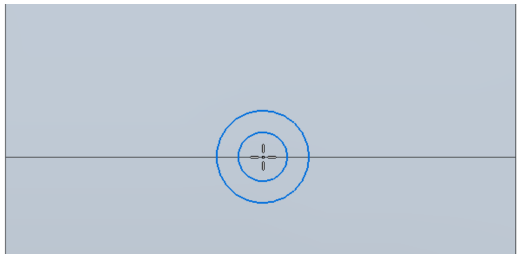


Select OK.

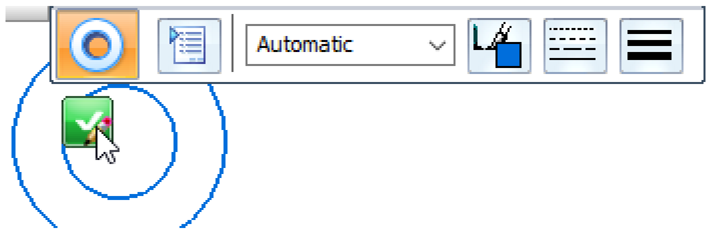
The prompt asks for a planar face for a reference plane. Select the end of the mold.



The view will change to a sketch view. Then select the center of the line between the mold halves.



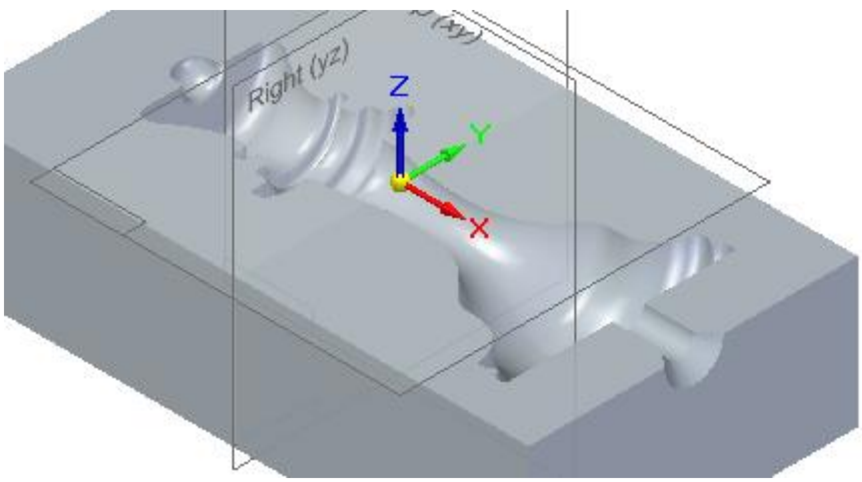
Then check the green check box.



The view returns to the original and the prompt is asking which way the hole should go. Be sure to select the inside of the mold.

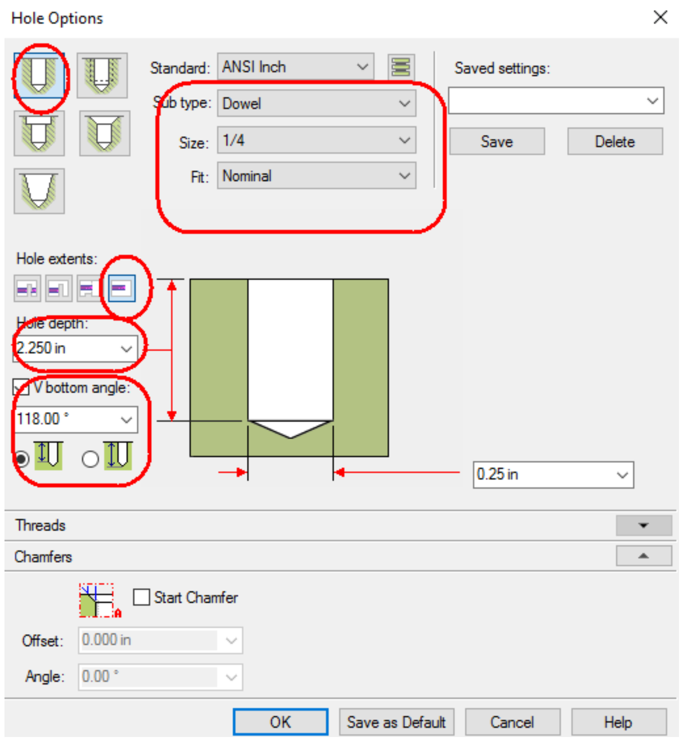
Then select the green check box on the tool. The hole will appear. Save the assembly.

Once the assembly is saved, open just the bottom half of the mold.

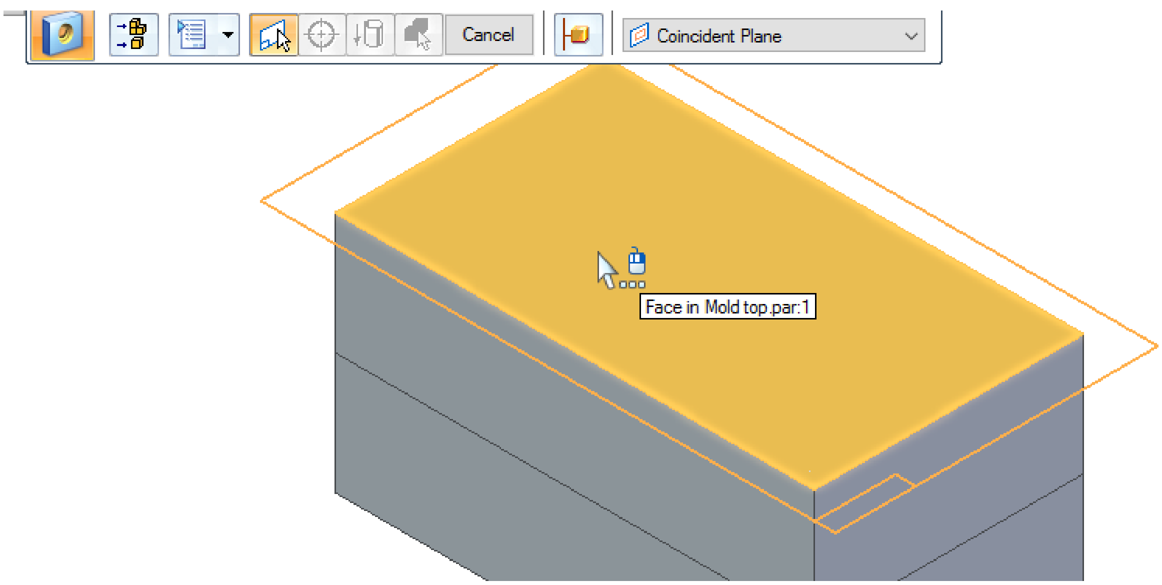


This will show that there is now a way to introduce material into the mold. Close the mold bottom and return to the assembly.

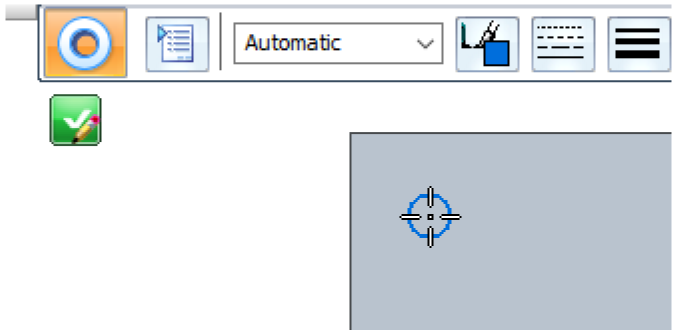
It is necessary to add locator pins to allow the halves to be perfectly aligned.
In the dialog box set the sub type to Dowel. Set the Size to ¼ and set the Fit to Normal. Set the extents to Finite, the Hole depth ¼ to ½ longer than the thickness of the mold top. Add a V bottom angle of 118°.



Select OK and then select the top of the mold to set the plane.



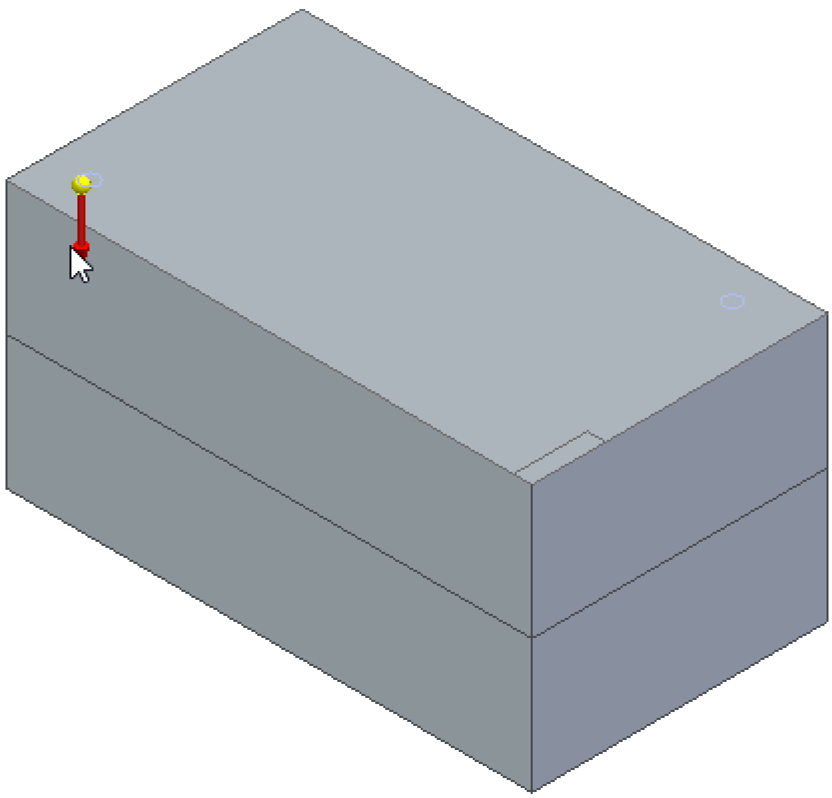
The view orientation changes and a circle appears on the cursor. Move the cursor close to a corner so it will not intersect with the chess piece cavity.



Click once in diagonally opposite corners.

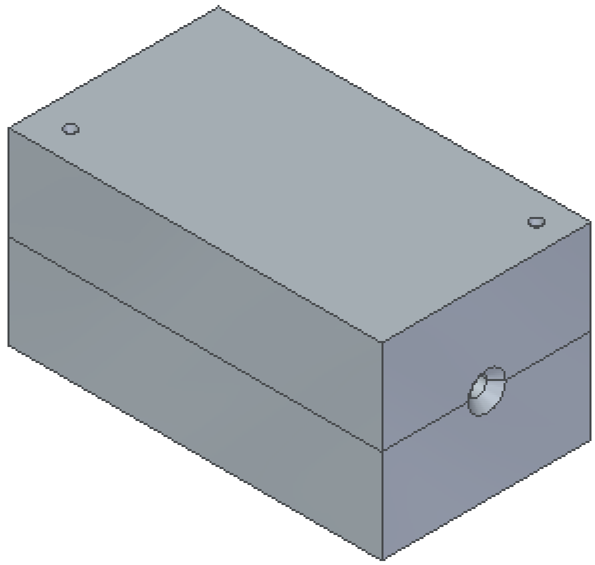
Click the green check box.

This returns the view to isometric. A prompt will require a direction.

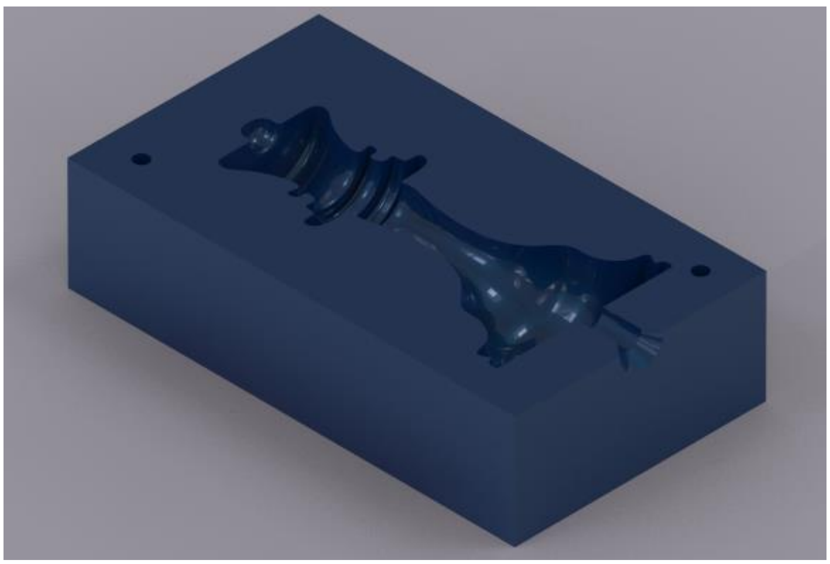


Select the down arrow. Select Finish.

Hit Esc to exit the command.



Save the assembly again. Open the mold top and the mold bottom to see what has happened to the two parts.



Design a dowel pin to fit the holes and add that to the assembly.

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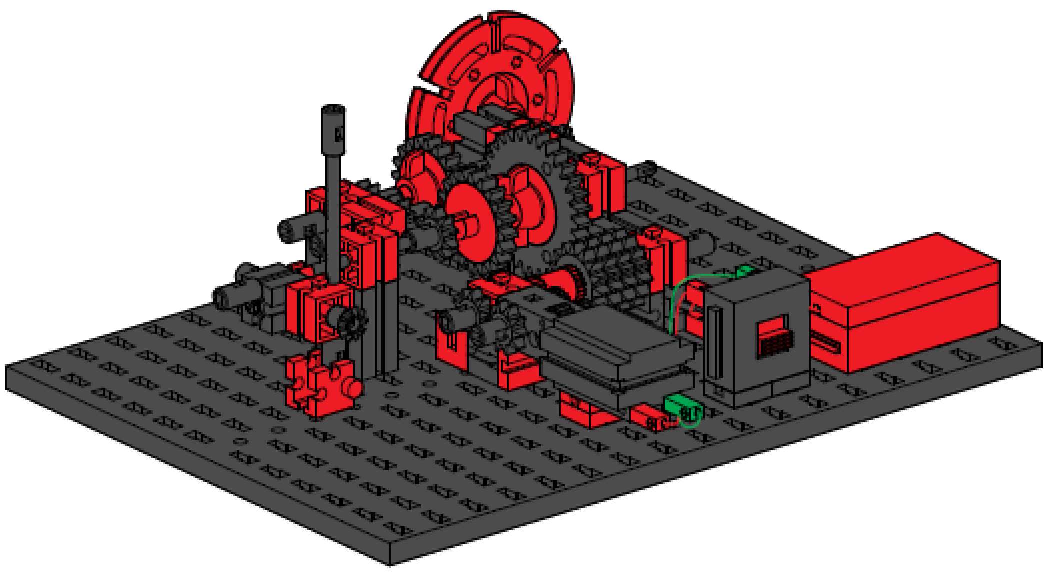
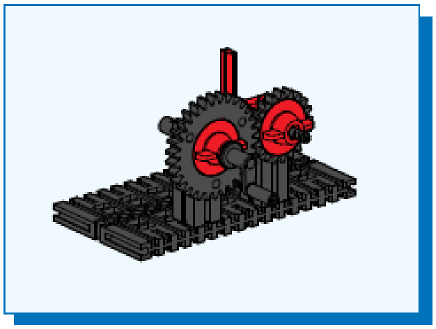
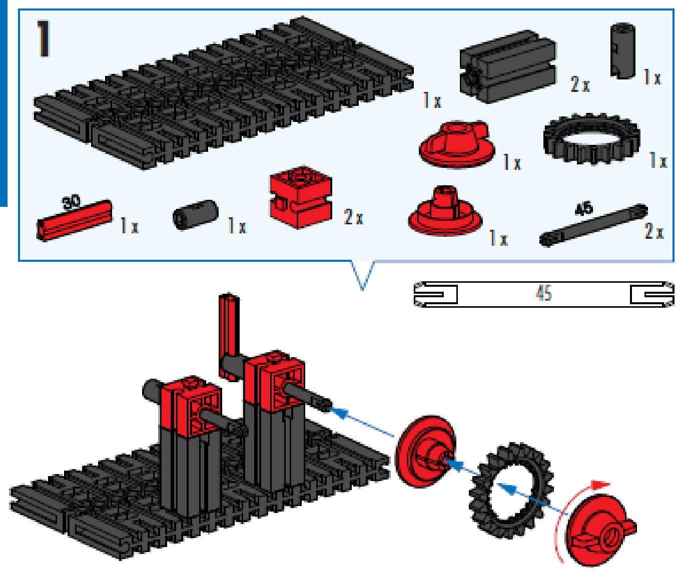
Gears with fischertechniks

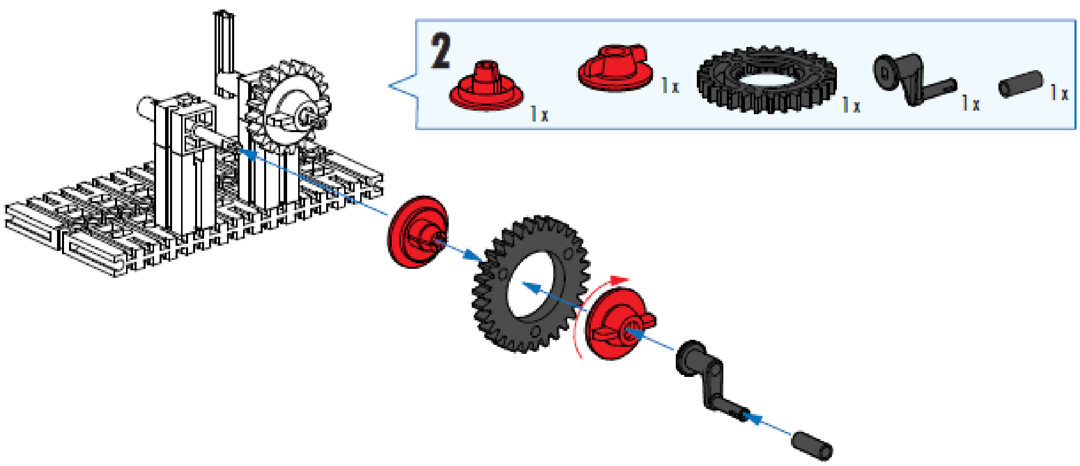
The pages following this one are copies from the manuals included with the sets. This will provide you with an exposure to some gears and how they work.

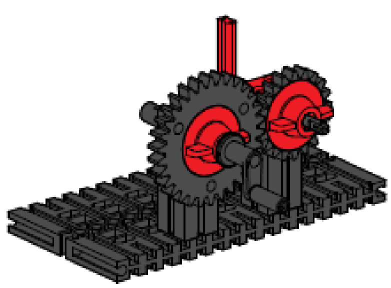




Kurbelgetriebe 2
Crank gear 2
Mécanisme à manivelle 2
Krukasoverbrenging 2
Mecanismo de manivela 2
Engrenagem de manivela 2
Ingranaggio a manovella 2
Кривошипный механизм 2
曲柄传动机构 2







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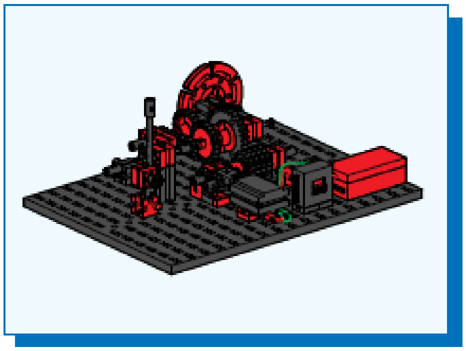
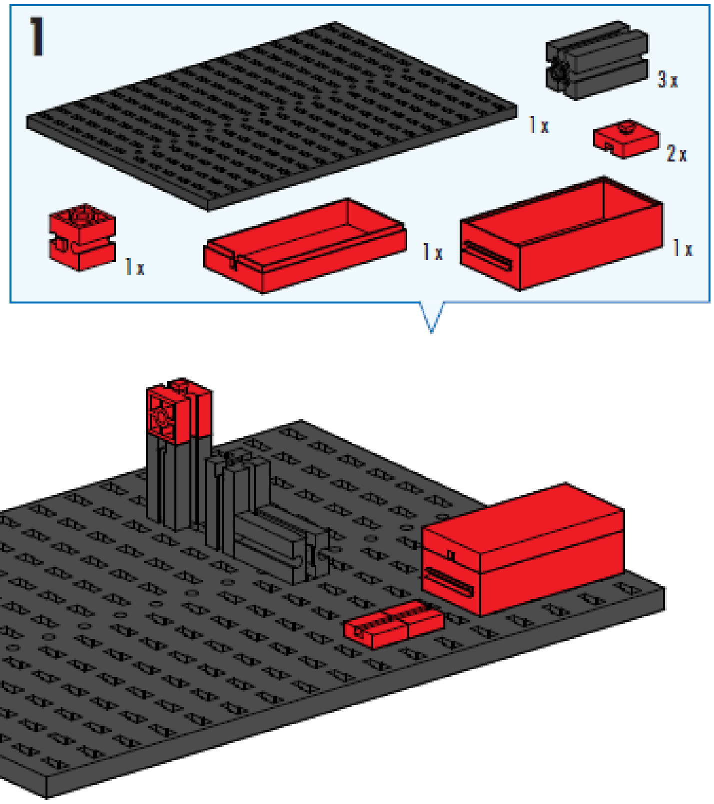
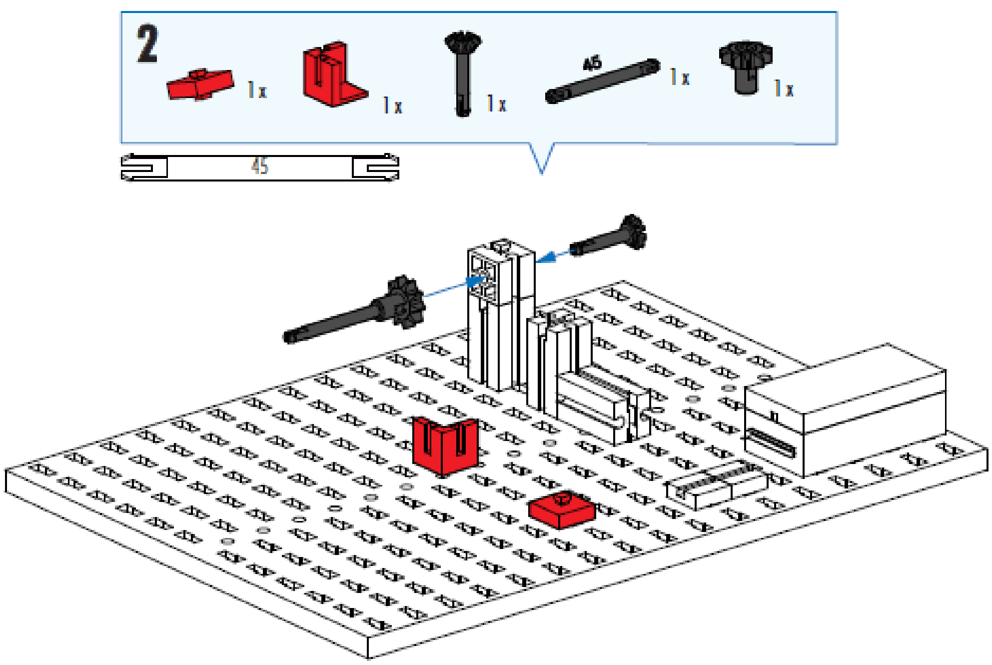
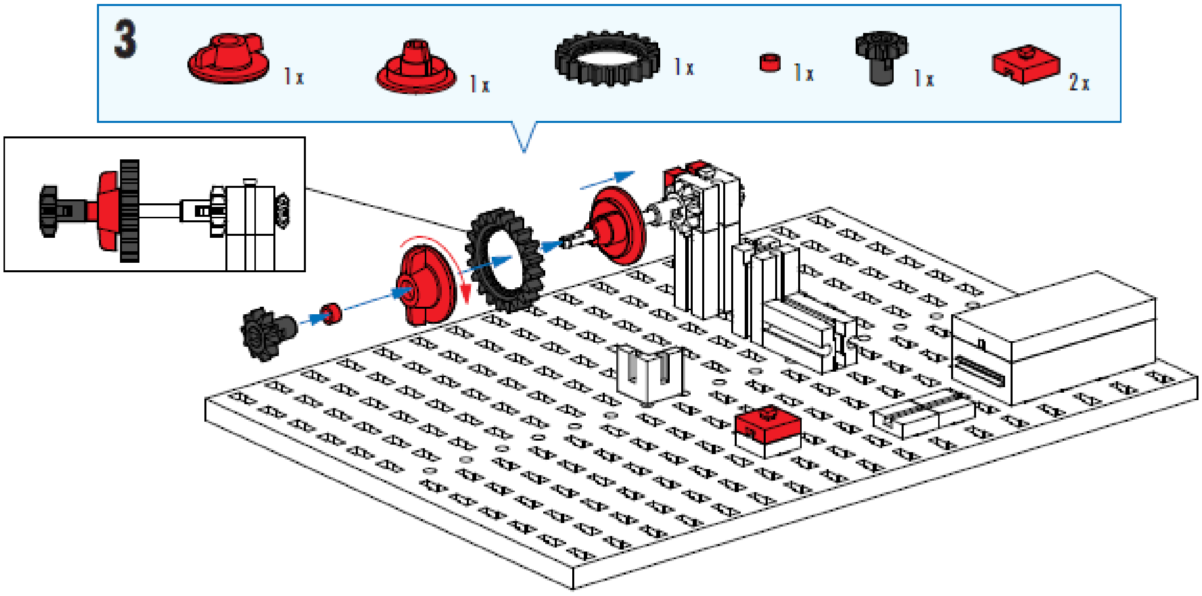
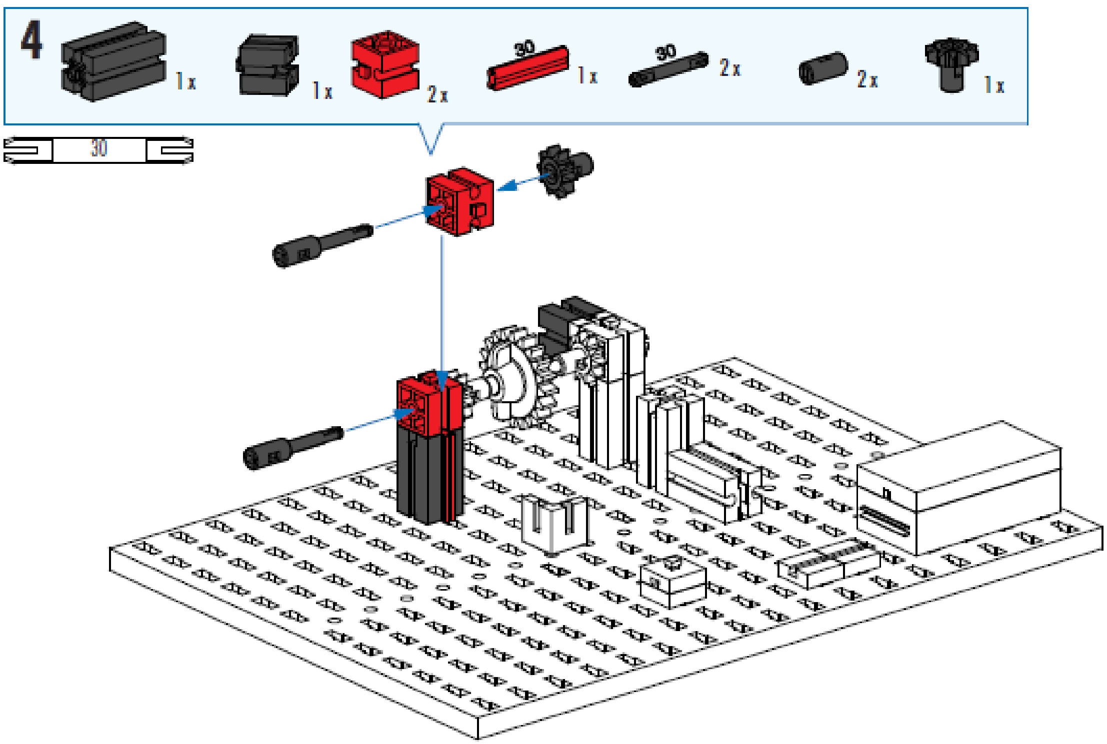


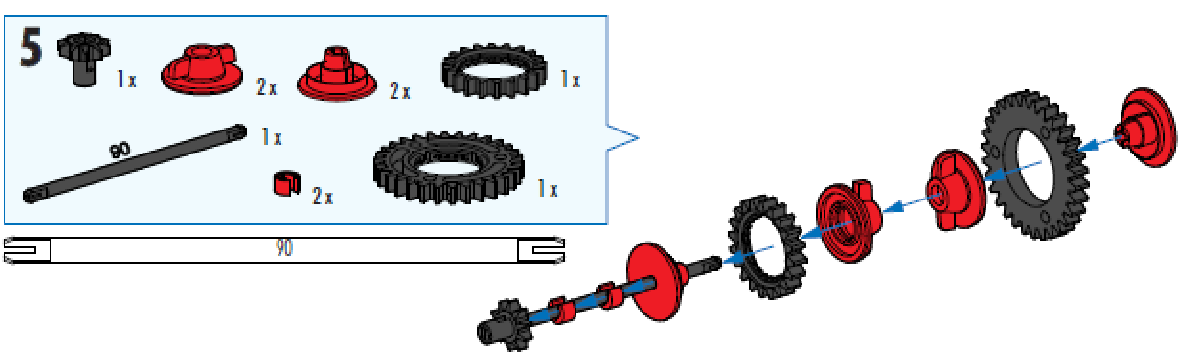
Schaltgetriebe
Gearbox
Mécanisme intermittent
Schakeloverbrenging
Cambio de velocidades
Caixa de câmbio
Cambio meccanico
Коробка передач
变速器



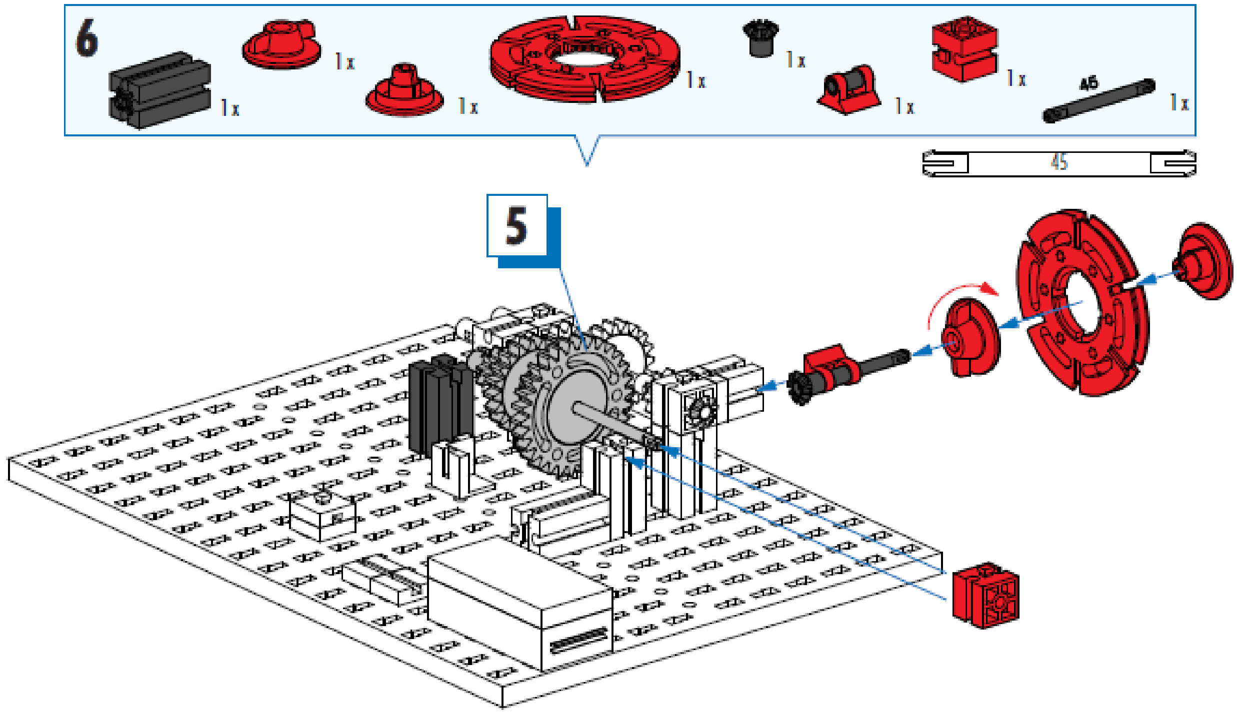


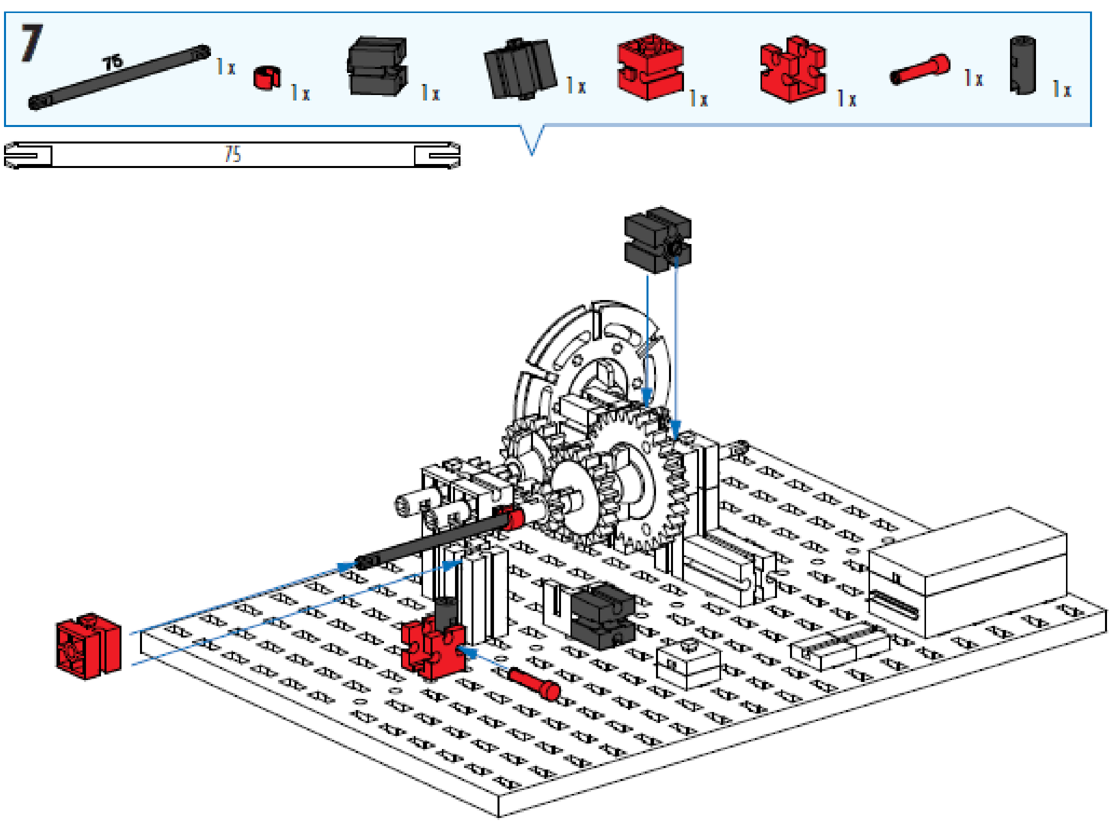

3
1 x
1 x
1 x
1 x
1 x
2 x


4
1 x
1 x
2 x
30
1 x
30
2 x
2 x
1 x
30


5
1 x
2 x
2 x
1 x
90
1 x
2 x
1 x
90

26





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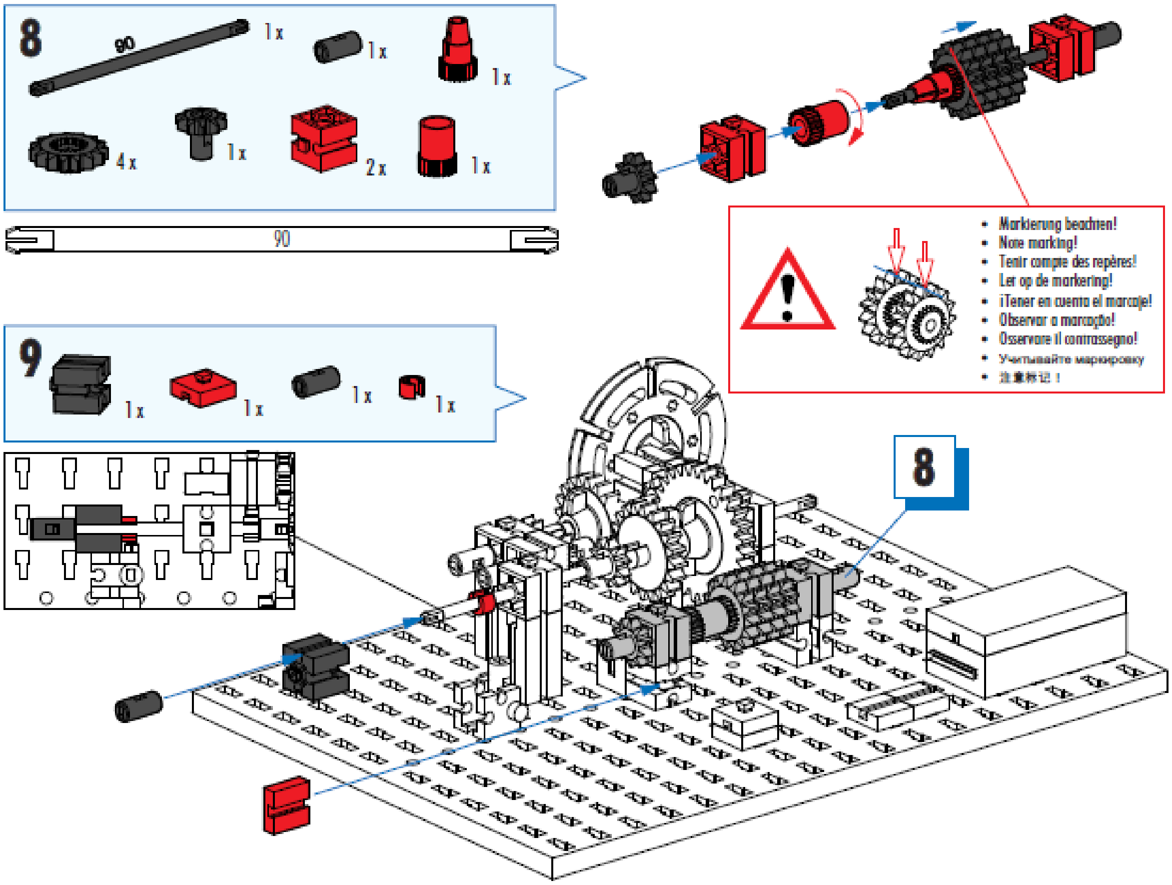
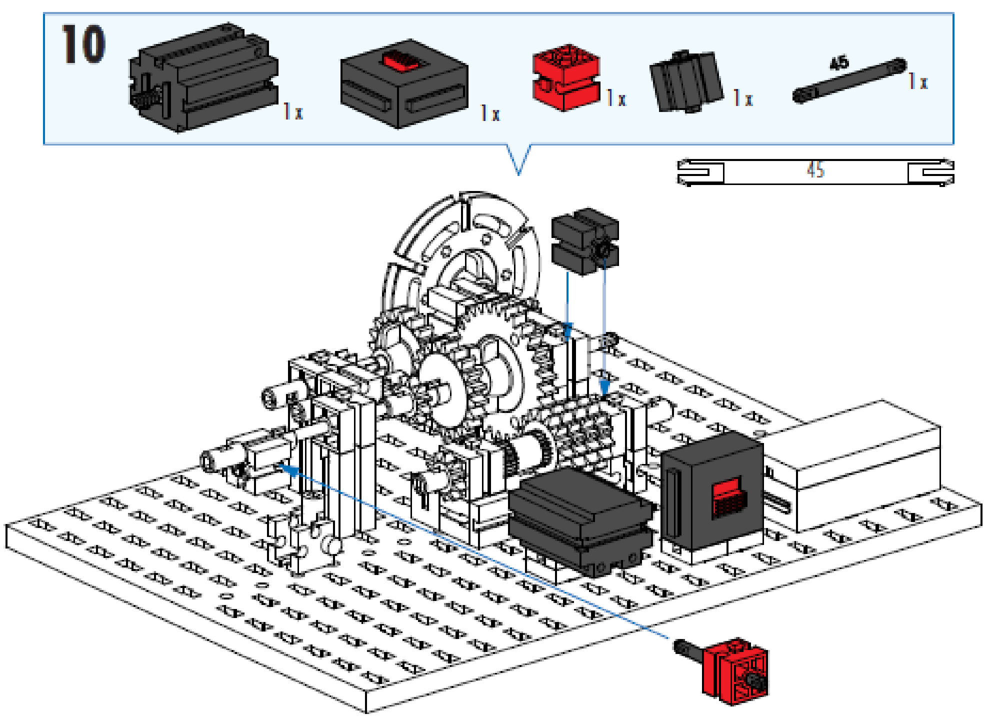
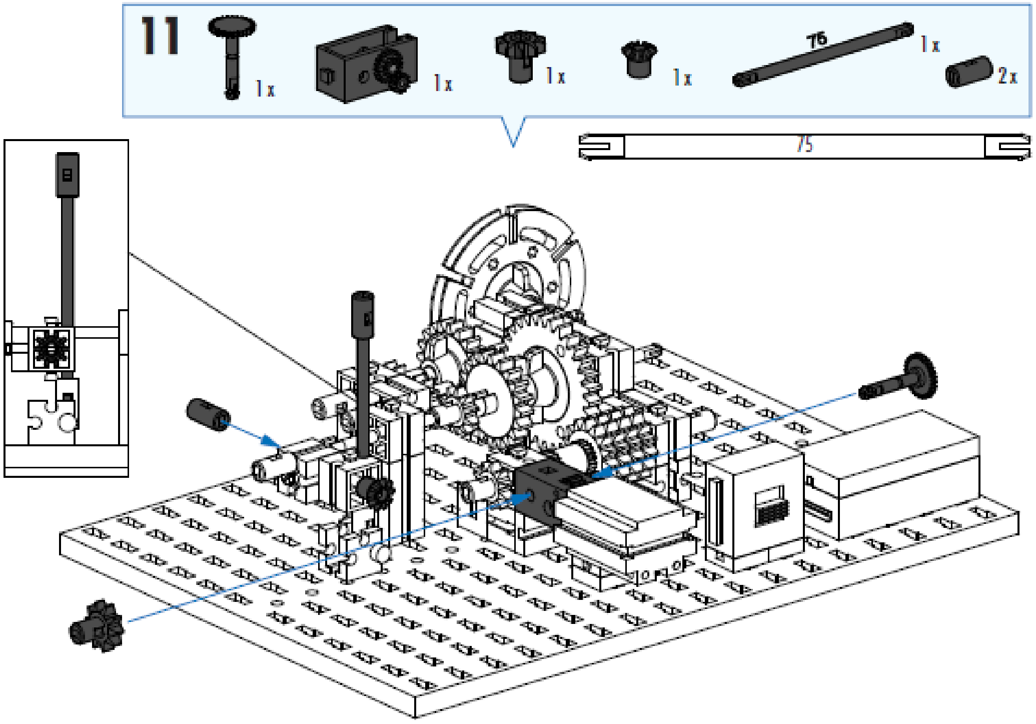
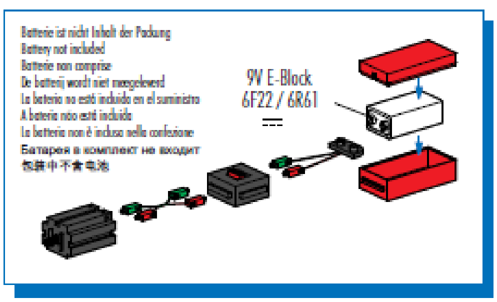
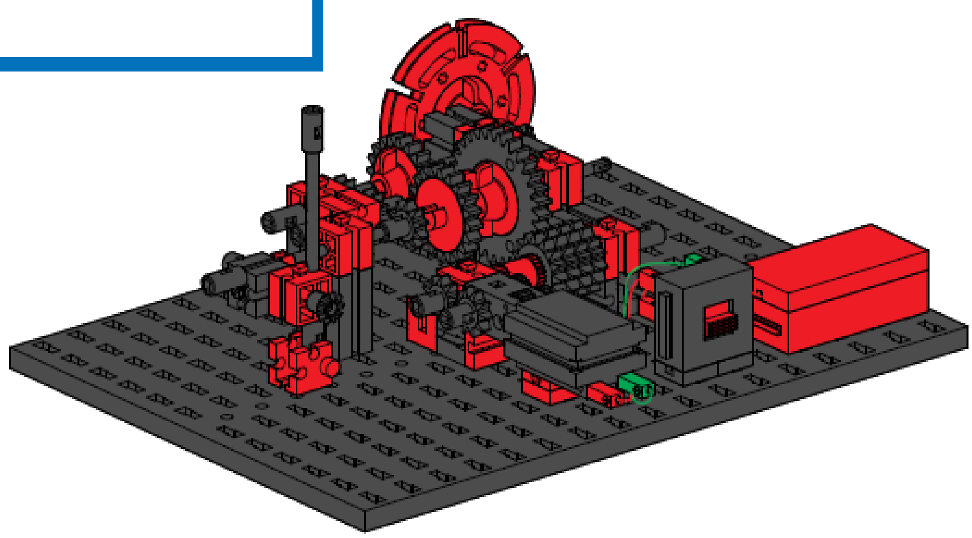

8
90
1 x
1 x
1 x
4 x
1 x
2 x
1 x
90
Markierung beachten!
Note marking!
Tenir compte des repères!
Let op de markering!
¡Tener en cuenta el marcaje!
Observar a marcação!
Osservare il contrassegno!
Учитывайте маркировку
注意标记！
8
9
1 x
1 x
1 x
1 x


10
1 x
1 x
1 x
1 x
45
1 x
45

28


11
1 x
1 x
1 x
1 x
75
1 x
2 x
75


Batterie ist nicht Inhalt der Packung
Battery not included
Batterie non comprise
De batterij wordt niet meegeleverd
La batería no está incluida en el suministro
A bateria não está incluída
La batteria non è inclusa nella confezione
Батарея в комплект не входит
9V E-Block
6F22 / 6R61



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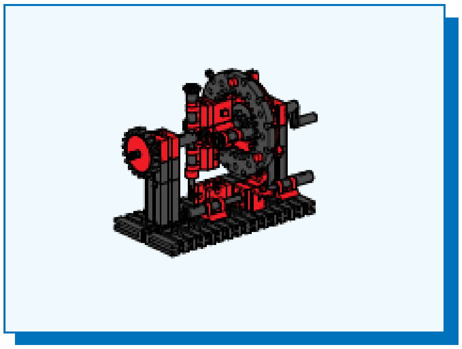
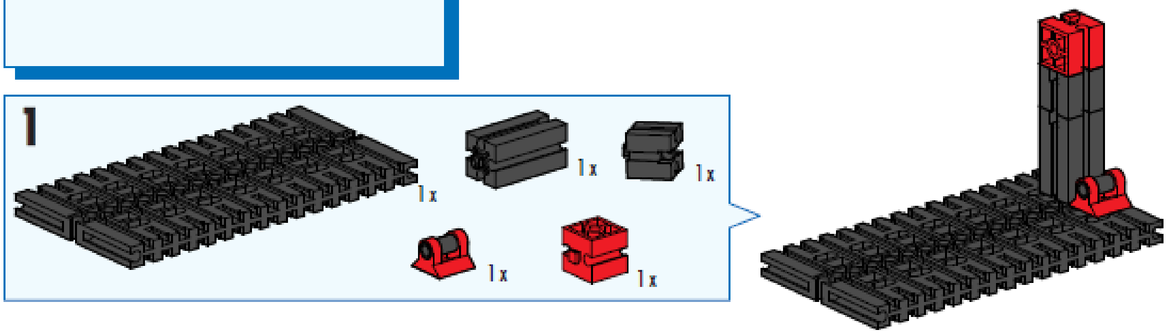
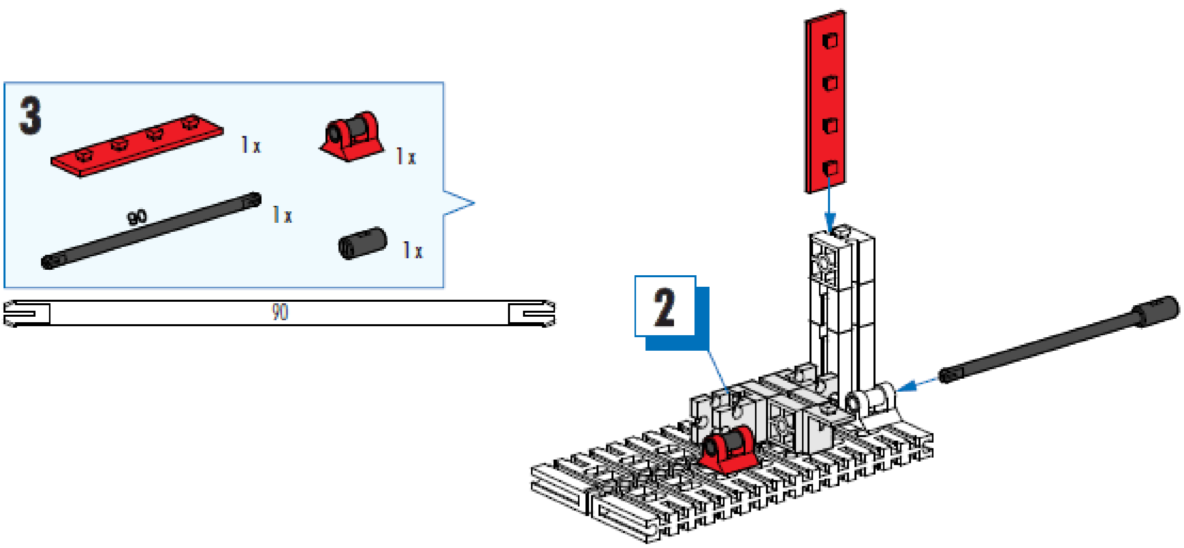
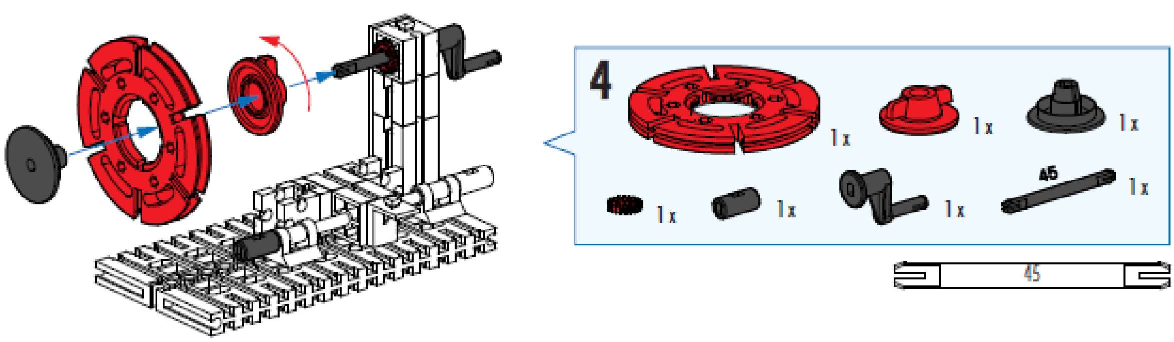
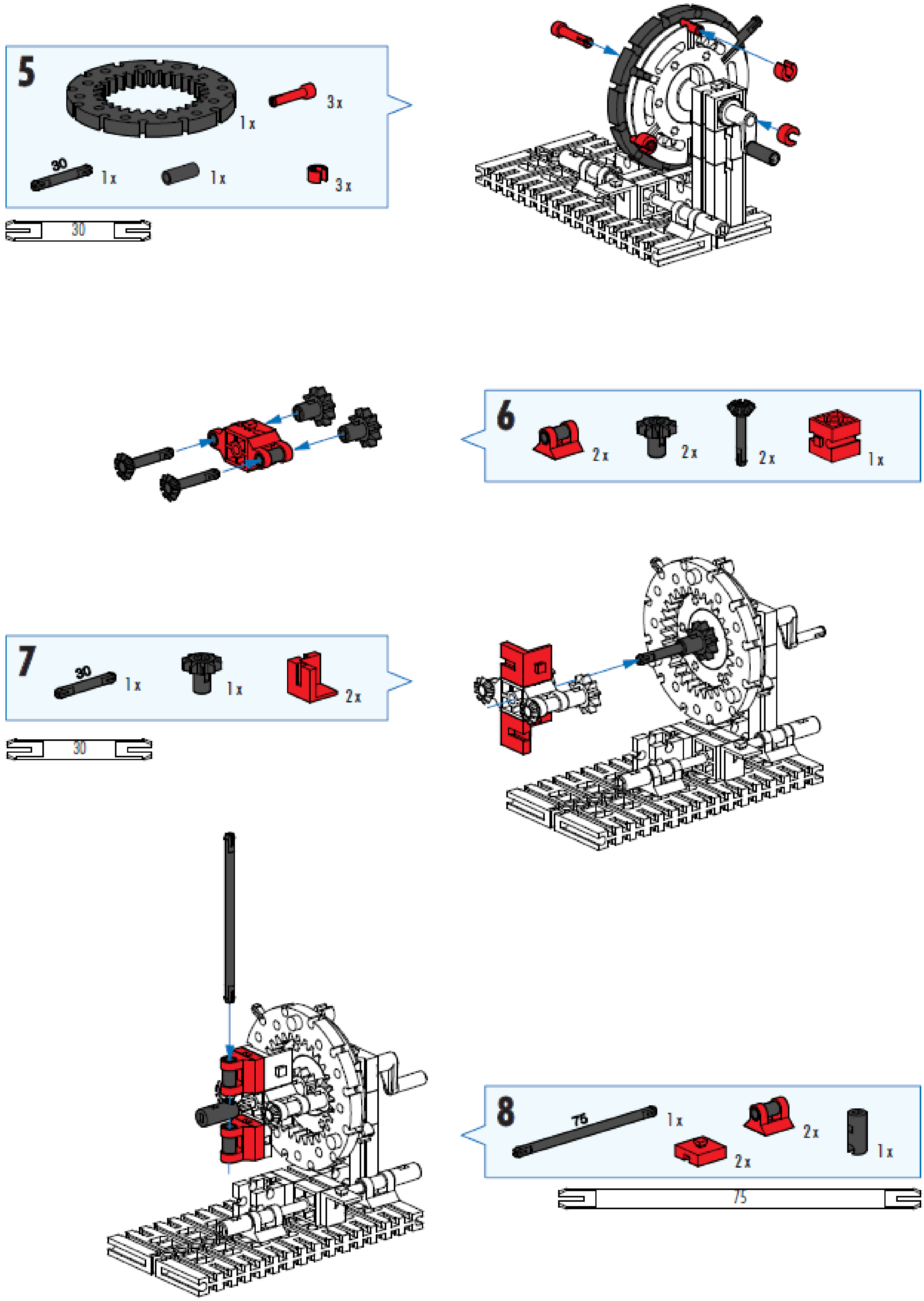


Planetengetriebe
Planetary gear
Engrenage planétaire
Planeetwieloverbrenging
Engranaje planetario
Engrenagem planetária
Rotismo epicicloidale
Планетарный редукто
行星齿轮机构









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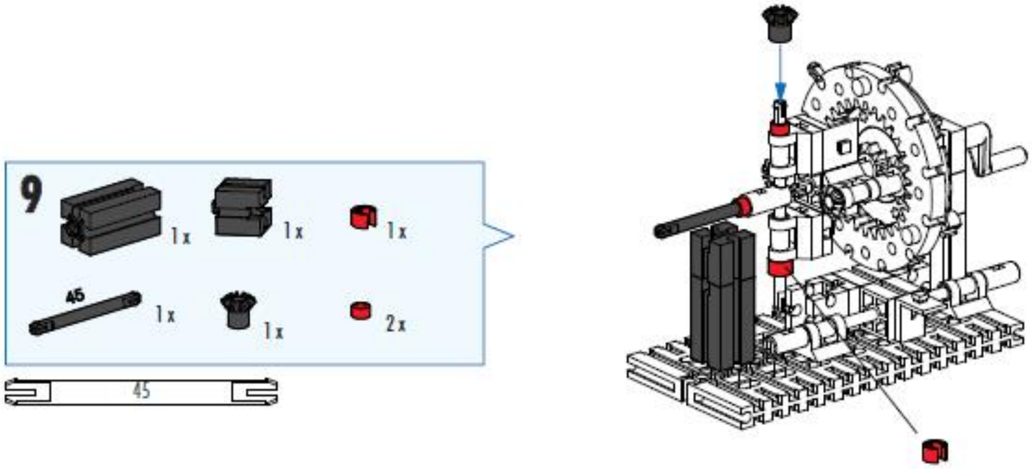

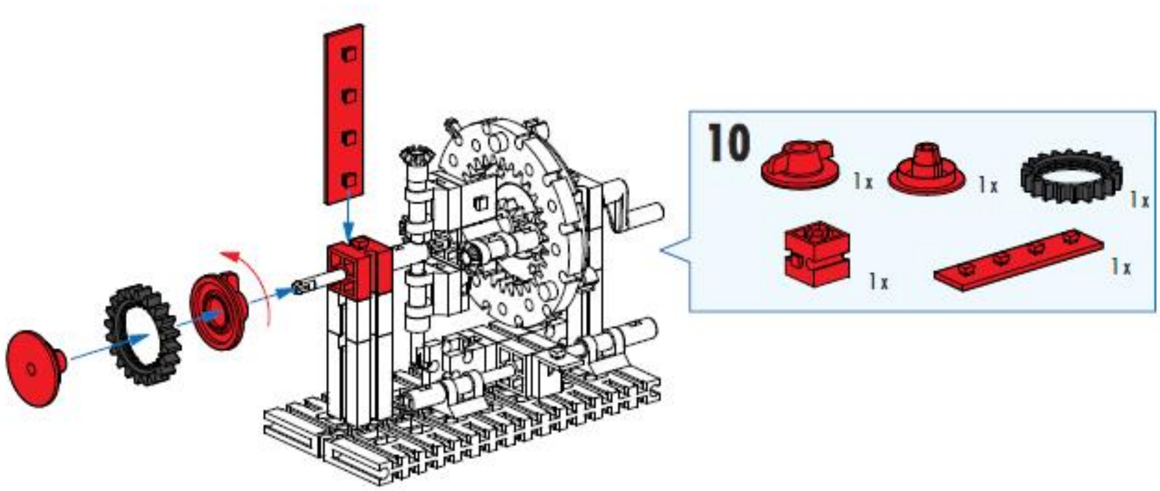

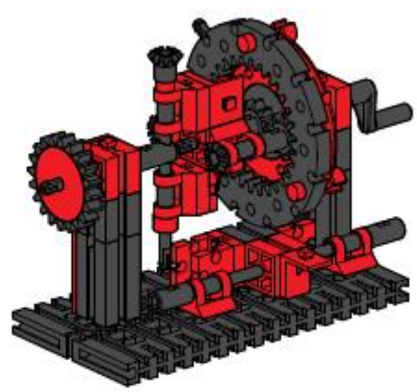

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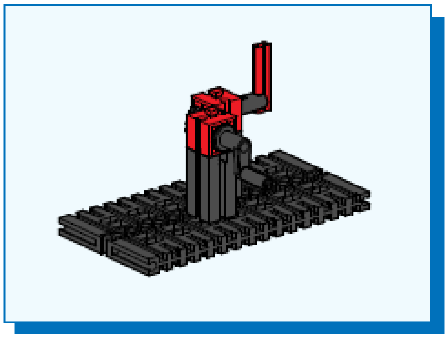
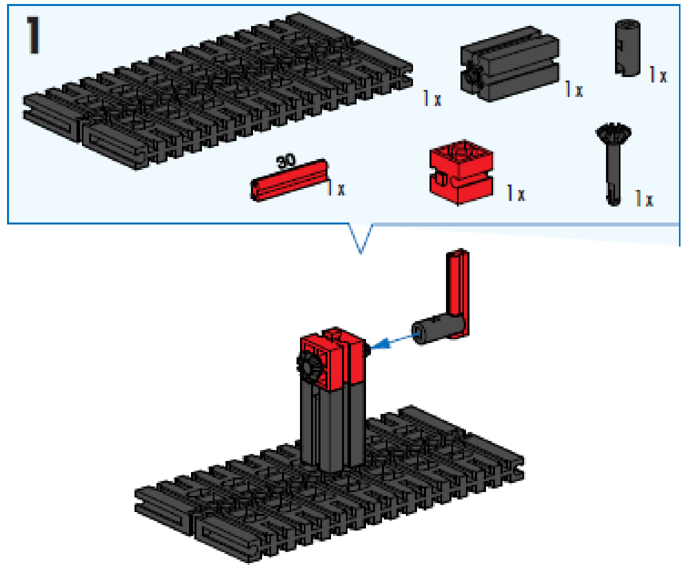
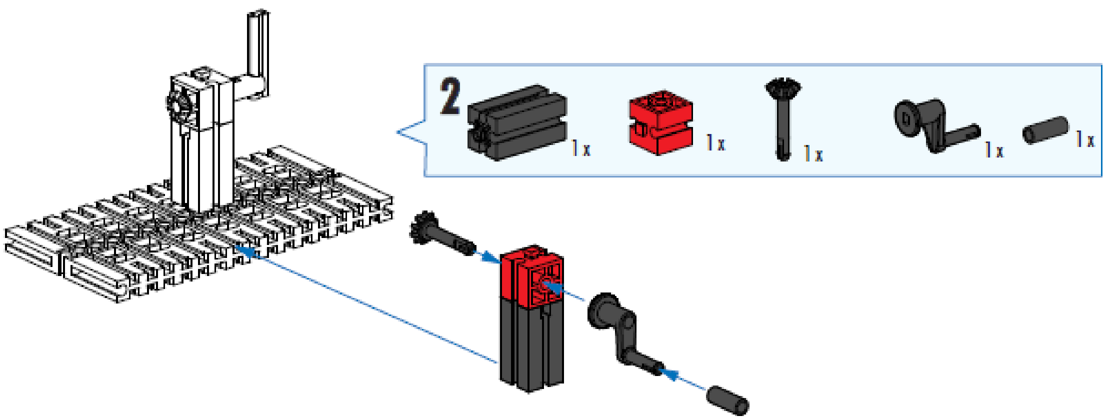
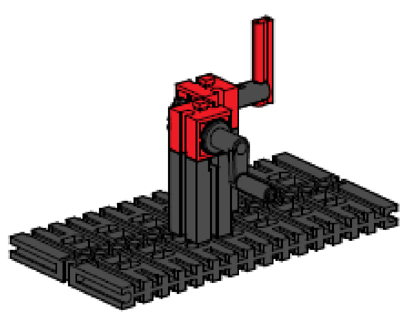


Kegelradgetriebe
Bevel gear
Engrenage à pignon conique
Conische tandwieloverbrenging
Engranaje de ruedas cónicas
Engrenagem cônica
Ingranaggio conico
Конический редукто
锥齿轮传动机构







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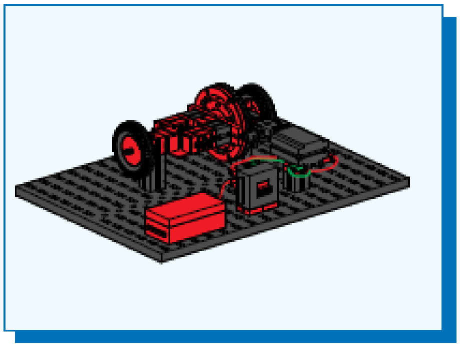
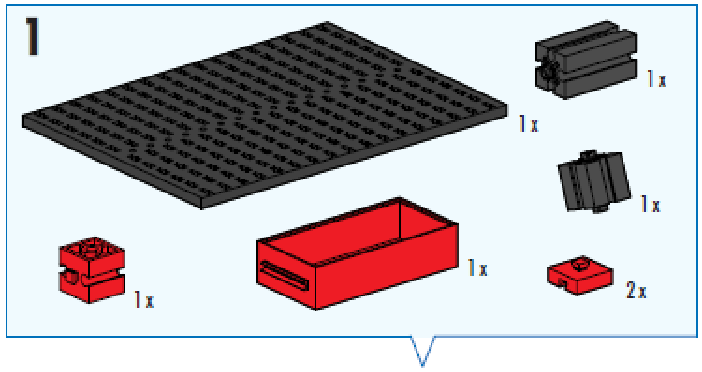
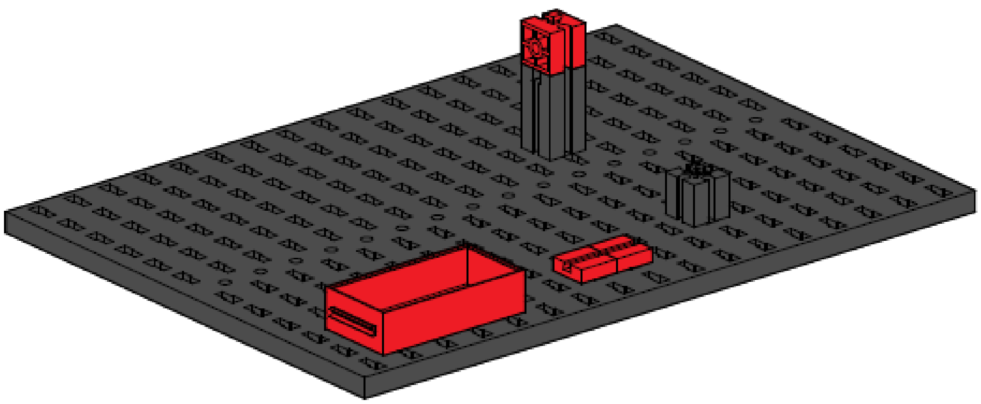
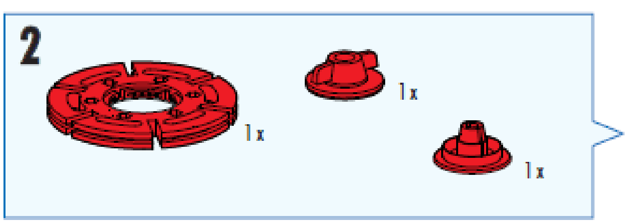
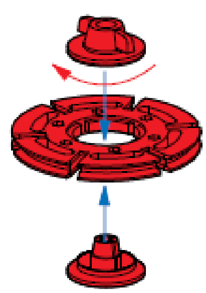


Differentialgetriebe
Differential gear
Engrenage différentiel
Differentieel
Engranaje diferencial
Transmissão diferencial
Differenziale
Дифференциал
差速机构









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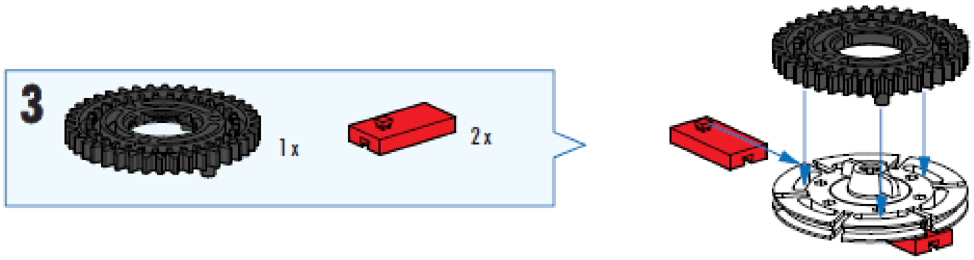
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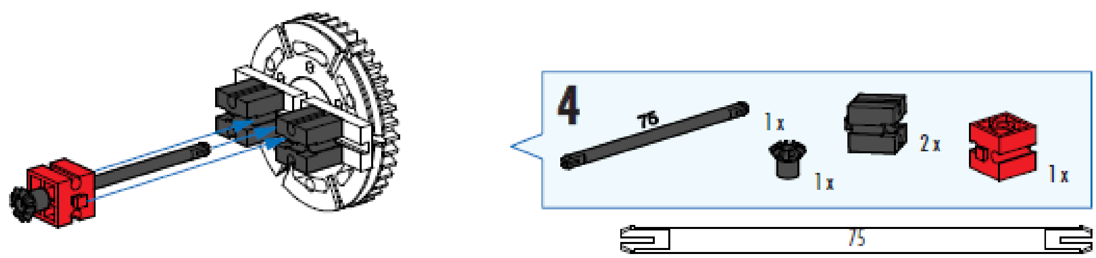
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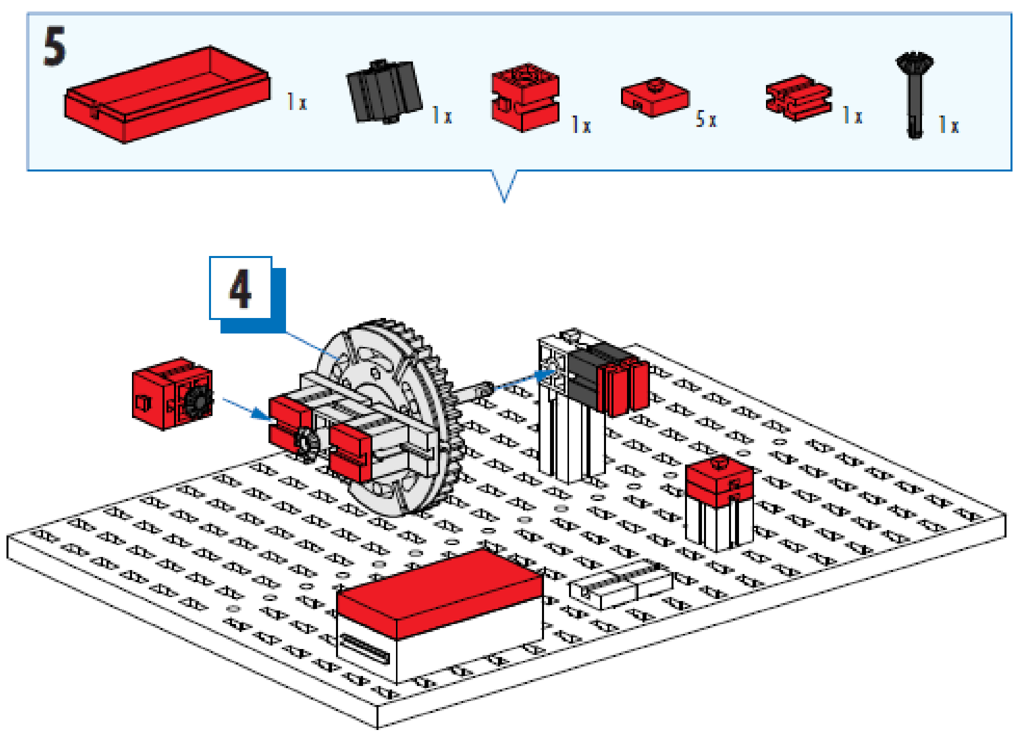
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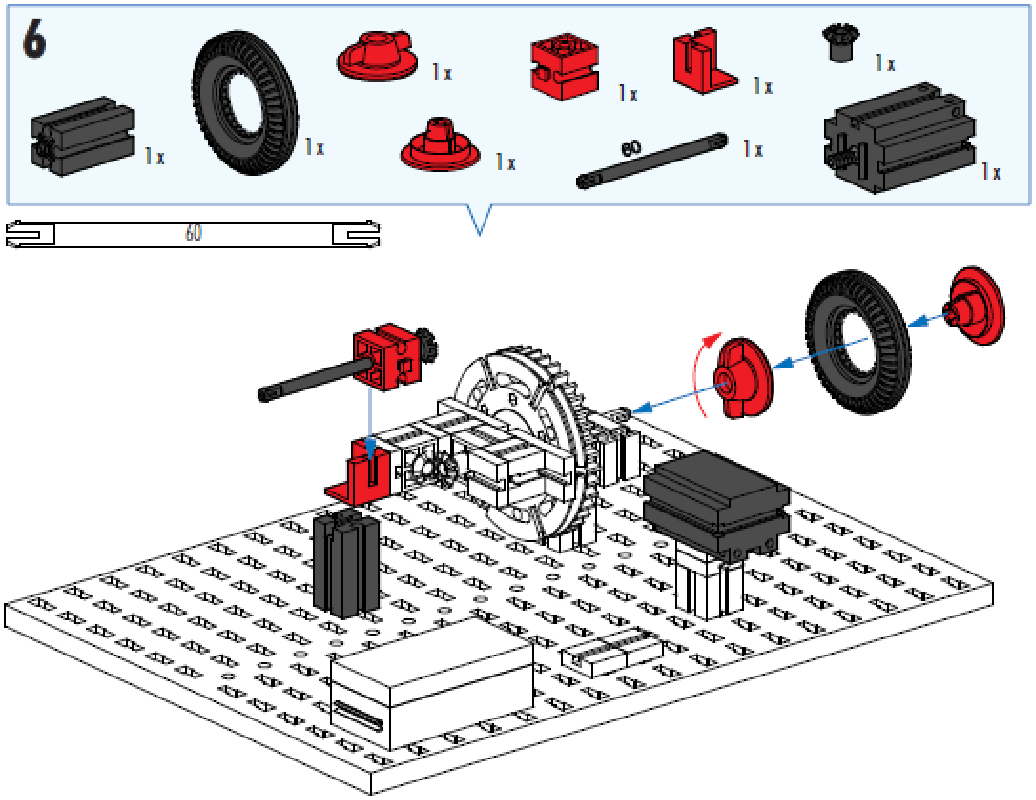

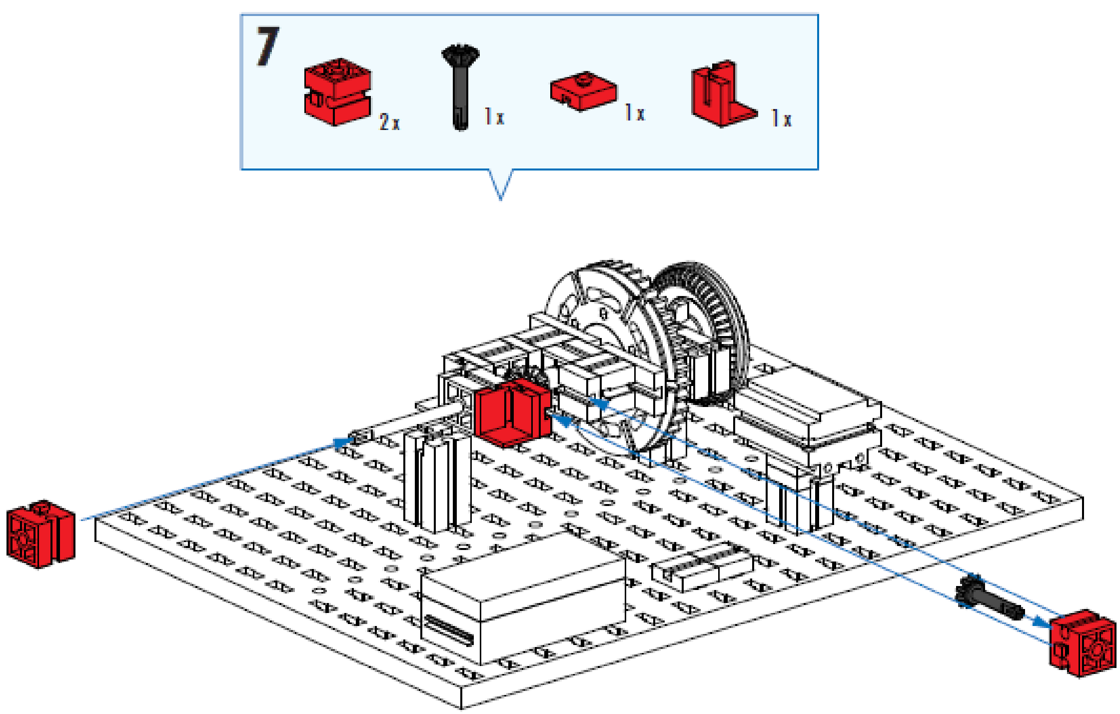

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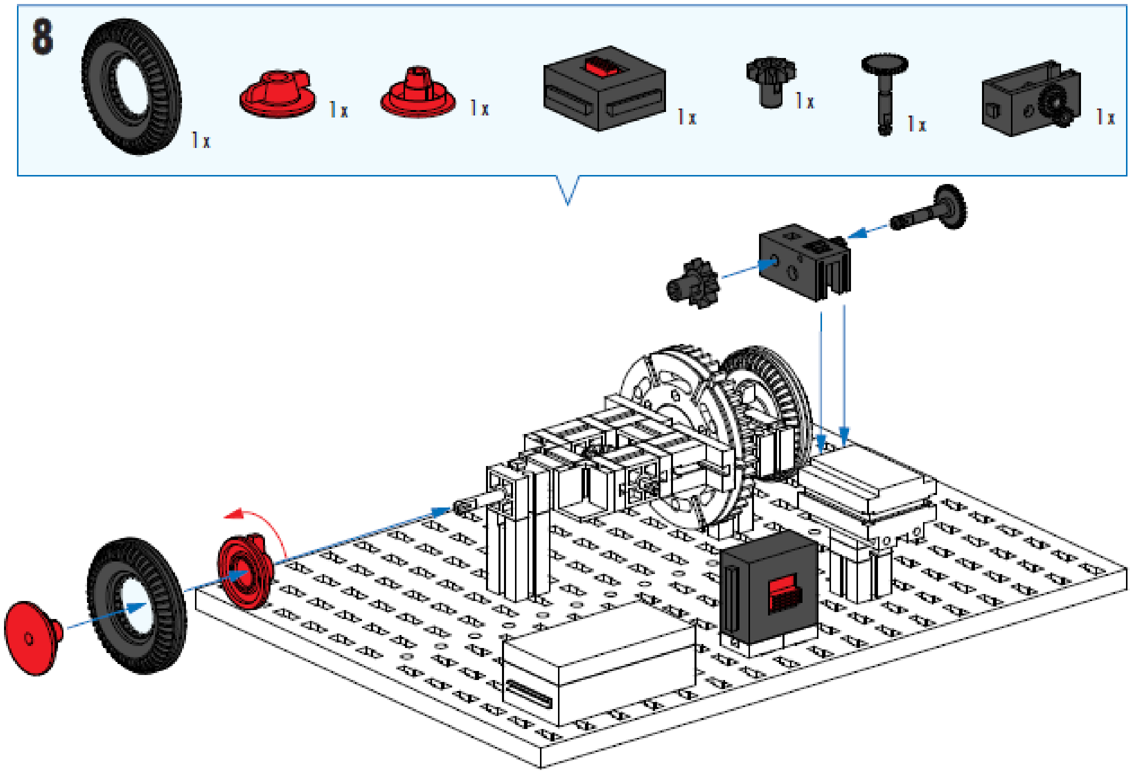
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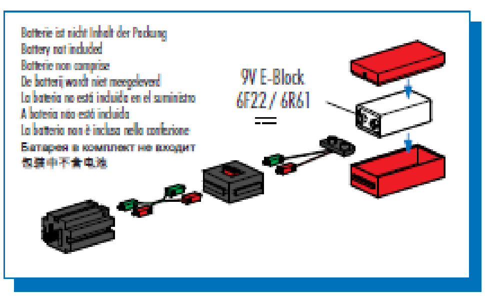
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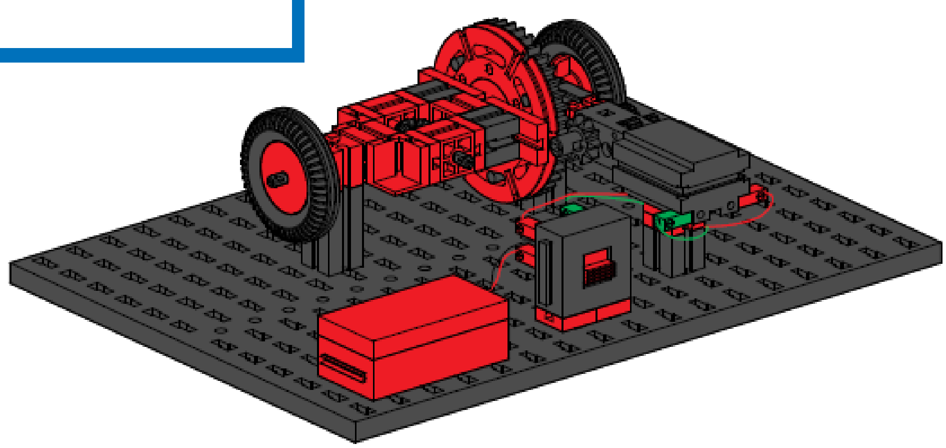

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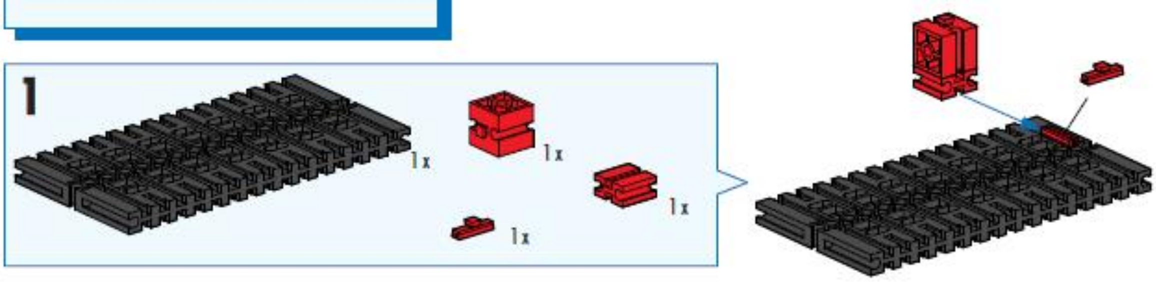
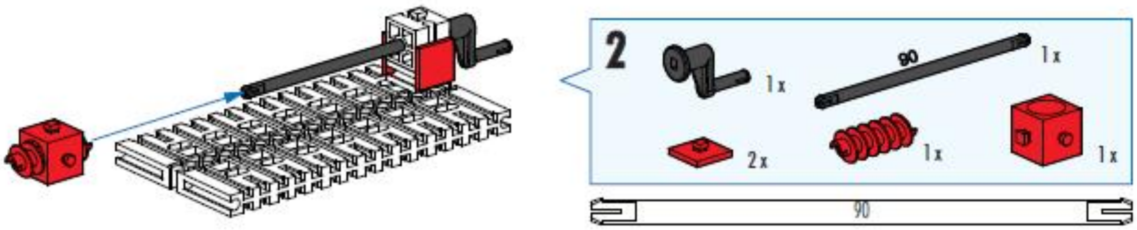
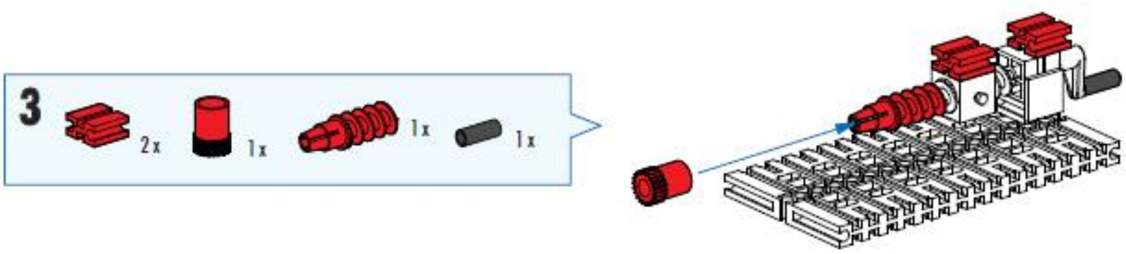
Wagenheber
Car jack
Cric

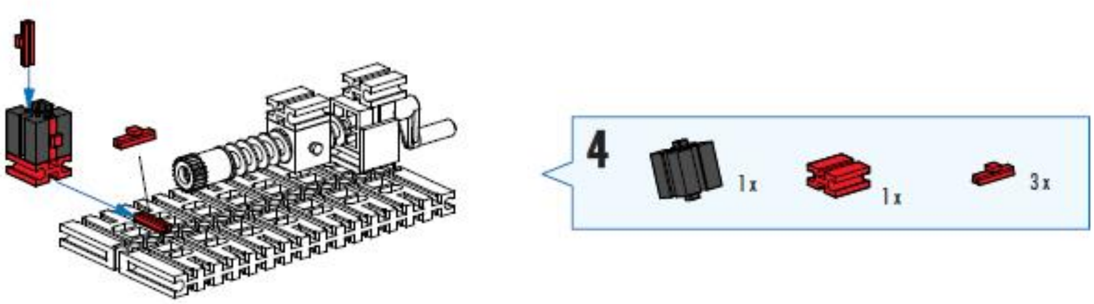
Wagenkrik
Gato
Macaco

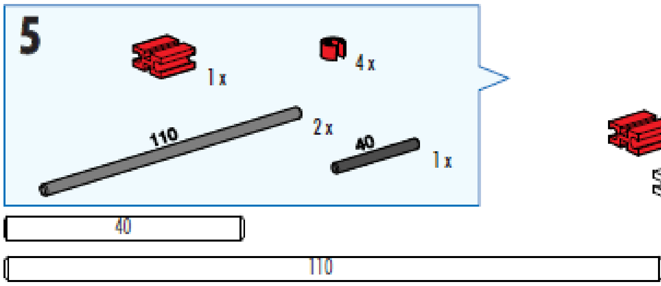
Cric
Подъемник
车辆升降机

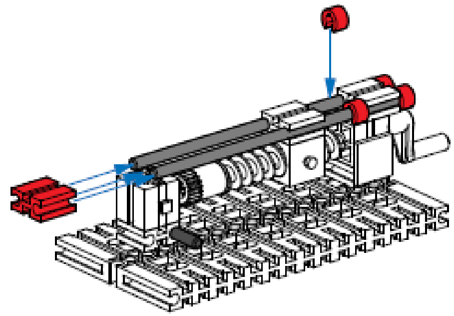


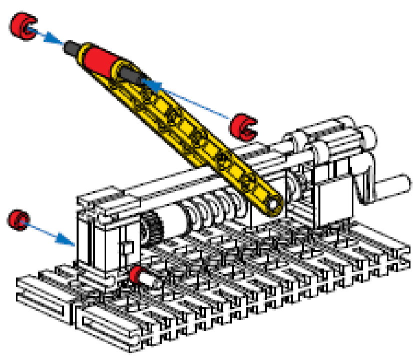


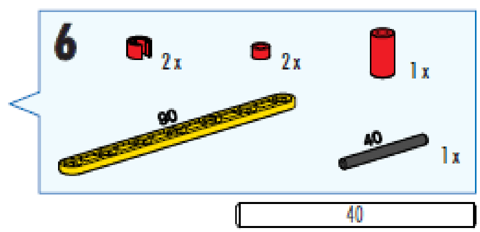


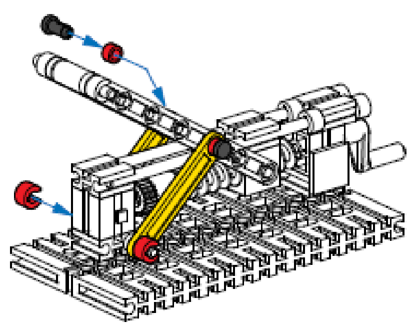


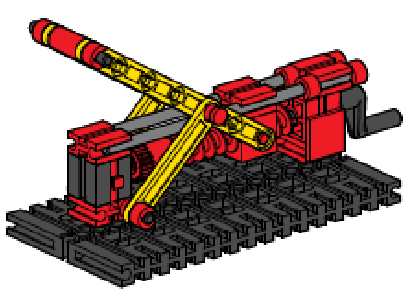












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SIEMENS

Ingenuity for life

Designing and Analyzing Beams

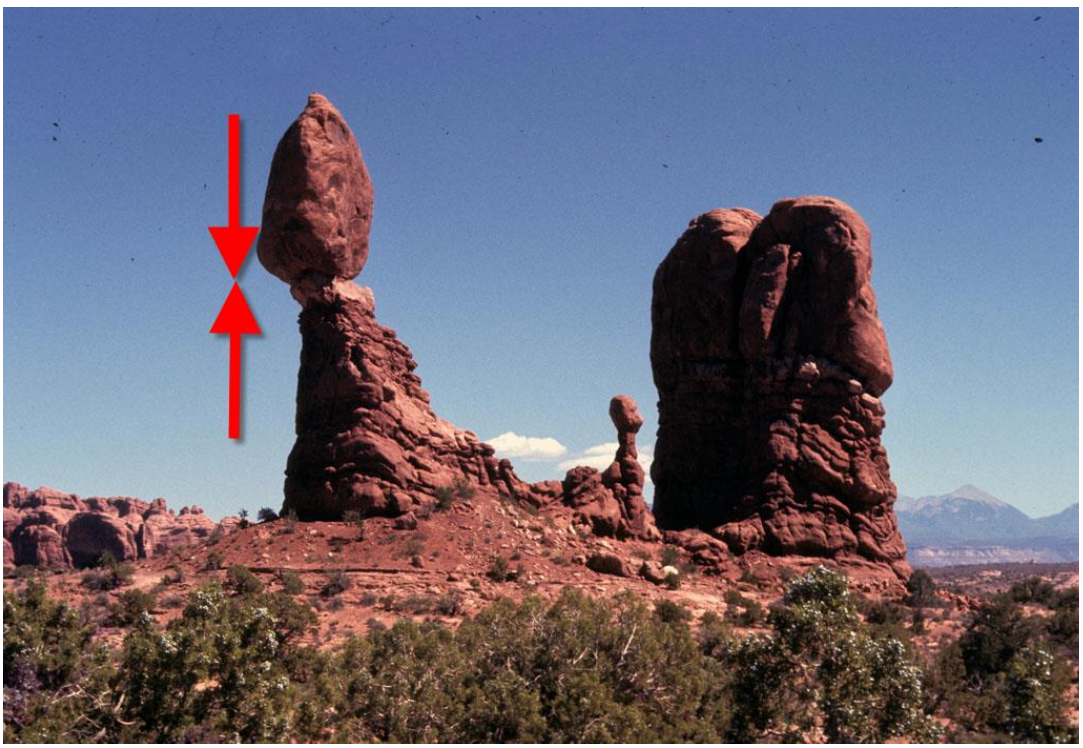
Forces

Forces act upon solids and the resultant behavior can be predicted by the applications of Newton's three laws. Before digging deeply into the design of structures, it is necessary to explore these forces to see how solids react.

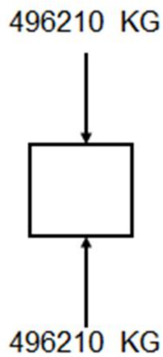
Newton's first law states that an object at rest will remain at rest or in uniform motion in a straight line. These rocks are at rest and not moving. Since the rocks are not moving there is no acceleration of the rock. Static equilibrium is a state achieved by objects obeying Newton's first law. There might be several forces acting on an object but as long as they are canceling each other out we can say they are in a state of static equilibrium.

Force is an interaction which tends to change the motion of an object. A child pushing a toy car across the floor is exerting a force on the car and it accelerates in the direction of the push the child is giving the car. This is an example of Newton's second law which states the acceleration of an object as produced by a net force is directly proportional to the magnitude of the net force, in the same direction as the net force and inversely proportional to the mass of the object. Simply stated, force is mass times acceleration or $F = ma$. Imagine a force that could move the rocks in the picture above. An earthquake would probably provide enough force to actually cause the rock to fall from its perch.

Newton's third law states for every action there is an equal and opposite reaction. This is why when a person strikes a ball with a bat the energy of the bat it transferred to the ball and it travels away from the bat. It is also why the rock sits on the perch. If the rock is pushing down then the ground must be pushing up to balance the forces so the rocks are in state of equilibrium.



You can create a simple diagram from this to represent the forces. These diagrams are Free Body Diagrams and we use them to help us simplify and solve problems. The diagram is below. The weight of the bolder pushing down equals the force of the earth pushing back.



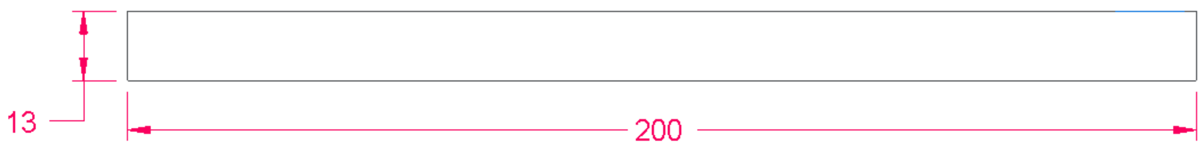
In structures there are two basic forces to consider. These are tension and compression. Compression is what happens when pushing down on an object.

Tension occurs when pulling on an object such as a rope or fishing line.

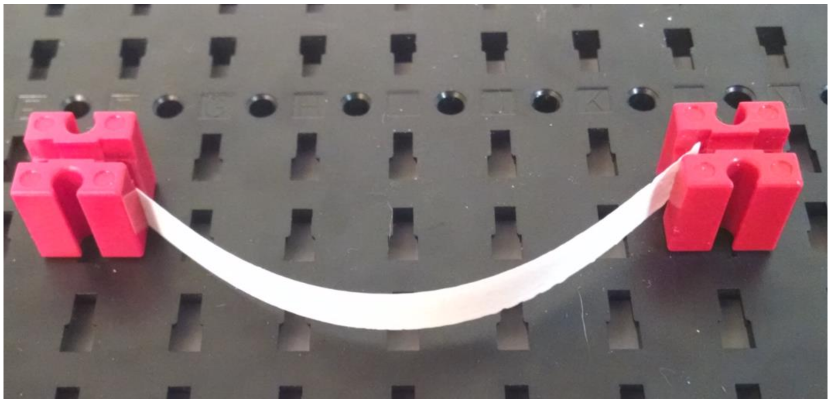
Forces cause materials to react. Even a fly landing on a table causes some deflection of the surface of the table. It might be too small a change to see but it happens anyway. Some materials perform better in tension, such as metals and others perform better in compression, such as concrete.

The model for this tutorial will be ABS plastic as that is the material in use in the 3D printer. Experiment with the plastic before beginning your design.

Begin by using Solid Edge to create a basic rectangle so you can create a small element to experiment with.



Using this as a guide, make a flat piece of stock using the 3D printer. Make this a solid piece consisting of one or two layers. Hold the cooled part at each end with your fingers, and then push the ends toward each other. This will have an effect similar to the picture below. This is compression.



What happens with just a little pressure? Now try pulling the two ends away from each other. This is tension. What happens when you pull on the material? A small compressive force caused the material to change a lot. When you think about this material do you think it performs better in tension or compression?

Materials all deform when force is applied. When the force is removed the material could return to its original size and shape. If it does we can say it is in its elastic state, like a rubber band when the force is released. The rubber band returns to its original shape. When we pull or push too hard the material permanently changes shape. At that point, the limits of elasticity have been exceeded. In the world of material science the term used when this happens is plastic deformation.

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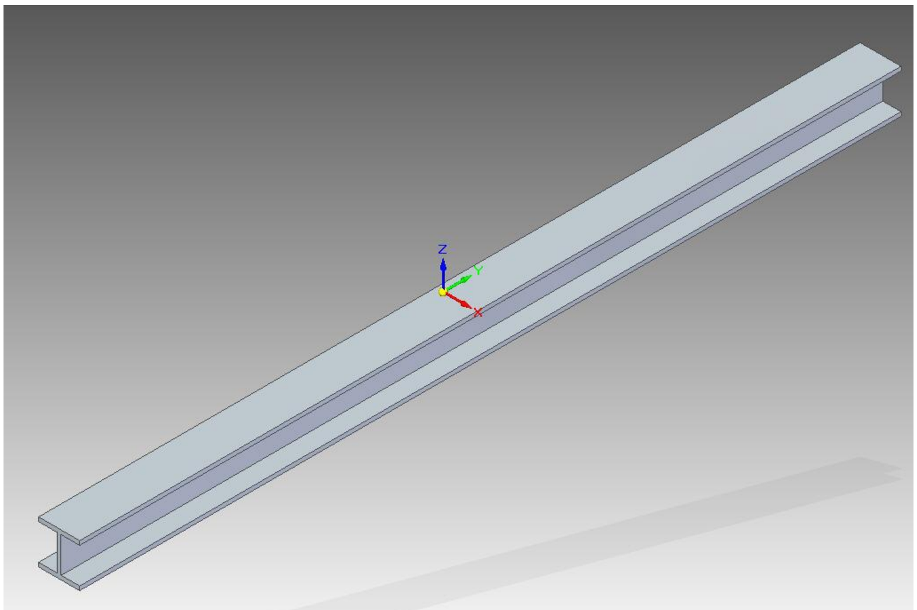
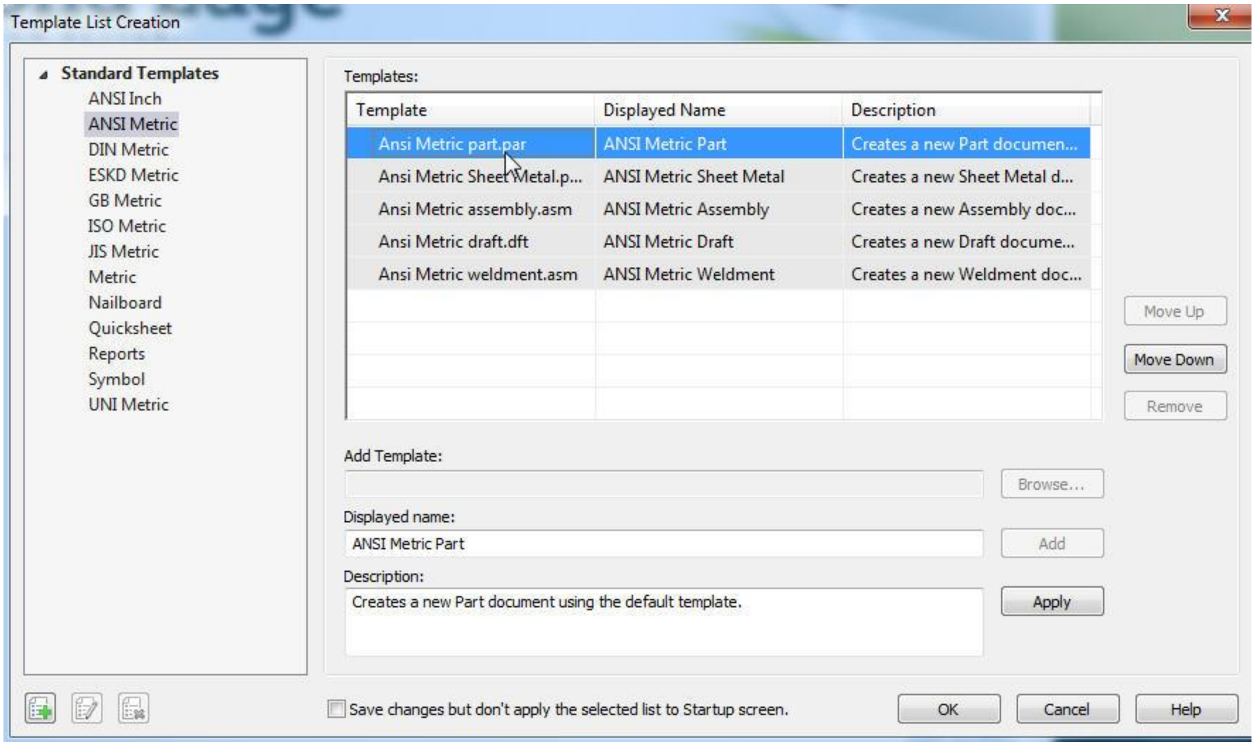
Beam in Solid Edge



Drawing an “I” beam in Solid Edge is a fairly simple operation. This activity will demonstrate the process necessary to draw and analyze a beam.

Begin a new part document. You can select the template of your choice by selecting Links for Edit List as shown below.

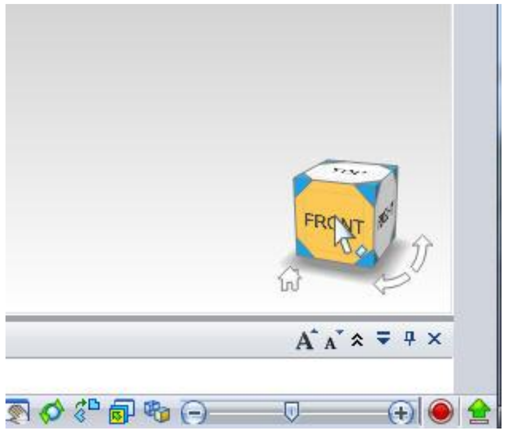
Select the system specified by your teacher.



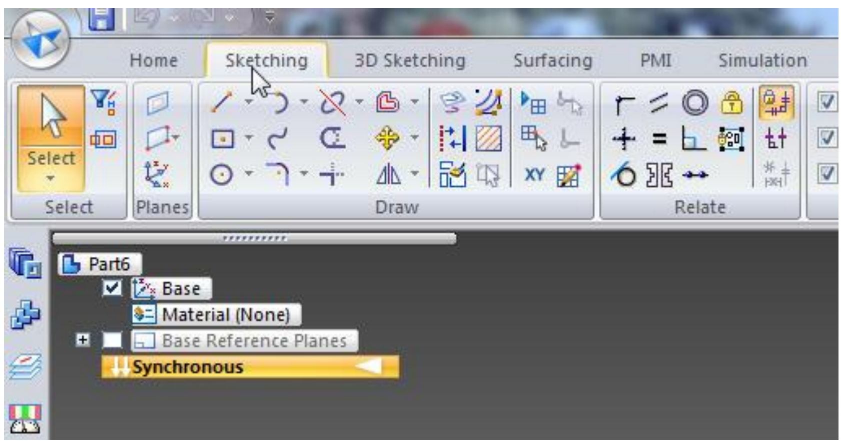
From the list of choices from the specified system select the “Part.par” option to place the choice on the list. Select Apply. Select OK to place the selection as the default system.

Select the Part option. As shown below, the ANSI Metric Part is selected. This will open a new part file.

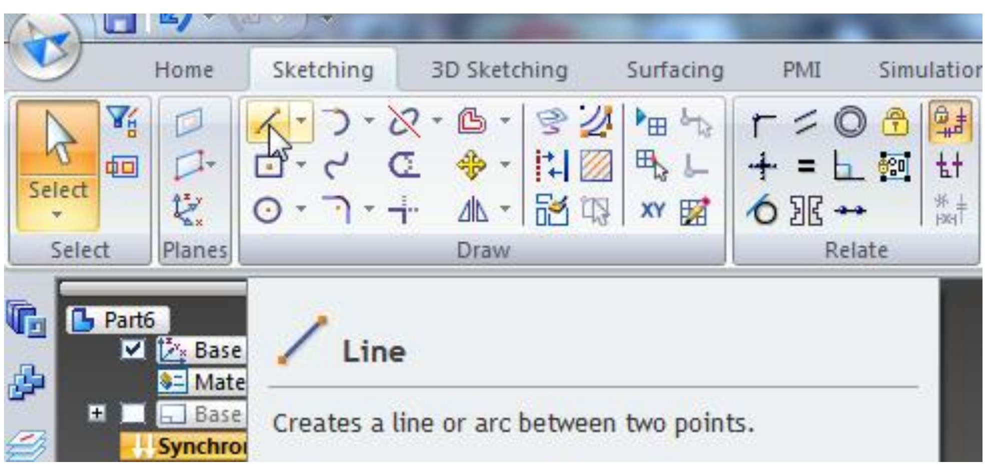
Once the part file opens, select the view control in the bottom right corner of the screen. Click on the Front to center the view.



Next, select the Sketching ribbon at the top of the screen to bring up the Sketching Tools.

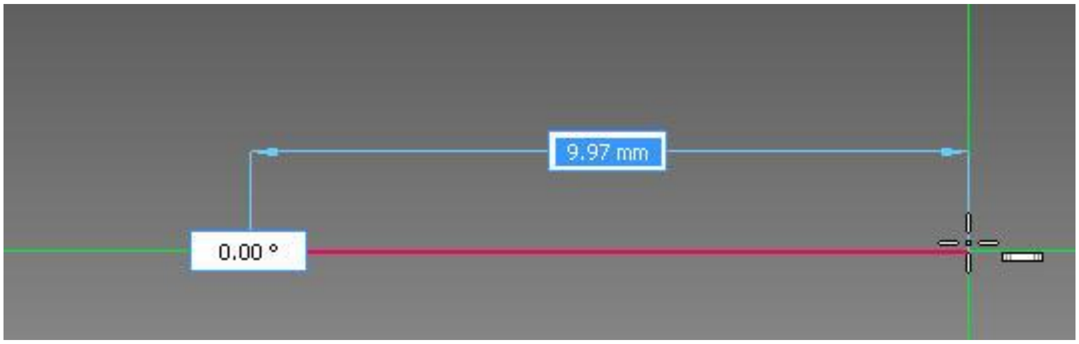


Select the Line command from the Sketching ribbon.

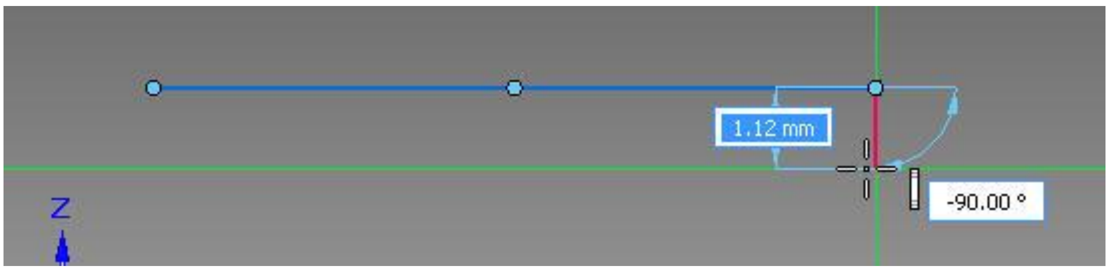


Begin drawing your “I” shape. It doesn’t have to be totally accurate but if it is close it will be much easier to complete the shape to analyze. Begin by clicking on the screen and then moving your mouse to the right. In this instance the line about 10 mm in length.

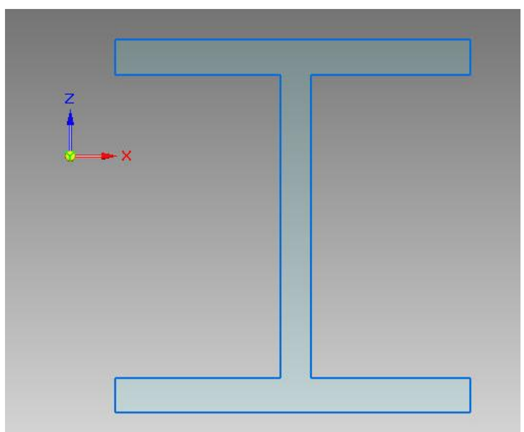
After the shape is identified it will later be constrained to be accurate. If the scale is incorrect zoom in and out using the wheel in the middle of your mouse.



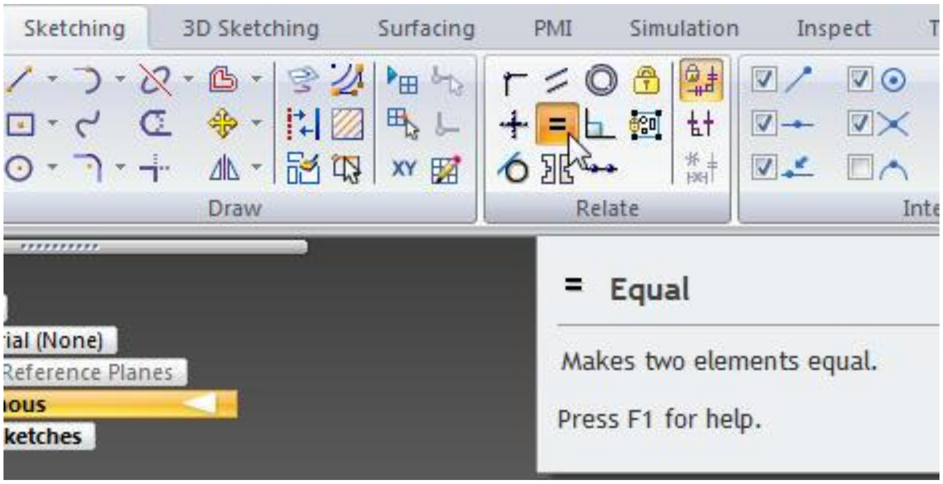
The software is intuitive. Moving at a right angle locks in at -90 degrees. A top web thickness of about 1 mm is desired. Don't worry if it is not quite exact.



Continue around the "I" getting the shape close.

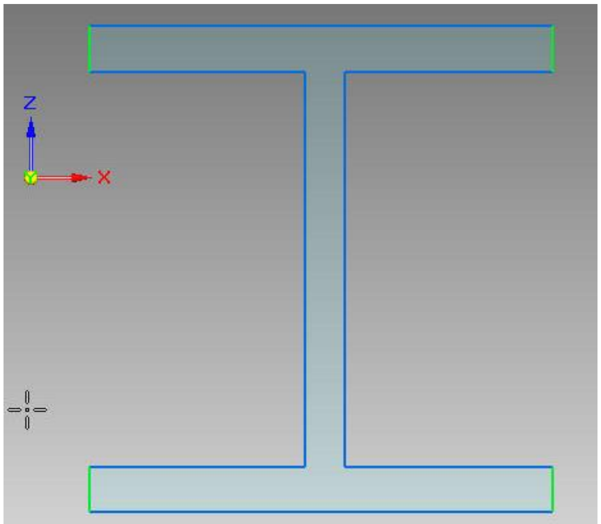


The next step is to set exact dimensions desired by constraining and dimensioning the beam. The top and bottom webs are equal. Begin by selecting the Equal selection from the Relate section of the Sketching ribbon.

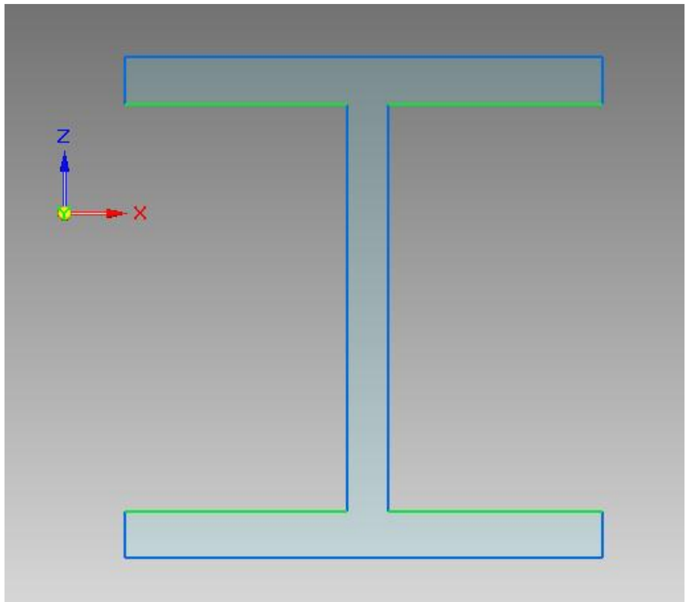


This command will create lines exactly the same length. Multiple lines can be selected by holding the shift key down. Select the vertical line at the top left and then hold the shift key down while you select the other lines to set them all to the same length.

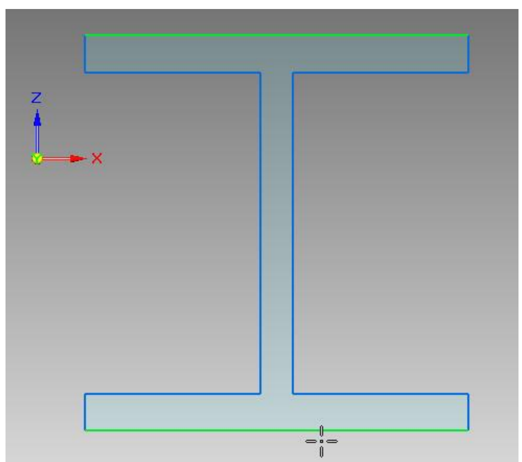
Notice how all the vertical lines are now green. This will allow us to use one dimension and then set all the dimensions to be identical. A prompt will request selection of the primary element to control the dimensions. Select the top left line again. It will now be applied to all the lines that were selected.



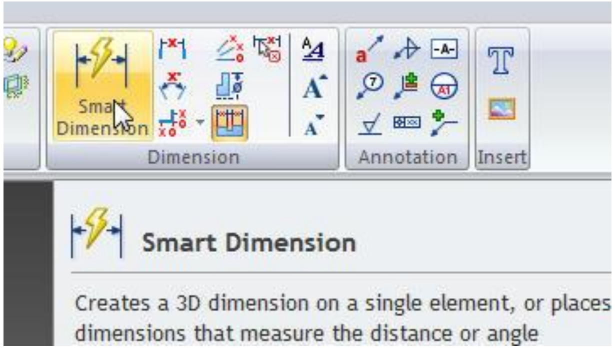
Repeat the process for the horizontal lines that make up the middle of the “I”. Select the top left inner horizontal line to control the rest.



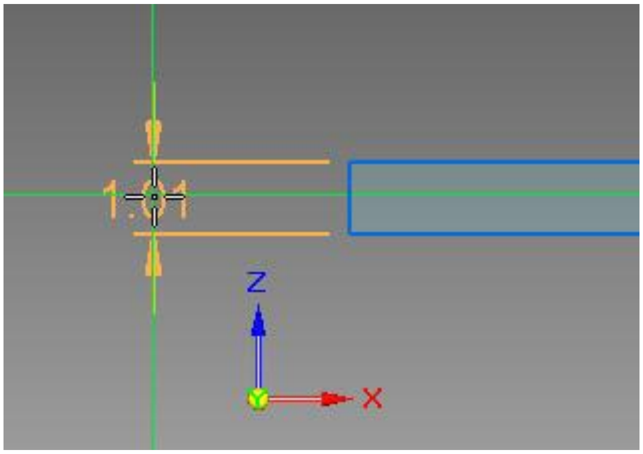
Next set the top and bottom lines equal to each other. It will not be necessary to hold the shift key down as there are only two lines. The lines will be green only momentarily before becoming all blue again.



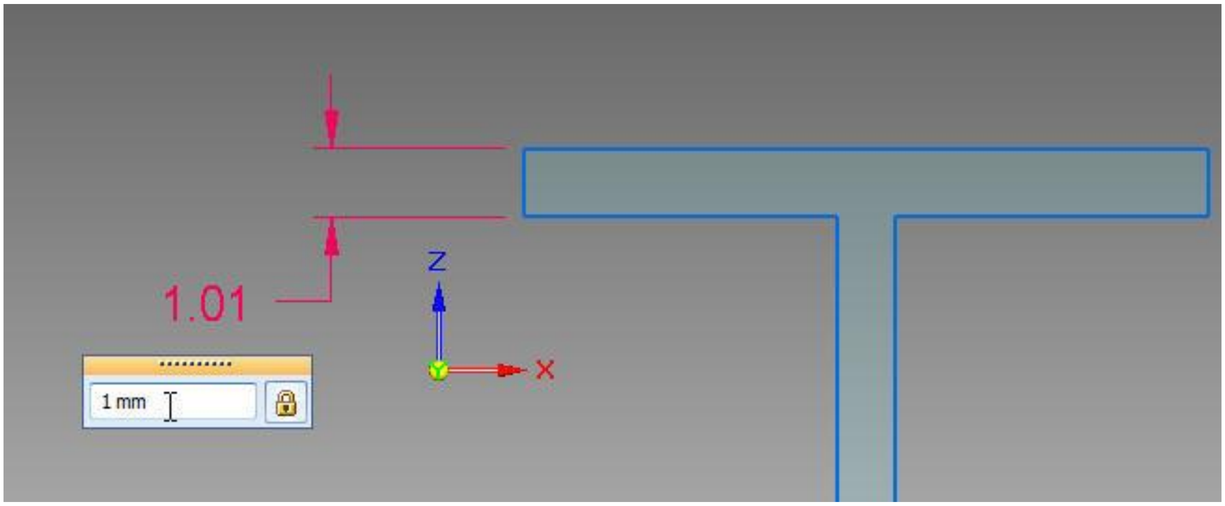
Next add a couple of dimensions to finish the sketch. To begin, select the Smart dimension from the Sketching ribbon.



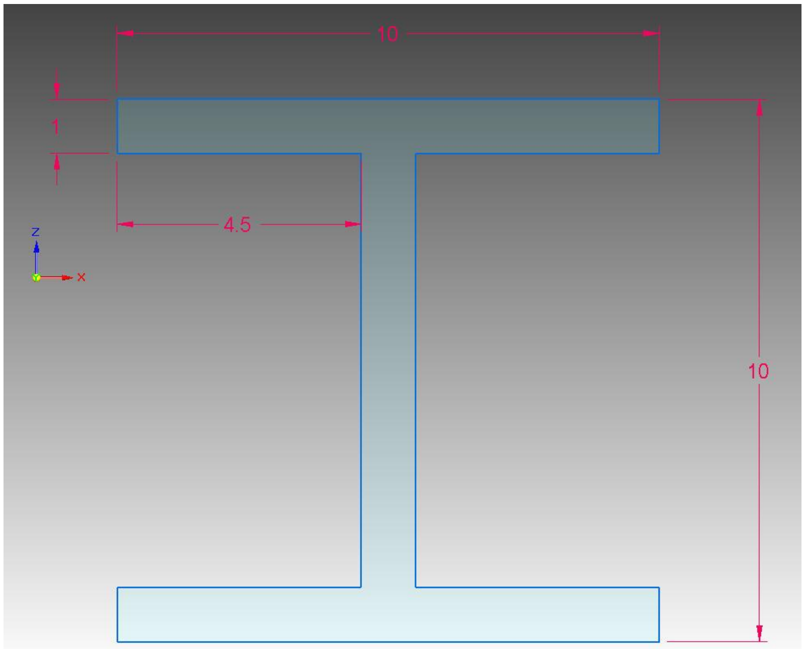
Select the top vertical line on the left previously used as the primary element. After clicking on the line, pull off to the left and the dimension will travel with the mouse.



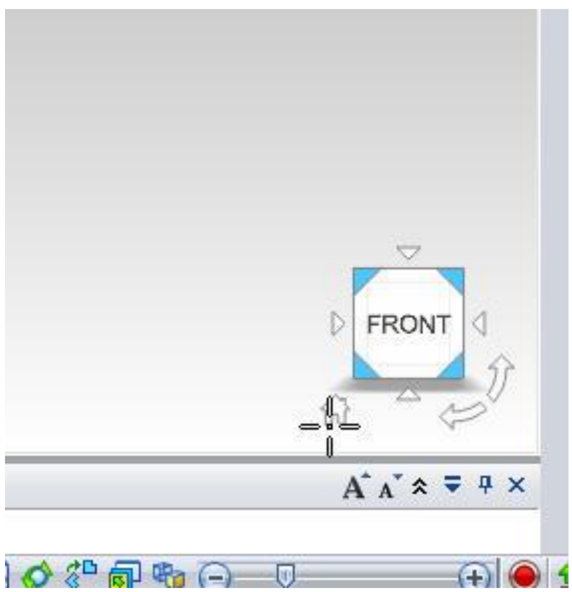
Left click again to place the dimension. The dialog box will open. Set the dimension to the desired size. In this case 1 mm is used.



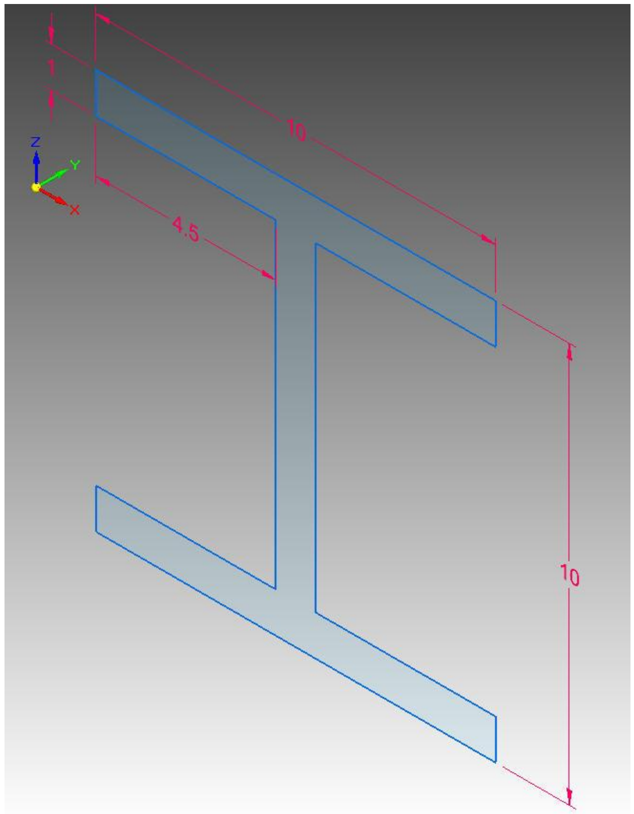
Click on the enter key and the dimension will change and the rest of the lines established as equal will now be 1mm. Add two more dimensions to complete sizing the beginnings of the I beam. If correctly applied, the equal relationships should be consistent with all elements being 1mm thick.



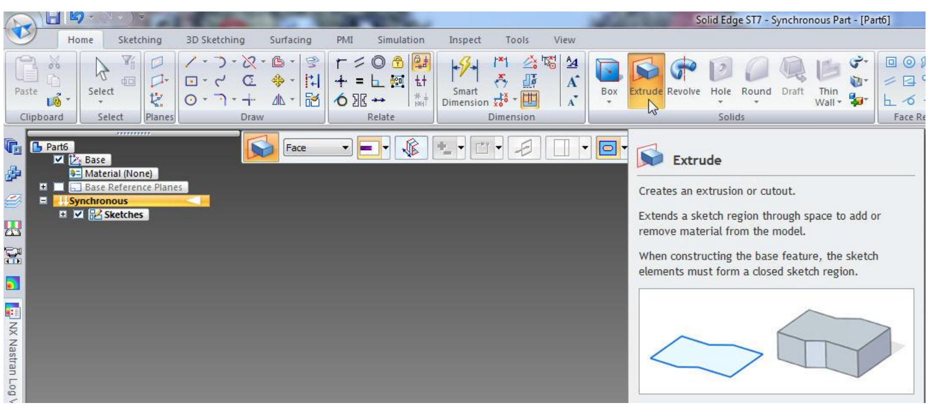
Set the view into an isometric view by selecting the Home on the view control at the bottom right hand corner of the screen.



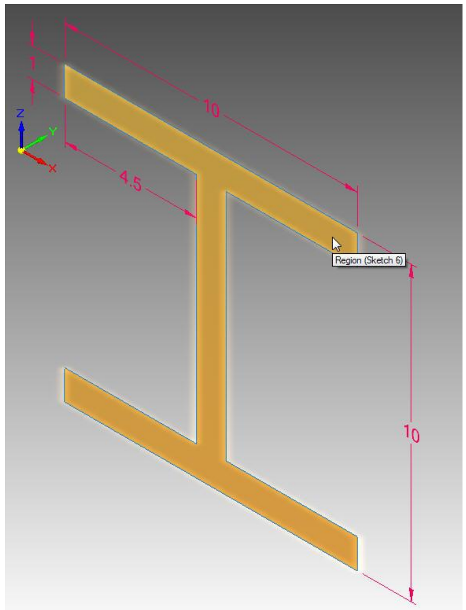
The view should now look similar to the picture below.



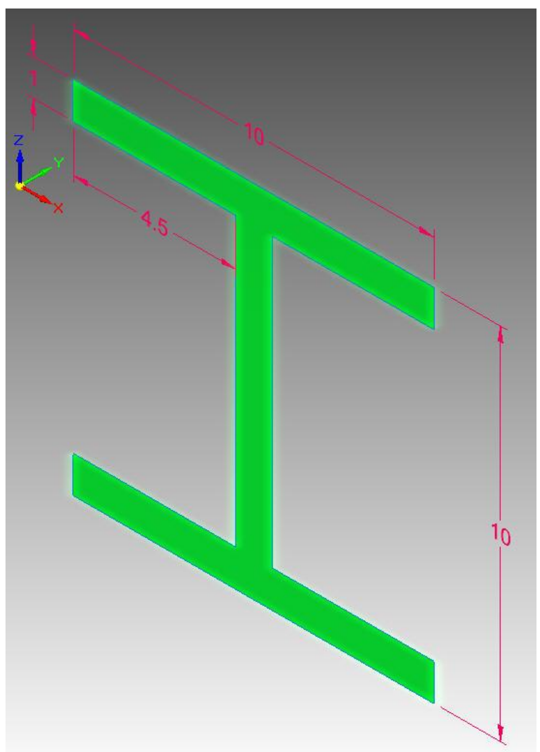
Now the beam is ready to be extruded to the desired length. In this case the beam will be set to 200 mm. Select the Home section of the Ribbon and then select Extrude as the desired option.



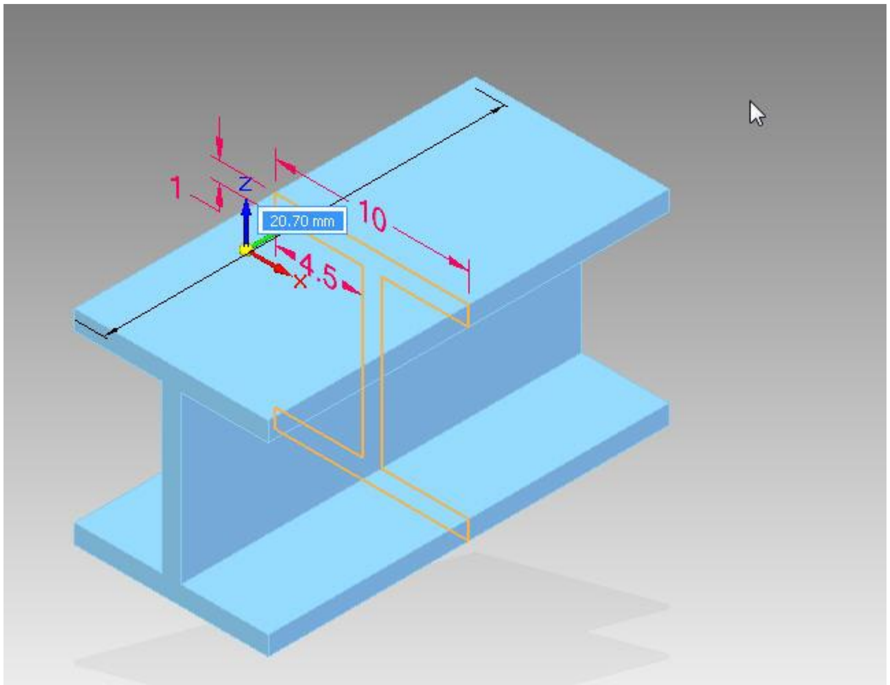
Slide the mouse over the “I” beam created. It will highlight.



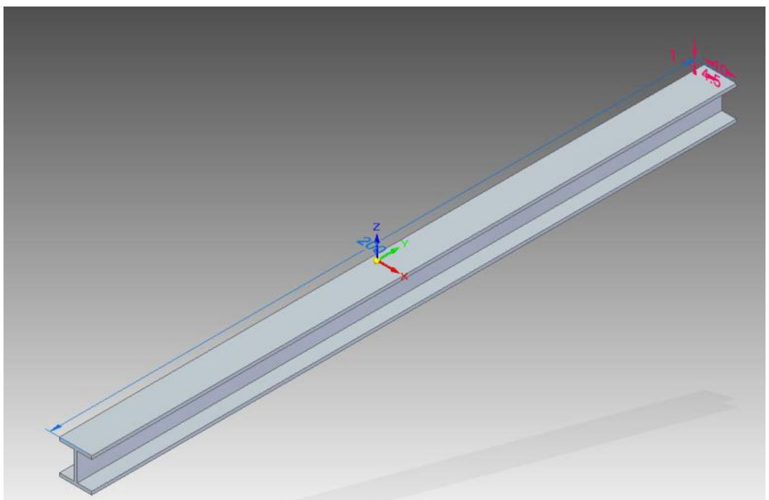
Left click on the “I” to select it. It will change color when selected.



Right click to finish selecting. Moving the mouse will begin the extrusion process. Type 200 on your keyboard setting the length of the “I” beam to 200.



The beam design should now appear as the one pictured below.



To hide the dimensions, right click on each one and select hide. The design is now ready to simulate the testing of the beam. Save the file to be sure it is safe.

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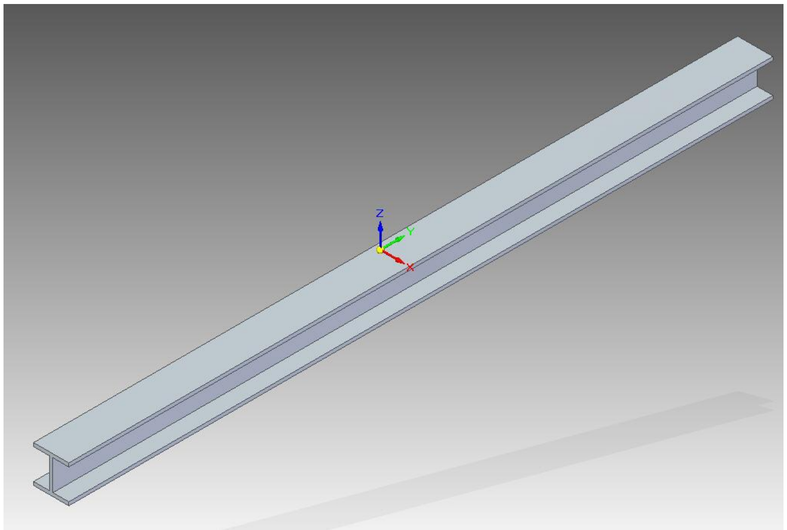
Analysis in Solid Edge



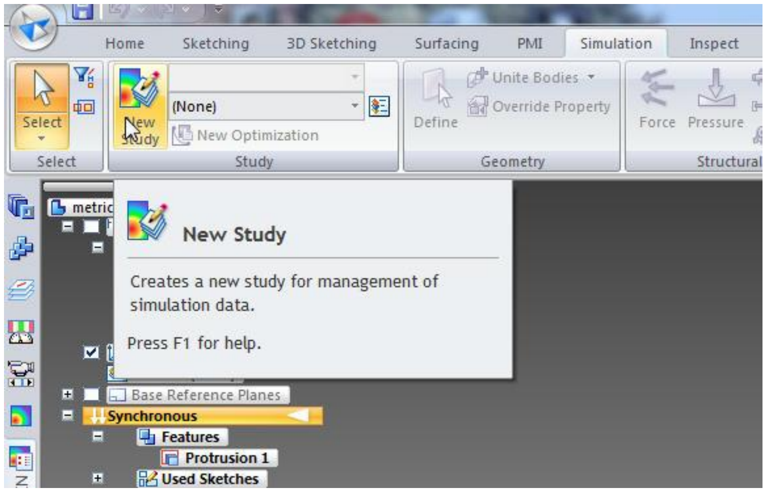
The Analysis function in Solid Edge allows us to simulate loading conditions on the model and determine its behavior or response at different locations. This information allows us to determine how our model will actually perform before we spend the time and material to create the actual structure. To perform the analysis, certain parameters must be set and the process understood.

Finite element analysis predicts behavior by breaking the solid model into small elements. If you think of the beam as made up from hundreds of mini-marshmallows you can see that each marshmallow is one element of the entire structure. As we load the structure each marshmallow interacts with the one next to it so the behavior is easy to see. To perform the analysis on the beam we will need to define how many elements to divide the structure. We create something called a mesh to define the sections. This will allow a focused look at each element and how they all interact. The program will automatically perform the numerical approximation to create the solution based on the solid model boundaries. It is also important to provide the material so the analysis will understand how it will behave. We can then export a report of the analysis to see visually how our design will perform under conditions we are likely to see.

Analysis Setup

Open the beam file designed in the beam design activity.

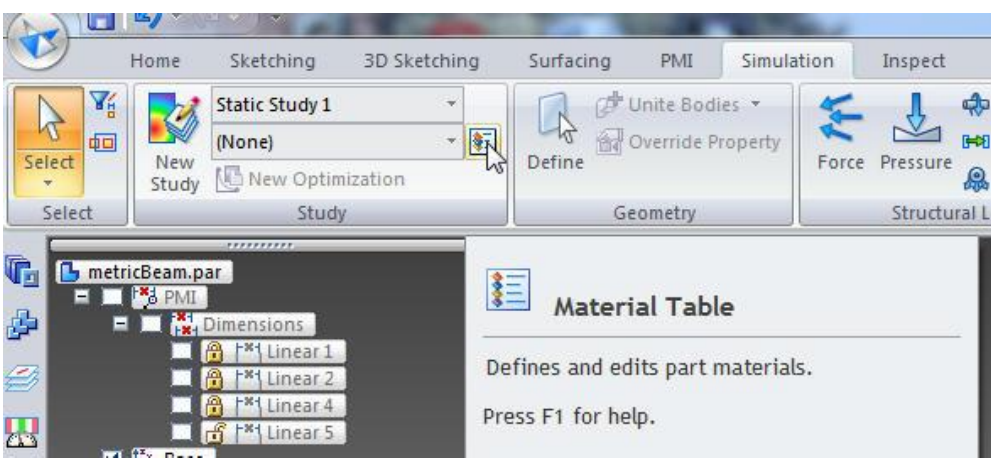
Select the Simulation section of the ribbon. When it appears, select New Study to begin the analysis setup.



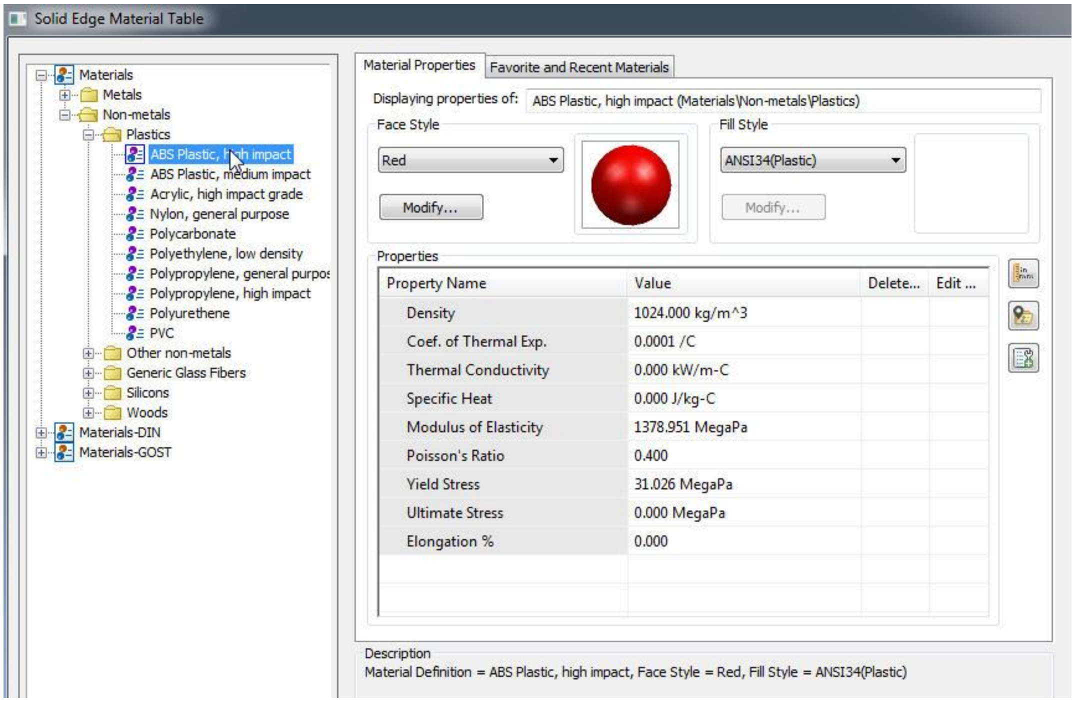
Click on New Study to see a dialog box for more details about the type of simulation available.

Select Linear Static as the study type and set the mesh type to tetrahedral. Select OK.

Next, assign a material to the beam. Select the button for the Material Table in the Study area of the ribbon.

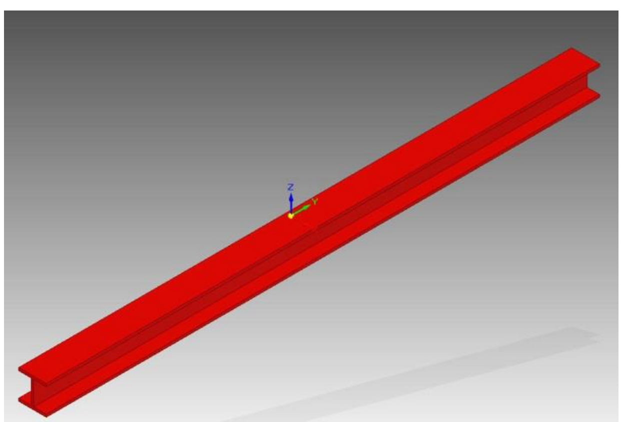


When the Material Table opens, expand the Non-Metals folder and locate the Plastics folder. This example is using the ABS Plastic as the material closest to the plastic the 3Doodler 2 printer uses. Change the color if desired. Designers can add materials based on the type of work planned. A good source for the information about materials can be found at www.matweb.com.



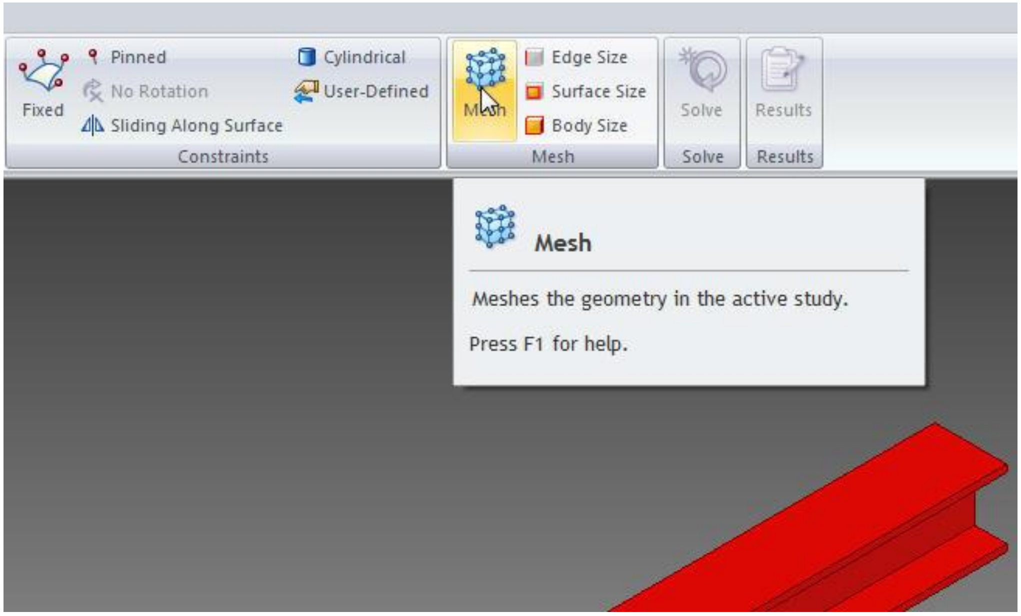
When all selections have been completed, click on the “apply to model” button at the bottom of the dialog box.

At this point, the color selected should be applied to your model. The color is a fun aspect of design work, but the parameters such as the modulus of elasticity will provide important information about how the model should behave.

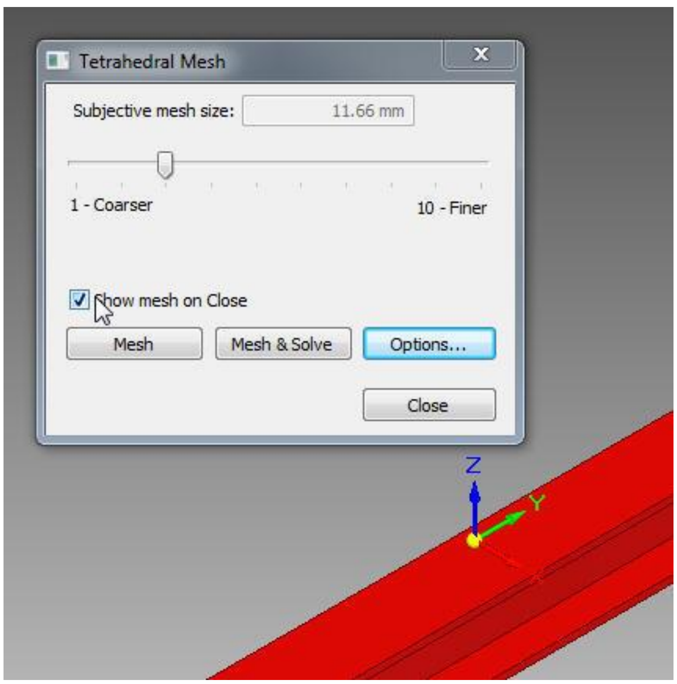


Now that the material has been applied we can set the mesh. If the mesh is too fine it will take a long time to solve. If the mesh is too large the computer will not be able to figure out how the structure will behave.

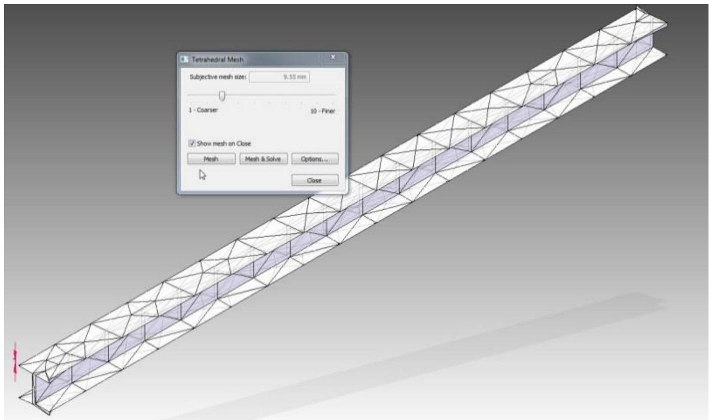
Select the Mesh icon from the Mesh section of the Ribbon.



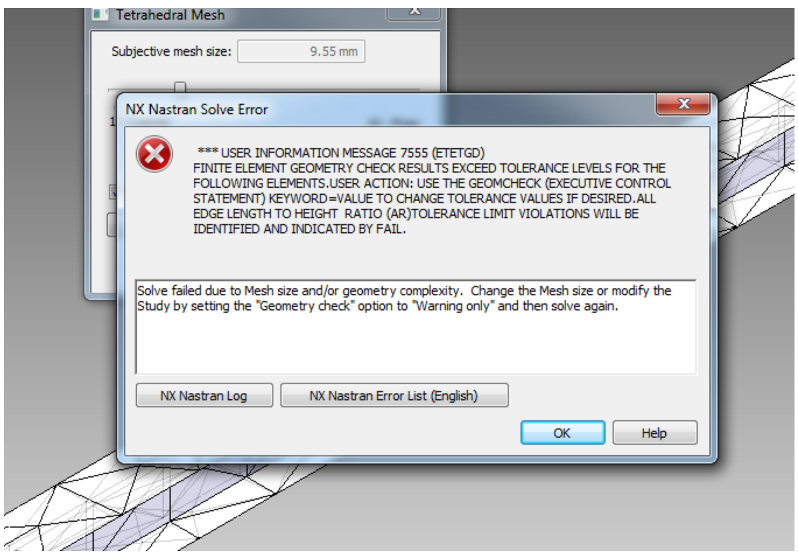
This will open the Tetrahedral Mesh dialog box. Begin by checking the box for Show mesh on Close.



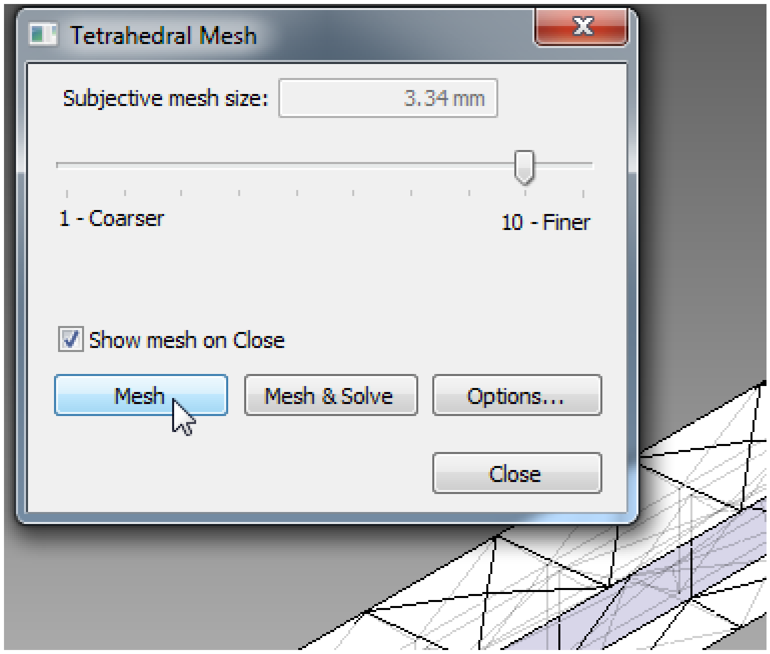
Click on the Mesh button. A mesh will be applied to your beam. The mesh should look fairly course.



Click on the Mesh and Solve button. This should indicate whether the program can actually solve the mathematics. In this case the program created a mesh that was too large.

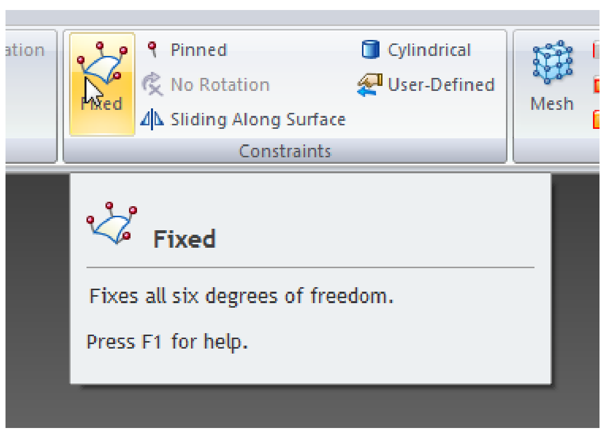


Since the error is about mesh size we can make the mesh smaller with the slider. Dismiss the error message and move the slider to make the mesh smaller.

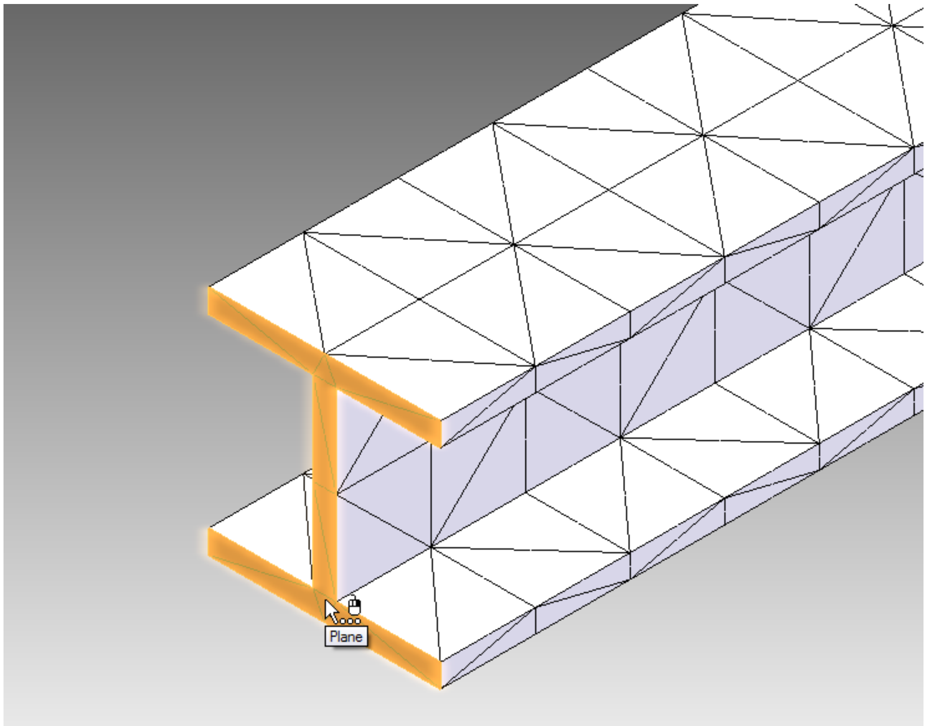


The result of clicking on mesh this time will be a much smaller mesh. Select Close.

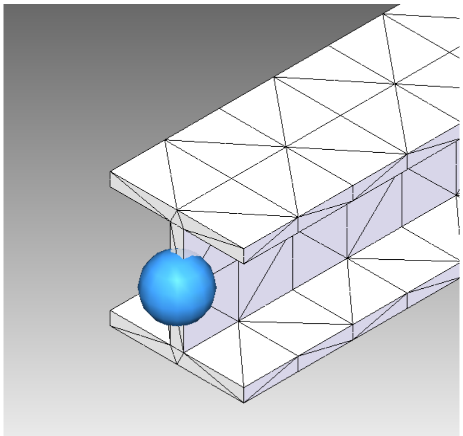
In order for the computer to solve the analysis, some constraints must be added. In the constraints section of the ribbon select the Icon for Fixed.



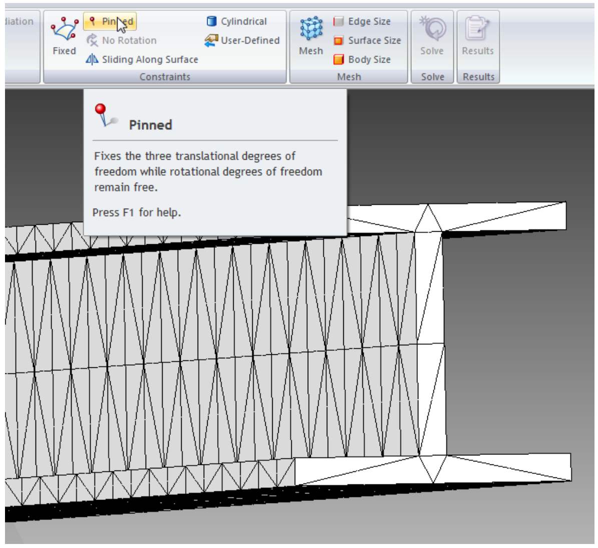
Now select the end of your beam. Wait until it highlights to ensure selection of the end plane.



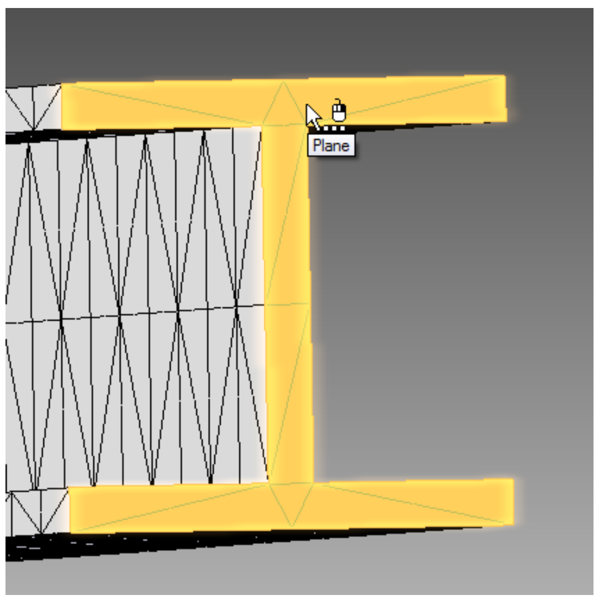
Left click to select the end and then right click to fix the end. A ball will appear to indicate that it is fixed.



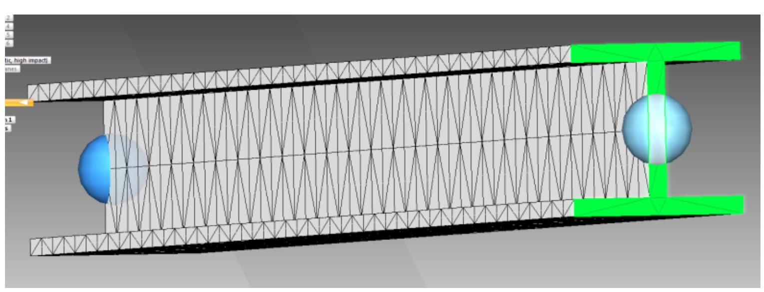
To truly see how this beam will behave it is necessary to pin the opposite end to allow it to be stationary but still allow the beam to move. Rotate the beam around to look at the opposite end. Select the Pinned Icon from the Constraints menu.



Select <u>just</u> the end. Left click to select and then right click to accept the end.

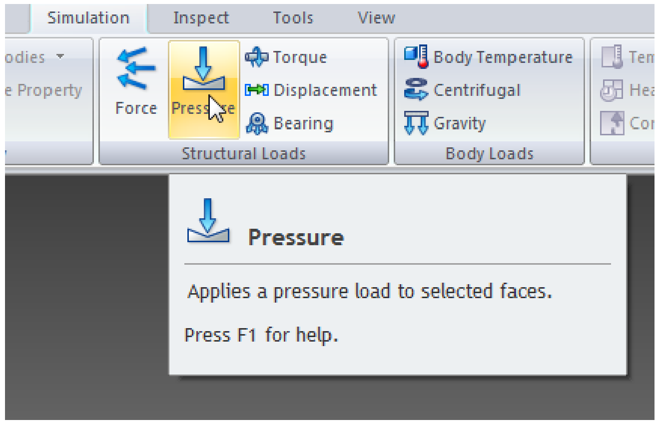


There should be a ball on each end of your beam.

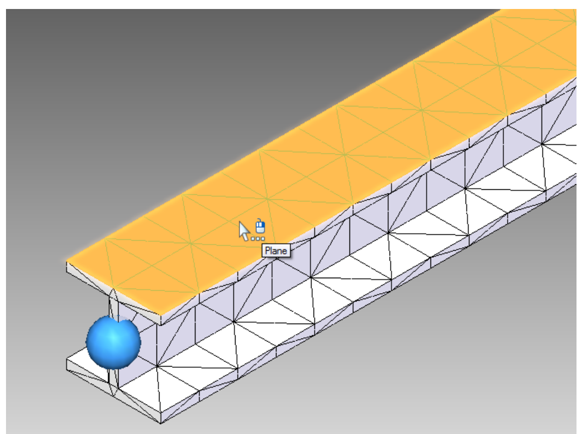


Return to the isometric view.

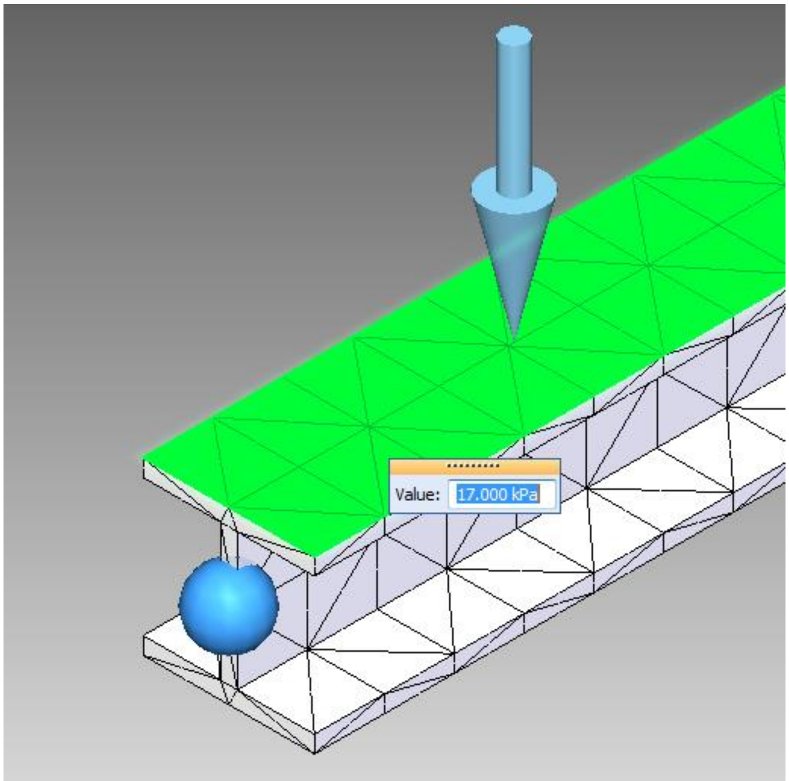
Define the load applied to the beam. From the ribbon find the Structural Loads section. Select the Pressure icon.



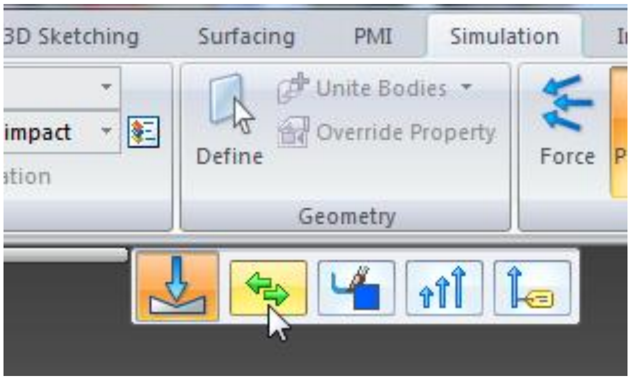
This will add a force equally along the face of the beam selected. Click on the top surface of the beam.



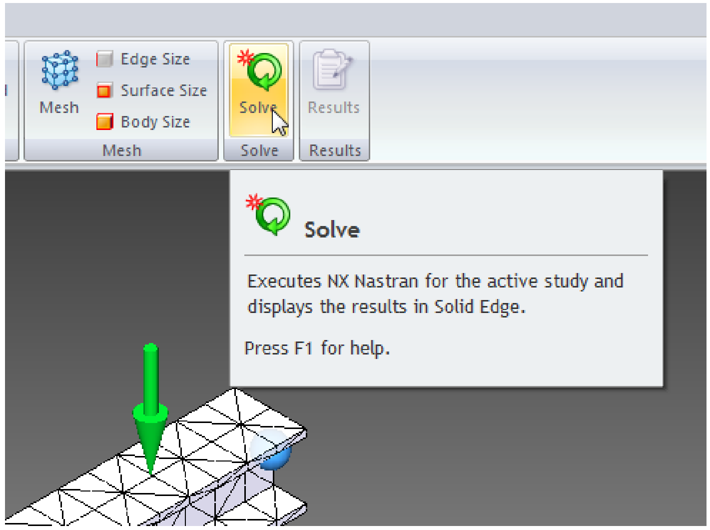
Force arrows appear. This example utilizes a force of 17 kPa in a downward direction.



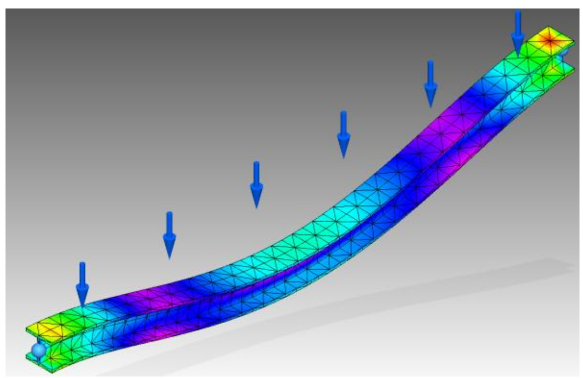
If the arrows are pointing up reverse the arrow by selecting the flip direction arrows on the tool bar or typing F to flip the direction. Right click to accept the setting.



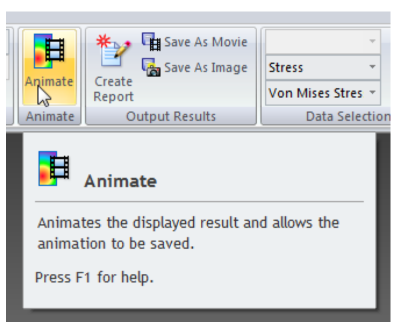
Now try to solve the analysis of the beam. Select the Solve button on the Ribbon.



After thinking for a few seconds the analysis solution appears.

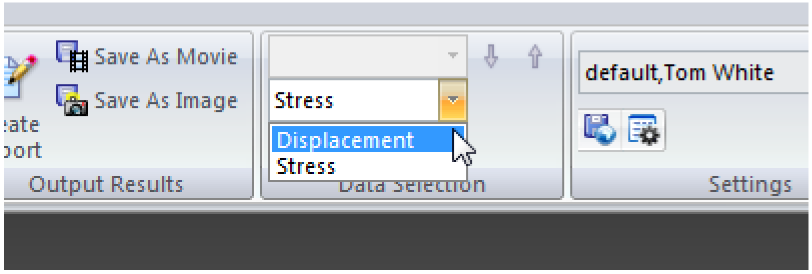


At this point it is possible to animate the force. On the ribbon select the Animate icon.

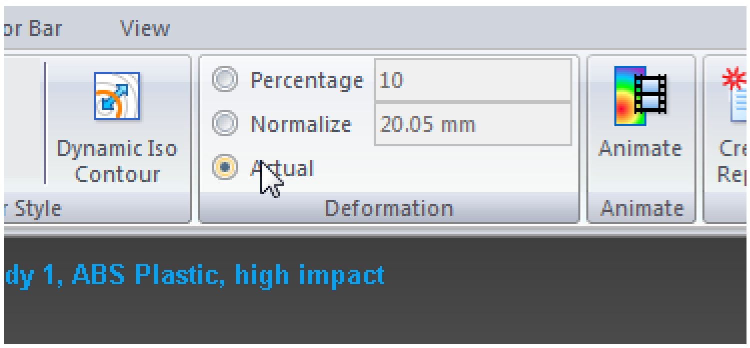


Select close on the Animation toolbar.

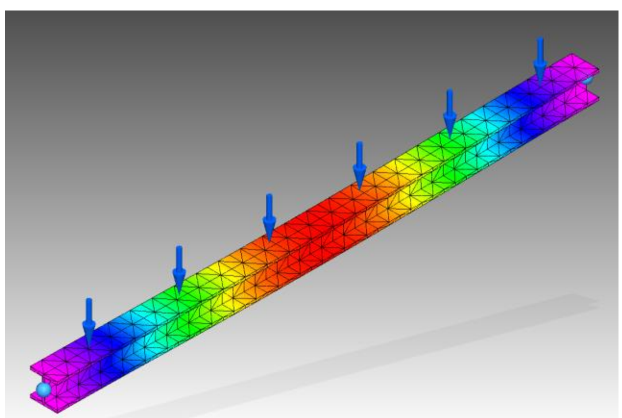
On the right of the screen see the display of the forces and the color they are assigned. Change the display to look at Deflection. From the Data Selection section of the ribbon change the selection from Stress to Displacement.



The colors associated with the deflection are visible. The computer exaggerates the image to magnify the change making the effect visible. To show the display without the distortion select Actual radio button in the Deformation section of the ribbon.

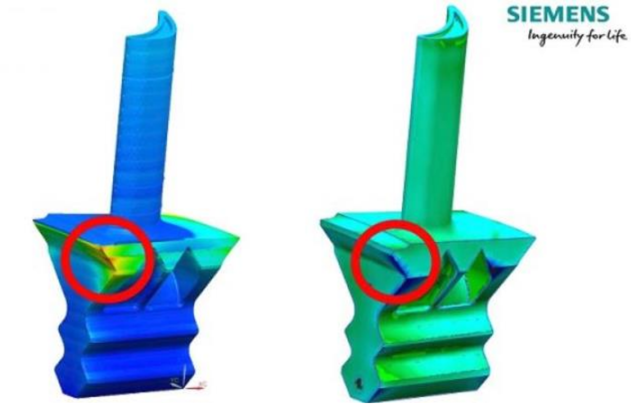


The effect will be seen immediately. Now the display is showing the displacement in proportion to the object.



Save the animation movies to play back during a report. It is also possible to print out the entire report of the simulation results. Control of these options is found in the Output results of the ribbon.

Back

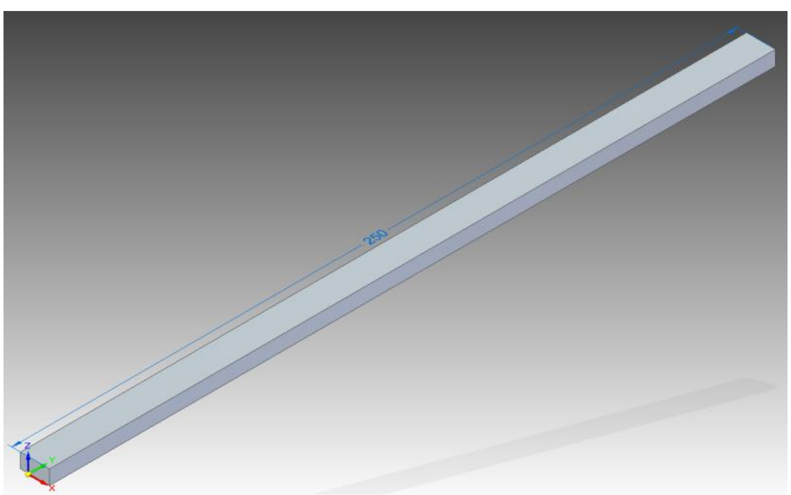


Testing Beams

When designing beams, there are numerous formulas to use to predict behavior. While engineering and design software can do much of the work for us we can also utilize some basic formulas and design a quick test to see how materials will behave.

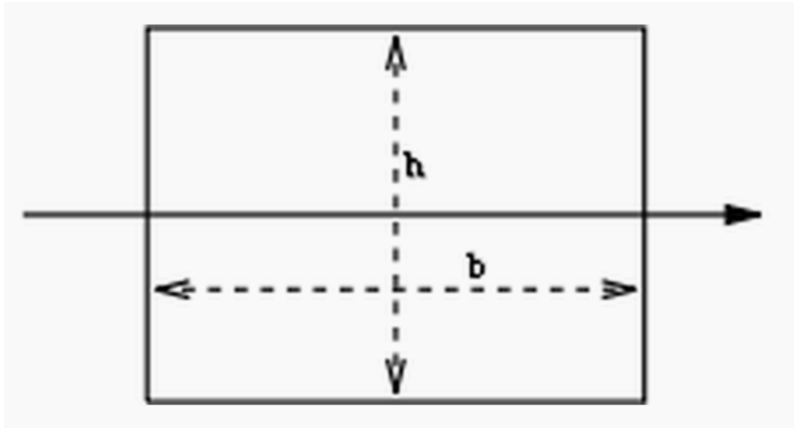
Materials needed:
Dial Caliper
Blocks or pencils
Plastic cup
Sand
String
Paper clip

Design and print a rectangular beam that is 5X10X250 mm.



To predict how this will behave we need to test this beam by applying a load and seeing how it will behave.

The area moment of inertia is a number applied to predict the strength of the shape. With a simple shape such as ours we can utilize a basic formula to calculate this value.



$$I_x = \frac{bh^3}{12}$$

Where b is the width of the base and h is the height.

This number represents the area moment of inertia.

Deflection is how much the beam will bend in the middle. We use the formula

$$Deflection\Delta = \frac{L^3 \times F}{48 \times E \times MI}$$

Where
L = Length
F = Force in Kilograms
MI = Moment of Inertia
E = Modulus of Elasticity
Δ=deflection

In our case we will be measuring the deflection. We know the moment of inertia from the calculation. We know the length of the beam and we can weigh the plastic cup and sand. Our unknown in this formula is the actual Modulus of Elasticity. There are tables where we can look up to see what the average value might be. In our case we will be using the 3Doodler to create the beam. Due to the layered nature of the plastic it will not be uniform so we test to see what kind of a value we might use in future calculations.

The formula is rearranged and the values of the base and height are used to provide us with the missing information

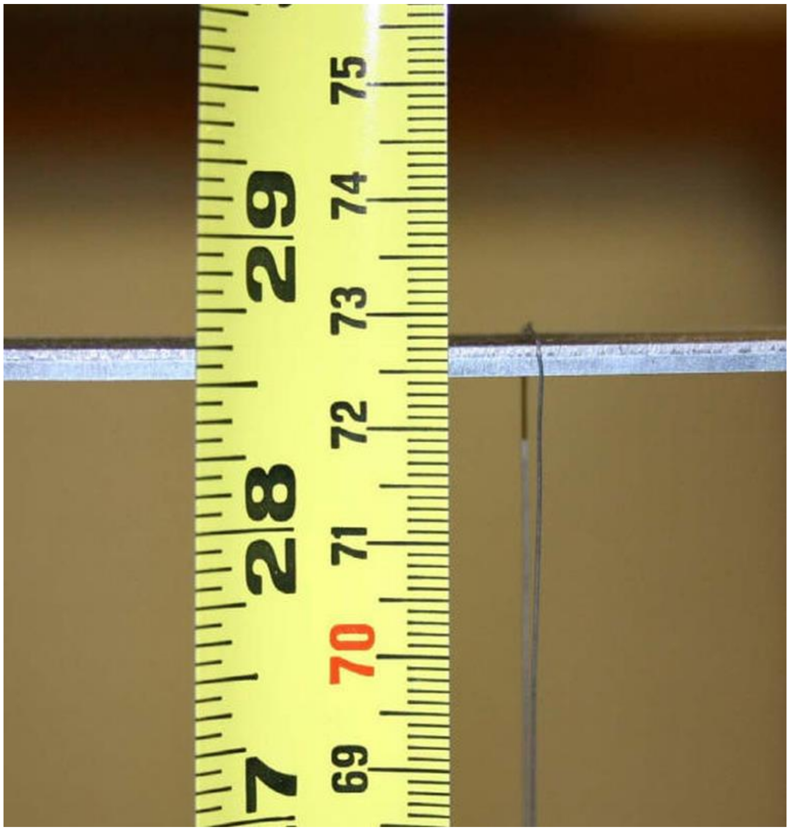
$$E = \frac{L^3 \ x \ F}{4 \ x \ \Delta \ x \ bh^3}$$

The deflection is represented by the Δ

What the formula tells us is the longer the beam, the more deflection you will have from the same force. It is a geometric relationship so the length is very important.

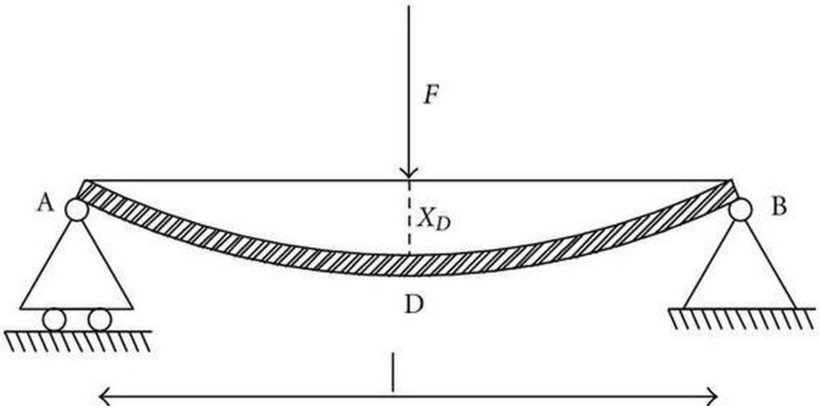
Testing

- Separate two pieces of same-height furniture (such as desks or lab stools) about 20-cm distance apart.
- Use masking tape to fix a pencil on the surface next to the edge of each.
- Measure the distance between two pencils and record this data in your engineering notebook.
- Place the sample beam on the top of two pencils so there is a known distance between the pencils and the beam is adequately supported.
- Measure and place a mark on your beam at the center of the span
- Measure the distance from the floor to the beam center mark.
- Measure the mass of plastic container with string on the triple-beam balance which will be the initial weight.
- Hang the plastic container in the center of the beam and measure how much the beam deflects. Record this in your engineering notebook.



- Add sand to your container a little at a time. The deflection will increase.
- Measure the distance to the floor. This difference between the original measurement and the new measurement is the displacement.
- Weigh the plastic container string and sand. This will give you the total weight in Kg for your force.

Use Excel to graph to display the relationships of “loading force vs. displacement” for the materials.



Testing with a torque wrench.

Normally a torque wrench is used to apply a specific torque to a fastener. They are used extensively in the assembly of all kinds of mechanisms. Assembly manuals will provide a specific torque that should be applied. In the picture below a mechanic is tightening a bolt to a specified torque.

In beams we see moments caused by the loading of the force. It creates a twisting force at the support. Eventually it will cause failure if the force is more that the structure can stand. Clamp the end of the beam in a vice so a small portion is protruding from the vice. Find a socket that fits the end of your beam. If you drew it to exact dimensions a 10mm socket will fit. Set the wrench to .1 N-m. Twist slowly until you hear the click. This is the same amount of torque that you would find if you placed the one kilogram weight in the center of the beam during testing.

Design your own beam shapes

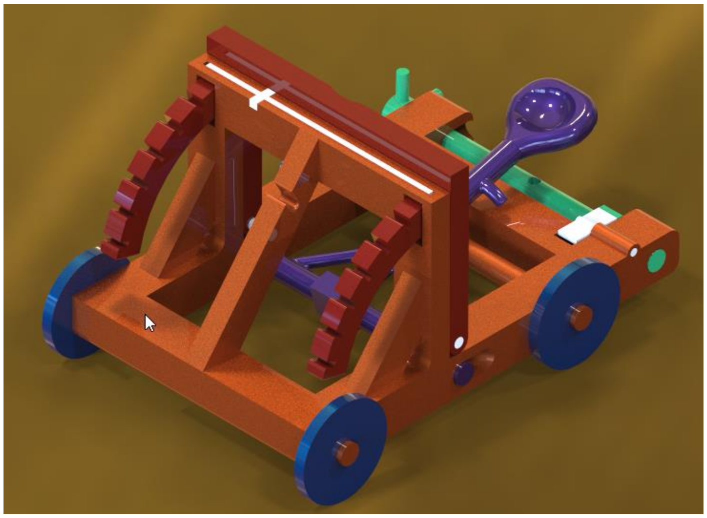
Using the Solid Edge you can create beams of different shapes and test them the same way. Create the different shapes you want to try and then apply weight and torque to see how they behave.

Back

SIEMENS

Ingenuity for life

Projectile Motion



Before beginning to create a chart in Excel to analyze the range and power needed to hit a target anywhere, watch some videos from the Khan Academy found at the following website: https://www.khanacademy.org/science/physics/two-dimensional-motion/two-dimensional-projectile-mot/v/horizontally-launched-projectile. This will help in understanding the two dimensional motion and how gravity affects the path of the projectile.

To develop a tool to predict where an object will land, data collection is required. In this example we will launch multiple times with the same power and the same angle. Then take those results and calculate the mean and the standard deviation. The mean provides the average distance and the standard deviation indicates what the range of results might be. A very small standard deviation means your prediction will be fairly accurate. A larger standard deviation means it will come close but might not be as accurate or precise. Thinking of a target, accuracy is hitting the bullseye. Precision is having all your arrows hit in the same spot even if it is not the bullseye.

With the data collected a graph can be created. A formula can be used to determine the angle to set the catapult to hit a desired distance. As shown in the Khan Academy videos, we can use the initial velocity and the launch angle to determine where the projectile will land mathematically utilizing vectors. You read about dividing the problem into horizontal and vertical vectors. The horizontal displacement remains constant if you don't allow for wind resistance. The vertical displacement depends on the acceleration due to gravity (when throwing a ball straight up in the air it eventually stops rising and then begins to fall.)

Your task in this activity is to take the equations watched and use them to create an Excel spreadsheet to help calculate where the projectile will fall.

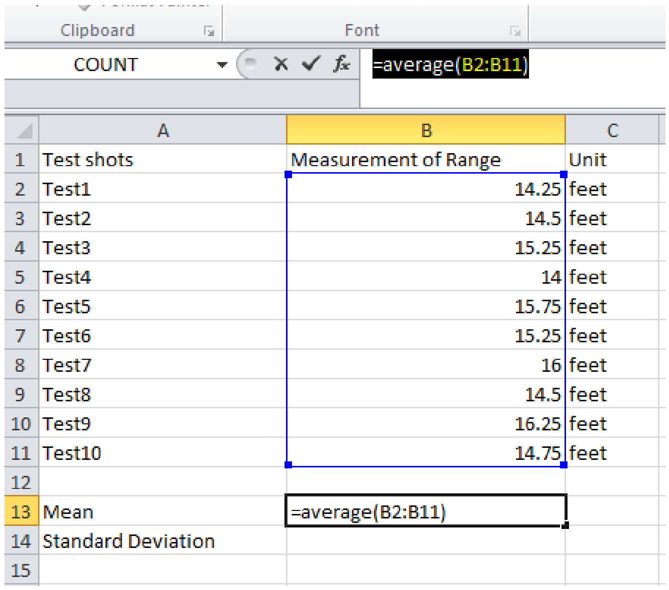
Procedure

Open a new Excel spreadsheet.

Prepare your launcher. We need to determine the initial velocity of the projectile. In order to do this we either we need to know the time the projectile is in the air or the angle of launch and distance traveled. You and your teammates will launch a ping pong ball ten times using the same angle each time. Measure the distance (range) the ball travels each time. Your measurements will be completely different from those found in the example here.

	A	B	C
1	Test shots	Measurement of Range	Unit
2	Test1	14.25	feet
3	Test2	14.5	feet
4	Test3	15.25	feet
5	Test4	14	feet
6	Test5	15.75	feet
7	Test6	15.25	feet
8	Test7	16	feet
9	Test8	14.5	feet
10	Test9	16.25	feet
11	Test10	14.75	feet

When you have data, begin to analyze the data. Use the Excel function to calculate the mean. Enter the formula =average(B2:B11) in cell B13. Once the formula is entered hold the CTRL key and the Shift key down while you hit the enter key. This lets the program know you are done with the formula. The sheet now displays the arithmetic mean of the data.



	A	B	C
1	Test shots	Measurement of Range	Unit
2	Test1	14.25	feet
3	Test2	14.5	feet
4	Test3	15.25	feet
5	Test4	14	feet
6	Test5	15.75	feet
7	Test6	15.25	feet
8	Test7	16	feet
9	Test8	14.5	feet
10	Test9	16.25	feet
11	Test10	14.75	feet
12			
13	Mean	=average(B2:B11)	
14	Standard Deviation		
15			

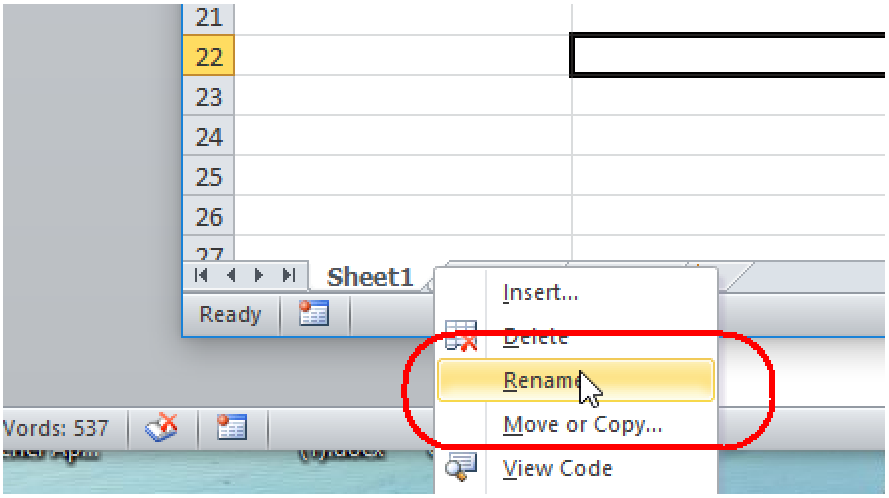
The mean is now a number.

12			
13	Mean	15.05	feet
14	Standard Deviation		

To find out how accurate the launch is find the standard deviation of the data. In Cell B14 enter the formula =stdev(B2:B11). Use CTRL Shift Enter to finish the formula

1	Test shots	Measurement of Range	Unit
2	Test1	14.25	feet
3	Test2	14.5	feet
4	Test3	15.25	feet
5	Test4	14	feet
6	Test5	15.75	feet
7	Test6	15.25	feet
8	Test7	16	feet
9	Test8	14.5	feet
10	Test9	16.25	feet
11	Test10	14.75	feet
12			
13	Mean	15.05	feet
14	Standard Deviation	0.771002234	feet

Rename this sheet by right clicking on Sheet one and selecting the rename function.



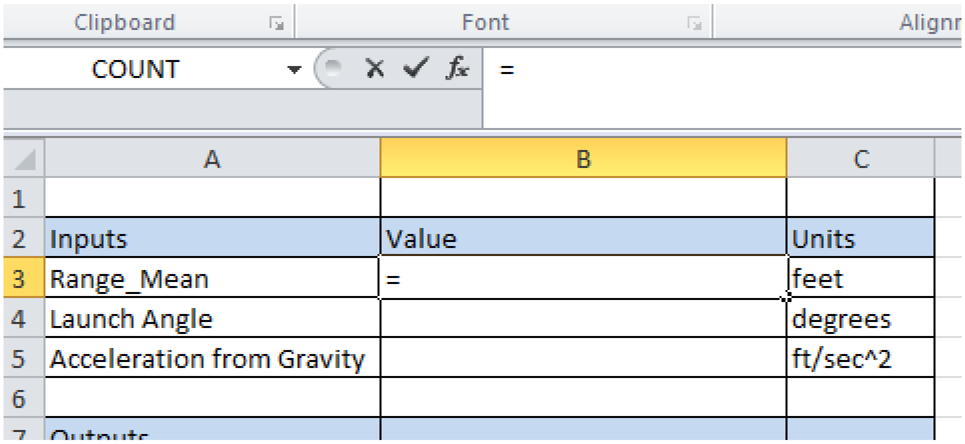
Name the sheet similar to Range_Mean

Switch to Sheet 2. Rename this sheet to Initial_Velocity

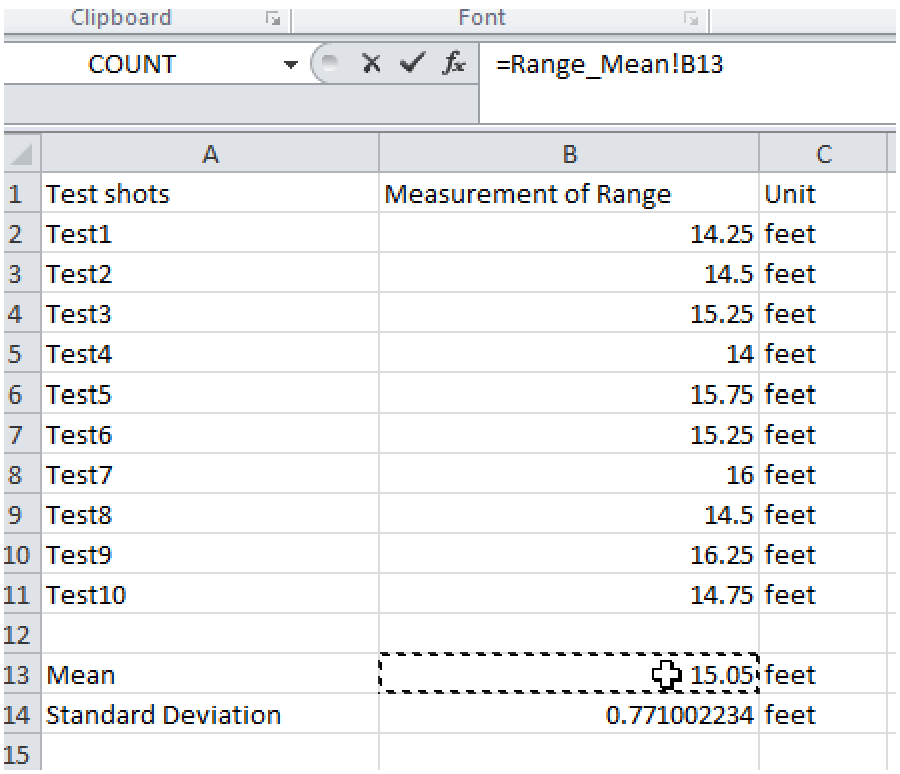
Set up a table similar to the one below.

	A	B	C
1			
2	Inputs	Value	Units
3	Range_Mean		feet
4	Launch Angle		degrees
5	Acceleration from Gravity		ft/sec^2
6			
7	Outputs		
8	Initial Velocity		ft/sec
9			
10			

This will allow us to utilize the formula $v_i = \sqrt{\frac{-gx}{\sin 2\theta}}$ to calculate the initial velocity from the acceleration due to gravity, range that we calculated and the angle that you launched the projectile. Since the Range_Mean was calculated in the previous step link directly to that cell. To accomplish this type the = sine into the cell B3.



Switch to the Range_Mean tab by selecting the tab at the bottom of the page. Select the correct cell. In this case it is B13. You can also type the entire formula of =Range_Mean!B13 into the cell. The ! symbol identifies the cell as being on another sheet.



Hit CTRL, Shift and Enter to finish the equation.

B3 fx {=Range_Mean!B13}

	A	B	C
1			
2	Inputs	Value	Units
3	Range_Mean	15.05	feet
4	Launch Angle		degrees
5	Acceleration from Gravity		ft/sec^2
6			
7	Outputs		
8	Initial Velocity		ft/sec
9			

Enter in the launch angle and the acceleration from gravity in the system of units you are using. The acceleration in the metric system is 9.80665 m/s^2 . When you are using the customary system the acceleration is 32.174 ft/s^2. In this example we can round to 32.2 feet per second per second.

	A	B	C
1			
2	Inputs	Value	Units
3	Range_Mean	15.05	feet
4	Launch Angle	30	degrees
5	Acceleration from Gravity	32.2	ft/sec^2
6			
7	Outputs		
8	Initial Velocity		ft/sec
9			
10			

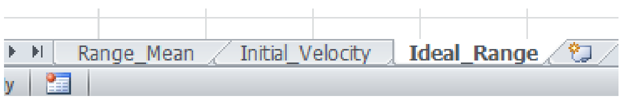
The formula $v_i = \sqrt{\frac{-gx}{\sin 2\theta}}$ is filled in with the values from the table. In this example Cell B8 is where you put the formula. =SQRT(B3*B5/SIN(RADIANS(2*B4))). CTRL, Shift, Enter to finish.

B8 =SQRT(B3*B5/SIN(RADIANS(2*B4)))

	A	B	C
1			
2	Inputs	Value	Units
3	Range_Mean	15.05	feet
4	Launch Angle	30	degrees
5	Acceleration from Gravity	32.2	ft/sec^2
6			
7	Outputs		
8	Initial Velocity	23.65543126	ft/sec

The initial velocity is now displayed in cell B8

The next step allows us to predict the ideal curve created by varying the launch angles from the data just calculated. Go to sheet 3 and rename the sheet Ideal_Range.



Create the following table.

	A	B	C
1			
2	Angle in Degrees	Ideal Range	Unit
3	0		Feet
4	10		Feet
5	20		Feet
6	30		Feet
7	40		Feet
8	45		Feet
9	50		Feet
10	60		Feet
11	70		Feet
12	80		Feet
13	90		Feet

To find the ideal range use the formula pointed out in the Khan Academy videos.

$$x = \frac{-v_i^2 \sin 2\theta}{g}$$

In Excel the formula is looking for other sheets. The $ in the formula keeps Excel from changing the exact cell as the formula is copied. In cell B3 enter the formula =Initial_Velocity!$B$8^2*SIN(RADIANS(2*A3))/Initial_Velocity!$B$5

Once the formula is finished with CTRL, Shift and Enter the results appear in cell B3. It shows a 0 which makes sense as gravity would make it hit the floor immediately.

B3 {=Initial_Velocity!$B$8^2*SIN(RADIANS(2*A3))/Initial_Velocity!$B$5}

	A	B	C	D	E	F	G	H
1								
2	Angle in Degrees	Ideal Range	Unit					
3	0	0	Feet					
4	10		Feet					
5	20		Feet					
6	30		Feet					
7	40		Feet					
8	45		Feet					
9	50		Feet					
10	60		Feet					
11	70		Feet					
12	80		Feet					
13	90		Feet					

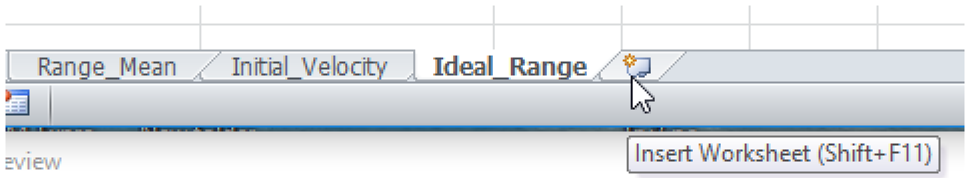
Copy the formula into the other cells by left clicking in Cell B3 and then clicking on the black spot in the lower right hand corner of the cell and dragging it down the page.

	A	B	C
1			
2	Angle in Degrees	Ideal Range	Unit
3	0	0	Feet
4	10	5.943709197	Feet
5	20	11.17051934	Feet
6	30	15.05	Feet
7	40	17.11422854	Feet
8	45	17.3782431	Feet
9	50	17.11422854	Feet
10	60	15.05	Feet
11	70	11.17051934	Feet
12	80	5.943709197	Feet
13	90	2.12909E-15	Feet

Do you see a pattern in the numbers?

The next step is to take readings at all the different angles to see how reality compares to the Ideal.

Add a new sheet to your Excel file by selecting the new sheet icon at the right of the last sheet in the list. Name this one Actual_Range.



Set up the following table

Angle	Test1	Test2	Test3	Test4	Test5	Range Mean	Standard Deviation	Units
10								
20								
30								
40								
45								
50								
60								
70								
80								

Conduct tests on each angle and enter the range into the sheet.

Angle	Test1	Test2	Test3	Test4	Test5	Range Mean	Standard Deviation	Units
10	5.5	5.25	6	5.25	5.75			feet
20	11	10.5	11.25	10.75	11.5			feet
30	15	14.75	14.75	15	14.5			feet
40	17.25	16.75	16.5	16.75	16.5			feet
45	17	17.25	16.75	17	16.5			feet
50	16.75	16.5	17	16.5	16			feet
60	15.25	14.5	14.75	14.25	14.75			feet
70	11	10.75	10.5	10.75	10.5			feet
80	6	5.5	5.25	5.5	5.75			feet

After entering the data, find the range for each angle. Also find the standard deviation.

Use =AVERAGE(B3:F3) in cell G3
Use =STDEV(B3:F3) in cell H3

Copy the formulas to the cells below.

Angle	Test1	Test2	Test3	Test4	Test5	Range Mean	Standard Deviation	Units
10	5.5	5.25	6	5.25	5.75	5.55	0.32596012	feet
20	11	10.5	11.25	10.75	11.5	11	0.395284708	feet
30	15	14.75	14.75	15	14.5	14.8	0.209165007	feet
40	17.25	16.75	16.5	16.75	16.5	16.75	0.306186218	feet
45	17	17.25	16.75	17	16.5	16.9	0.285043856	feet
50	16.75	16.5	17	16.5	16	16.55	0.370809924	feet
60	15.25	14.5	14.75	14.25	14.75	14.7	0.370809924	feet
70	11	10.75	10.5	10.75	10.5	10.7	0.209165007	feet
80	6	5.5	5.25	5.5	5.75	5.6	0.285043856	feet

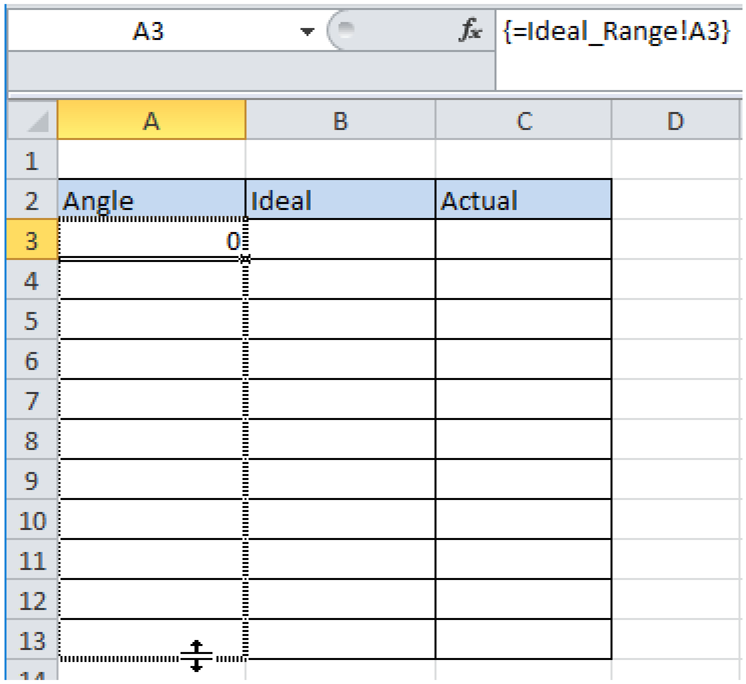
Add one final sheet to the Excel document. Name this one Range_Chart.

Create a table similar to the one below.

Angle	Ideal	Actual

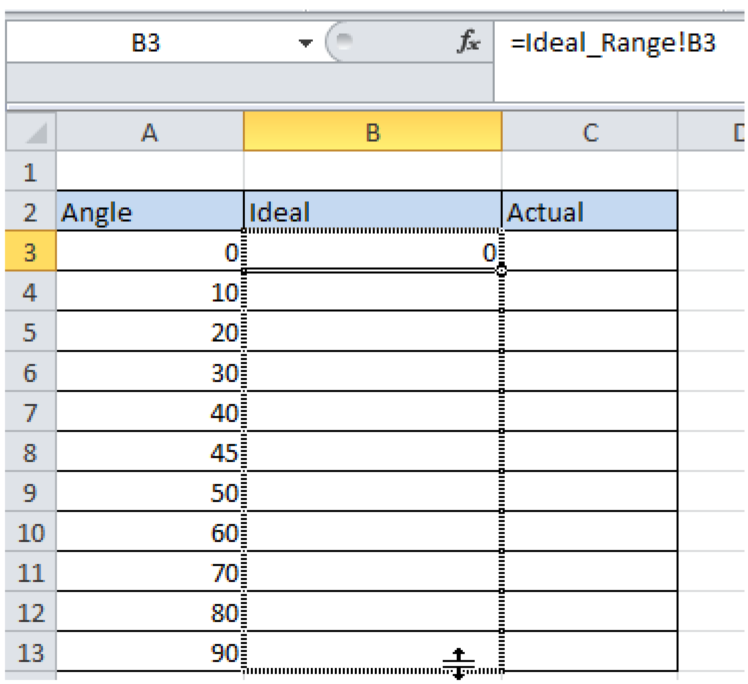
In this example you want the angle in the first column. In cell A3 enter =Ideal_Range!A3

Copy the function to the cells below.



Move to cell B3 and enter the formula =Ideal_Range!B3.

Copy that formula to the cells below.



Since our actual measurements didn't test the 0 degree angle or the 90 we will skip those data points. This time use cell C4 and entering in the location =Actual_Range!G3.

C4 | {=Actual_Range!G3}

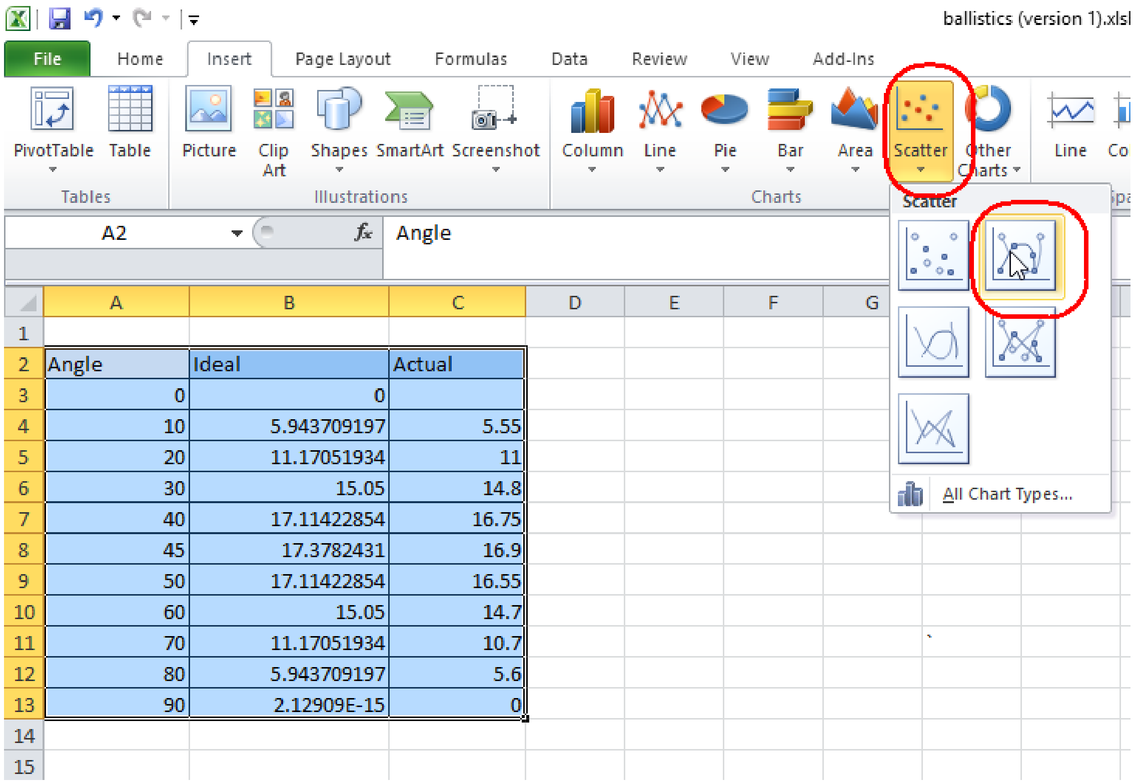
	A	B	C	D
1				
2	Angle	Ideal	Actual	
3	0	0		
4	10	5.943709197	5.55	
5	20	11.17051934		
6	30	15.05		
7	40	17.11422854		
8	45	17.3782431		
9	50	17.11422854		
10	60	15.05		
11	70	11.17051934		
12	80	5.943709197		
13	90	2.12909E-15		

Copy that to the columns below.

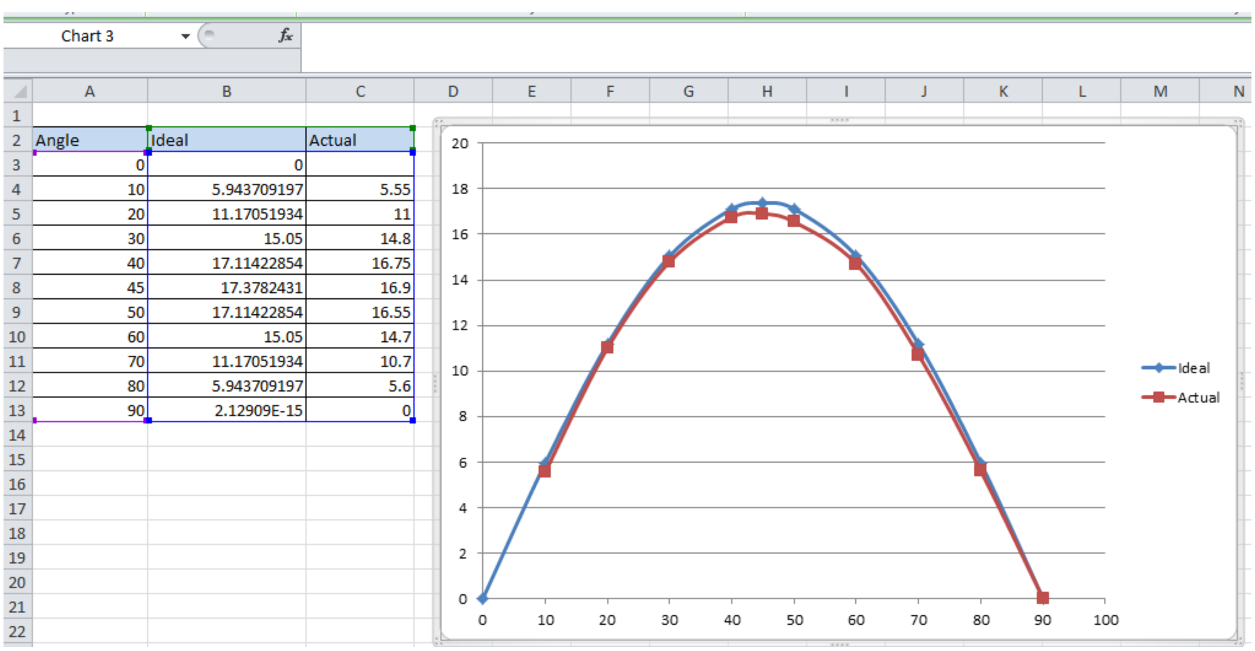
It should resemble the chart below.

Angle	Ideal	Actual
0	0	
10	5.943709197	5.55
20	11.17051934	11
30	15.05	14.8
40	17.11422854	16.75
45	17.3782431	16.9
50	17.11422854	16.55
60	15.05	14.7
70	11.17051934	10.7
80	5.943709197	5.6
90	2.12909E-15	0

Next create a chart to match the ideal with the actual. Highlight all three columns. Change to the Inset tab on the Ribbon. From the Insert Ribbon select Scatter from the Charts section and the option to select scatter with smooth lines and markers.



This will create your scatter plots.



Save your file for future use.

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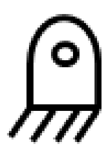
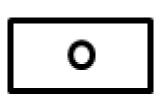
Linkage Diagrams

Purpose:
When sketching linkages it is standard practice to utilize schematic symbols to represent the parts. This allows a fast representation where the details can be filled in at a later time. It allows for the quick notation of existing systems and for quickly representing new ideas. In this activity you will be looking at mechanisms and creating a schematic representation of it.

Equipment:
Pencil
Engineering notebook

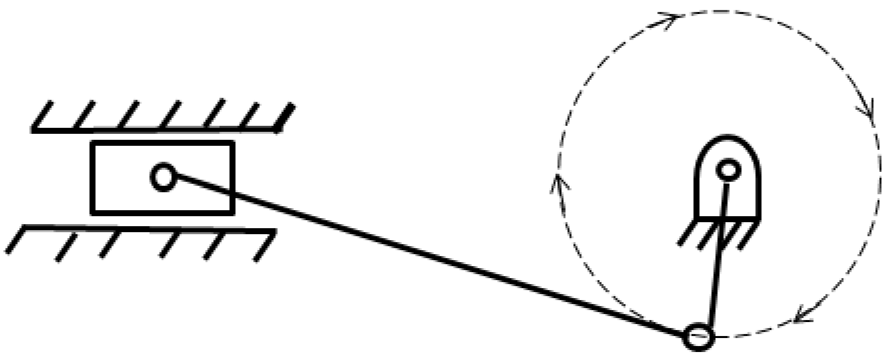
Procedure:
Since all the components of a mechanism are considered links the non-movable parts have a grounding symbol under them. See the fixed pivot point and housing symbols in the chart below. Everything else can move. The pins are placed where these components come together. The pin is a movable joint tying the two points together.

The chart below shows the most common symbols for you to use in your schematics.

	Pin Joint
	Fixed Pivot Joint
	Slider

	Housing
	Linkage

Browse to view the crank and slider at
http://www.technologystudent.com/cams/crkslid1.htm.
Watch the action. Compare the action to the schematic below.



Label the parts on the schematic.
Conclusion:

Now browse to http://www.technologystudent.com/cams/link1.htm

You will see four linkages on that page. Sketch the four linkage schematics in your engineering notebook. Check with your partner to be sure you agree on what you have drawn.

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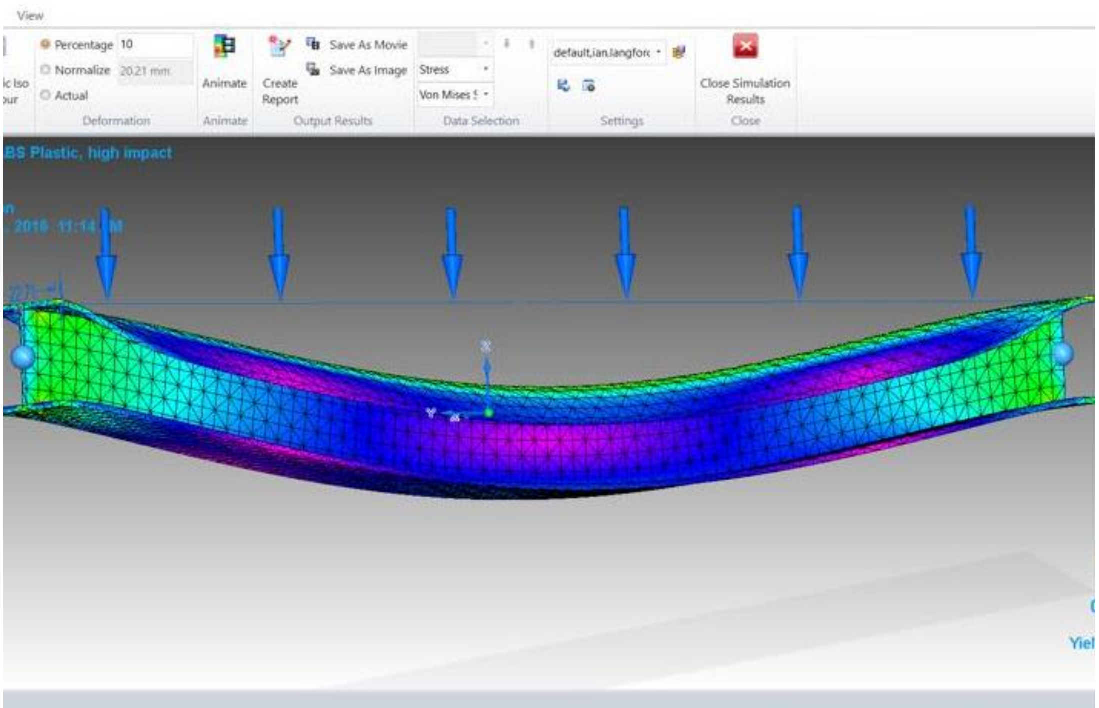
Engineering Documents

This section contains documentation to help students manage their projects. This allows students to take control and embeds technical literacy into the projects.



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Design Process

The engineering design process is a series of steps that engineers follow when solving problems. There are many variations of the design process in use and every situation or problem will have different elements that you should investigate. The steps listed below as well as the bullets included should inform the process but not dictate the process for every situation.

Design Process
Conduct Preliminary Research • Research Background Information and Identify Vocabulary. • Identify Criteria and Constraints for the Problem • Define Limits of the Problem to be Solved • Refine the Problem Statement in the Context of Criteria and Constraints • Define Areas of Research Needed to Solve the Problem • Independent Research • Enabling Activities • Lab Activities
Create the Project Management Plan • Overview • Scope • Schedule • Budget • Communication • Closure

Create a Design Brief • Objectives and Goals of the Design • Client and Context • Scope of the Project • Problem Statement or Description • Resources and Budget • Constraints • Time Needed
Brainstorm Possible Solutions • Generation of Ideas • Preliminary Sketches
Design Testing Methods and Protocol for Critical Assumptions • Introduction • Test Strategy • Data Collection Plan; Sampling Plan • Definition of a Successful Test, Pass / Fail Criteria • Test Conditions, Setup Instructions • Logistics and Documentation: • Analysis of Data • Conclusion
Create Optimization Matrix for Decision Making and Select Solution • Design Matrix • Identify Key Criteria • Assign Value to Each • Rate Possible Solutions
Develop, Refine and Document Selected Solution • Creation of Design Documentation • Identify New Issues
Create a Prototype • Turning the Plans into a Prototype
Test and Acquire Data • Design Testing to Evaluate the Prototype • Acquire Testing Data
Analyze Test Data • Creation of Graphs and Charts • Statistical Examination of Data

Refine and Iterate the Design • Apply the Changes Suggested by the Analysis of the Test Data. • Retesting of the Prototype • Repeat
Finalize Documentation of Design • Complete Documentation of Changes • Finalize Analysis
Prepare Communication Plan for Authentic Audience • Research Audience • Plan for Explanations and Graphics • Plan for Feedback
Prepare Communication Documents • Reports • Design Documentation • Design Proposals • Presentations for the Authentic Audience
Present/Defend to an Authentic Audience with Feedback

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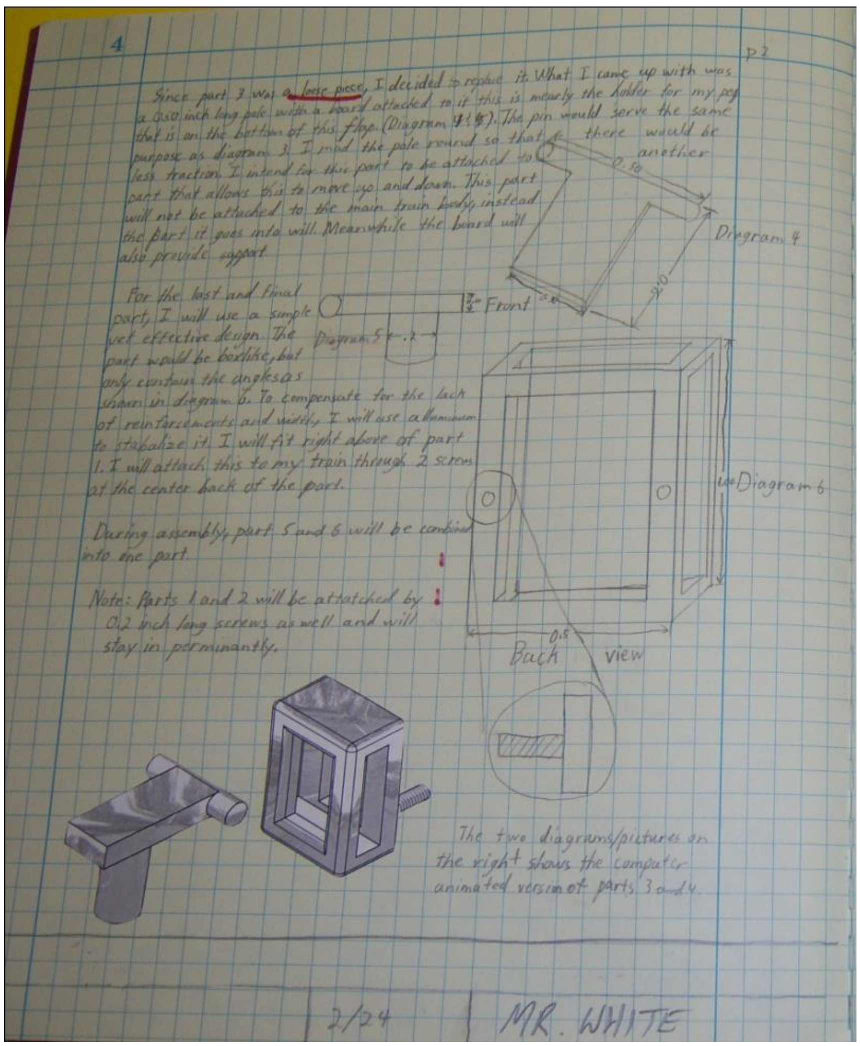
The Engineering Notebook



An Engineering Notebook is known by several names depending on the person and industry it is being used in. It is a bound book that contains the time-sequential written documentation of the development of the ideas of its author, along with all notes, data, observations, calculations, and other information relevant to the discovery or experiment being conducted. It provides an important record of the progress of an engineer, scientist's or inventor's work. When properly maintained, it may be submitted as a legal document for patent purposes or legal records.

It is the equivalent of a technical diary and has multiple uses. It presents the authors thought process and work in an easy to access manner, allowing an author to confirm conclusions, details, or dates.

Engineering research and development organizations usually require their engineers to keep a running record of their activities. In the event that a project is shelved or the person leaves employment it can provide others working on a project the paths of inquiry that have been investigated, and can offer justification for decisions or courses of action taken.

Use a bound notebook with a stitched binding. Do not use a loose leaf or Spiral bound notebook.

All entries should be in ink not pencil.

The title, project number, and book number should be accurately recorded when starting a new Page.

All data is to be recorded directly into the notebook. Elaboration of details is preferable. Notes and calculations should be recorded in the notebook. In the case of an error, draw a single line through the incorrect data. Do not erase or use correction fluid. All corrections should be initialed and dated. When making a correction, make a notation of the page number where the correct information is found.

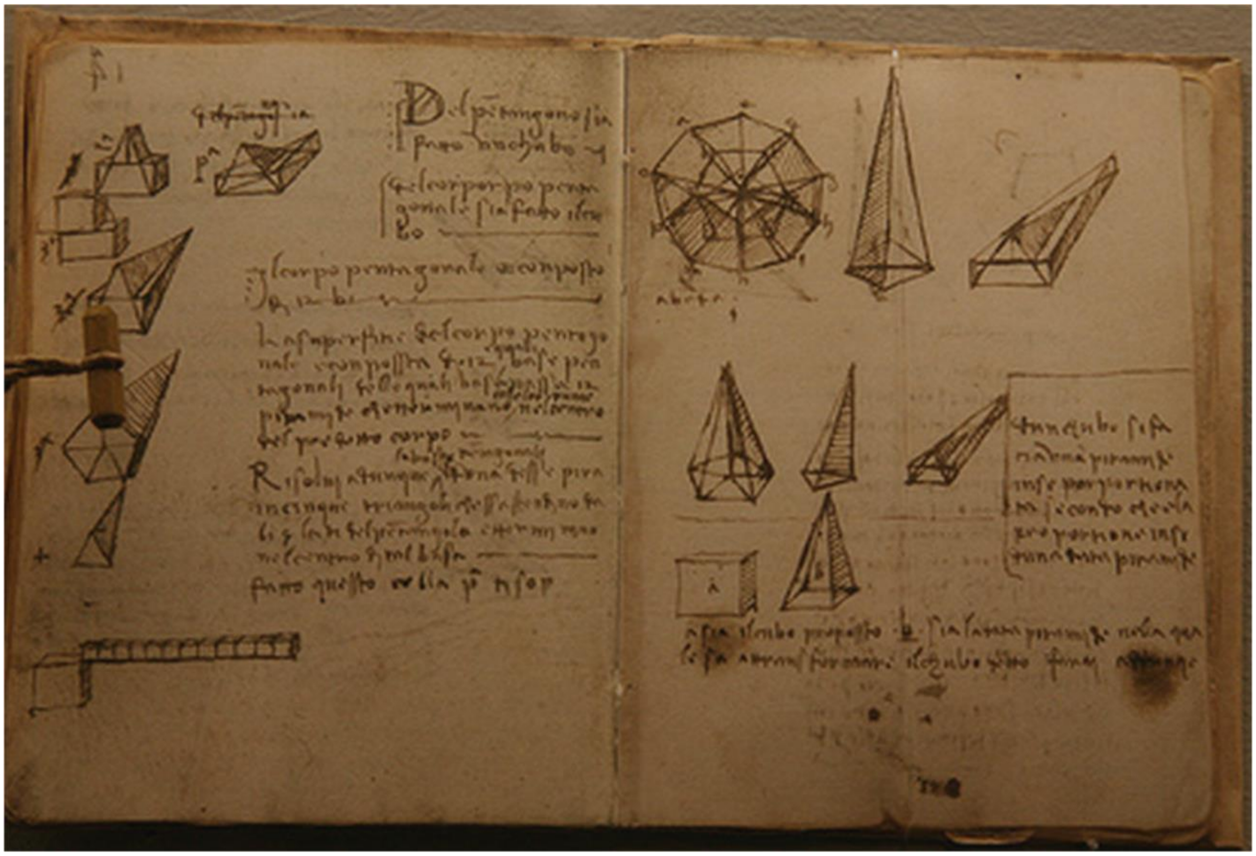
After entering your data, sign and date all entries. Witness or witnesses should sign and date each entry. The witness must observe the work that is done, and have sufficient knowledge to understand what they have read. Names of all who were present during any demonstration, phone conversation or discussion should also be recorded.

Never leave any White Space: "X" out or Crosshatch all unused space, and don't forget to initial and date the entry. Use both sides of the page.

When the notebook is full, begin a new notebook with the title, project number, and book number. Also make a notation of the preceding notebook number. Archive the full notebook in a safe location.

If necessary, items may be taped into the notebook with a handwritten date and title. Permanently attach inserted items (glue is preferred). Sign across the edge of the inserted sheet with half of the signature on the page.

Following this procedure can help students. It will foster improved documentation, research and sketching skills. It can help with time management skills and provide a convenient method for class closure. Early adoption by students of the use of the Engineering Notebook will help with project reports they will be expected to complete.



The pages above come from an Engineering Notebook kept by Leonardo da Vinci. It is a bound notebook containing sketches and explanations.

An example can be found at:
http://web.mit.edu/me-ugoffice/communication/labnotebooks.pdf

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Design Documentation

- A design isn't "read" it is "used".
- The design process goes from least specific to most specific.
- Never write a paragraph when a sentence will do.
- Never write a sentence when a bullet point will do.
- Use Diagrams.
- A good table replaces long narratives.
- Never use adjectives. That is the function of sales people and project managers. (Examples: great, beautiful, wonderful, etc.)
- Use appendixes for supportive information that you think is relevant.

Design documentation is the collection of details about the final design requirements and specifications that illustrate and thoroughly describe a designed product. Writing effective design documentation (like design itself) is really all about making sure you serve the needs of your audience.

Each document must have identification such as Project title, original date of document and names of students in the team, name of person approving the original document, dates of revisions and name of person approving the revision and brief explanation of the revision. Each design might include conceptual drawings, assembly drawings, parts' list, parts drawings, process drawings, flowcharts, state diagrams, use cases, relational tables, tables, programs developed, charts, graphs, rules, symbol diagrams, decision matrix, ladder diagrams, CNC Control programs, schematics, etc.

Items might include:

- 3D CAD Design
- Analysis
    - Finite Element Analysis (FEA)
    - Stress
    - Load Distribution
    - Fluid Flow
    - Heat Transfer
- Conceptual Designs
- Flowcharts

- Instructions
- Linkage Diagrams
- Reference Guides
- Sketches
- Specifications
- Tutorials
- Working Drawings
- Prototypes
    - Black Box Prototype: An existing enclosure or box with mechanical, electrical, optical and or software internals fully functioning.
    - Concept Model: formally describing some aspects of the physical and social world around us for the purposes of understanding and communication
    - Evolutionary Prototyping (also known as breadboard prototyping) a very robust prototype in a structured manner with the ability to constantly refine it.
    - Feasibility Prototype: Determine feasibility of various solutions
    - Functional Storyboarding: Determine useable sequences for presenting information
    - Horizontal Prototype: Demonstrates outer layer of human interface only, such as windows, menus, and screens
    - Mathematical Prototype: algorithm development for analysis operations
    - Mock up: A rough construction using crude materials such as cardboard, foam, paper or wood typically done to show the idea in 3D form.
    - Model: A form built and painted for aesthetic appearance only
    - Presentation Prototype: representation of the product as it will be manufactured. Often used for promotional purposes.
    - Proof of Concept: The use of existing materials, parts and components to prove the new Idea works or not.
    - Rapid Prototype: A group of techniques used to quickly fabricate a scale model of a part or assembly using three dimensional CAD data. Frequently associated with 3D printing.
    - Usability prototypes used to define, refine, and demonstrate user interface design usability, accessibility, look and feel.
    - Vertical Prototype: Refine database design, test key components early
    - Virtual Prototype: 3D Computer Aided Design (CAD) rendering
    - Working Prototype: A fully functioning item yet may not be fully designed & engineered for manufacturability, nor it may not be appearance like.

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Problem Statement

The problem statement is the statement that the students write from their preliminary research and is their definition, or redefinition, of the problem as they understand it. It is a clear and concise description of the issues that need to be addressed by the team.

The problem statement becomes part of the Design Brief and consists of several parts in a few sentences. It includes:

- The **Vision Statement**: This statement describes the goals, values or the desired results that solving the issue will have.
- The **Issue Statement**: This statement is a sentence or two that describes the problem or what is preventing the vision from being accomplished using specific issues. This would consist of the "Who, What, When, Where, and Why" of what is getting in the way of solving the issue.
- The **Method Statement**: This describes the approach the team will take to solve the problem.

Example:

Bicycles are an efficient and low pollution method of transportation in overcrowded urban areas that frequently move faster than motorized transportation. Secure storage, passenger safety and inclement weather all impact the desirability of adopting this mode of transportation. We are proposing to design an enclosed hybrid pedal powered vehicle that will allow use in all weather, provide greater passenger safety and have the same ability to be secured as a car while taking up a fraction of the space.

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Design Brief

A design brief is used to provide a summary of how a problem will be approached. This way the customer will know the exact problem you will be solving for them and a projection of the resources needed. This is usually a one to two page document meant to quickly communicate the scope and goals of a specific design project. The document is focused on the desired results of design. It is frequently done in conjunction with the client.

Design briefs should have the following sections.

- Objectives and Goals of the Design
- Client and Context
- Scope of the Project
- Problem Statement or Description
- Resources and Budget
- Constraints
- Time Needed
- Other (depending on need)

Example:

Client and Context of the Problem
Reflective Gear, manufacturer of safety gear for cyclists is designing a new line of gear for people who cycle or run in periods of low light. Accidents are four times more probable at night.

Problem Statement:
Ideally the clothing should be lightweight, comfortable to wear, durable and washable. Existing clothing is either uncomfortable or not reflective enough for safety in dark environments. The company has contacted us to design new reflective designs, either passive such as reflective tape or active LED based systems.

Criteria and Constraints:
The design proposed needs to provide a reflected light with minimum loss so it is plainly visible at 100 feet. If we select an LED system it must be visible at 100 feet and have a

minimum battery life of 50 hours. The design must survive repeated washings and not lose reflectivity. The total weight allowed is 6.5 ounces in addition to the base clothing.

Objectives and Goals:
We will experiment and report back on various ways to achieve the necessary visibility within the weight and comfort limits.

Scope of the Project:
We will test various methods of utilizing reflective strips. We will develop a method of attaching the reflective strips with the goal of less than 1% failure after 10 washings. We will experiment with various methods of using LEDs in clothing. We will not design the clothing, only using clothing provided by Reflective Gear. We will not test for clothing survival over a period of years.

Resources Needed:
Our team will need access to the latest clothes designs from Reflective Gear. We will need access to reflective materials and plastic strip sealer/heaters to experiment with easy methods used to incorporate the reflective material. LED strips and power sources will also be needed. We will need resources for three members of the team for a month along with necessary computer and measuring resources.

Time needed:
It is our estimate that testing and reporting can be done in one month's time from the date of the agreement. We will provide our report and examples of our visibility solution with the report.

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Project Management Plan

A project management plan is a formal written document to establish the process and procedures used to guide a project from inception to conclusion. The larger the project the greater the detail needed. It communicates to the team and their clients, information about the management of the necessary details and who will be responsible for each component. Every project will be different but the following sections give you an idea what to include.

- Customer:
- Project Summary (includes purpose, goals, assumptions/guess, and constraints):
- Scope (deployment and management, lists work to be included and excluded):
- Budget (breakdown of costs to complete the job):
- Team Communication Plan (Who should be invited, what skills, backgrounds and professions should be represented, will the audience members be presented with information/documents prior to the presentation? If so, what information? How?):
- Time Schedule (includes milestones to be met):
- Project Delivery Plan (how end products will be delivered to the customer):
- Quality Management Plan (how does it meet industry standards):
- Risk Management Plan (identification, assessment, and prioritization of risks):
- Compliance Plan (describe how it meets all regulations):

Example:

Customer:
Our client is the company Reflective Gear. They specialize in athletic clothing designed for people who work out in the dark, at dusk or dawn when accidents are more likely to occur. They would like us to design a way for their clothing line to show up better to keep their customers safer.

Project Team:
Our team consists of four people.

Wendy: Team Leader
Joe: Secretary and Editor
Linda: Time Keeper and Communications Director
Jose: Technical Lead and Researcher

Summary:
Our goal is to conduct research and experiments to determine which types of reflective devices should be incorporated to meet the customer needs. We believe that we must test several different combinations of materials and LED lighting. We will design testing to assure our final recommendation meets the needs of our client.

Scope:
Our goal is to research reflectivity and light generation to provide the most durable combination of elements with the greatest visibility to drivers. We will be testing reflective materials and various combinations of LEDs. We will make recommendations for how these materials will attach to existing clothing designs. We will not be creating new clothing designs or suggesting manufacturing options.

Budget:
Our team will need four weeks to complete our testing and report generation. We will need testing equipment such as cameras as well as computer equipment for recording the process. In addition to salaries and benefits our standard overhead of 40% applies to provide electricity, data connection, heat, phone service and printing costs.

Communication Plan:
The team will create a design brief to share with the client. Feedback from the client will be incorporated in our management plan. At the conclusion of our work we will provide an overview of the work, samples of our selection and a printed copy of our report including data gathered for client use.

Time Schedule:

Week 1	Week 2	Week 3	Week 4	
Team Formation				
Basic research				
Budget				
Management plan				
	Research into reflective materials			
	Preliminary Testing			
	Survey Designs			
	Testing Protocol			
		Prototype creation		
		Testing of prototype		
		Testing setup		
		Evaluate and Improve		
			Report generation	
			Presentation preparation	
				Presentation
				End of project life

Quality Management Plan
The team will develop the testing protocol and monitor testing to assure the prototype will last the predicted number of washings and to assure that the design can meet the visibility criteria
.

Risk Management Plan
The team will create a plan to identify and plan for addressing all types of risk. If the clothing will utilize LEDs the plan will include electrical safety.

Compliance Plan
The team will create a plan for compliance with all applicable regulations. The plan will include how the clothing will meet the UL electrical codes.

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Testing Protocol

- *Introduction:* What is the project about and what are the critical parts that need testing?
- *Test Strategy*: How are you going to test the part or component and under what conditions?
- *Data Collection Plan*: Sampling Plan: How are you going to collect the information? Will this be a random sample of a run? One time testing of a craft build prototype?
- *Measurement Capability and Equipment*: What are you measuring and how accurate do you have to be? What kind of testing equipment will be needed?
- *Definition of a Successful Test, Pass / Fail Criteria*: This is a description of what constitutes success. For example, not breaking after 100 repetitions or being within measurement tolerances etc.
- *Test Conditions, Setup Procedure:* How will you set up the test? If someone else has to duplicate your test, will they use the same procedure?
- *Logistics and Documentation*: This is a description of what was tested and how.
- *Analysis of Data – Design Summary*: What happened during testing?
- *Conclusion or Design Summary:* What did the test tell you?

Example:

Introduction:
This project involved the creation of a method to alert drivers to the presence of a person in the dark near the highway. The system to be tested must be visible from 100 feet away in dim light situations. To assure the design meets the criteria a testing method must demonstrate the ability of the product to communicate the bicycles presence to a driver more than 100 feet in advance.

Test Strategy:
Various designs will be tested for reflective light at 100 feet. All tests will require the equivalent of a car head light pointing at the reflective gear from 100 feet away. We will photograph results of each test of the reflective gear and/or LED display. The photographs will be compared and analyzed to determine the best selection or combination of strategies to incorporate. In addition to cameras we will also use light meters to measure lumens. Our last test will involve a survey of drivers who will provide feedback on the easiest system to see when driving down the road.

Data Collection Plan
Photos will be labeled and the data tagged upon the picture. The pictures will include data upon the brightness of the reflected light as well as the contrast. Surveys will ask four questions relating to the easiest design to see as well as the drivers comfort level when seeing the test reflected object. Surveys will be given to test subjects about the comfort of the item and ease of use.

Measurement Capability
We will need a standard digital camera and software to allow the pictures to be analyzed to show which combination of reflectors/LEDs are the brightest at 100 feet. Lumens will be measured utilizing a lux meter and the results added to the database of pictures and driver responses. A stationary headlight, 12V battery and a camera will be used to simulate cars at 100 feet. Real drivers will drive by the test subject and record their impressions. Visibility distance will need to be measured.

Definition of a Successful Test:
The selected solution will provide a combination of the greatest reflected light, driver responses and distance measurements. The solution will need to below the preset weight limit and be comfortable to test subjects. The solution must survive the laundry test and be comfortable to wear as judged by the survey of users.

Test Conditions:
The tests will be conducted at dawn, dusk and fully dark. Fog or mist would be beneficial to have when tests are conducted but not necessary.

The laundry test will be conducted after the first night light test. Items will be washed 10 times and then the tests with cameras, lights, and drivers will be repeated.

Two surveys will be given to people wearing the device. The first before the washing test and the second after it has been washed 10 times.

Logistics and Documentation:
Surveys for the test drivers will be combined with the measurement data for each proposed solution. Graphs of visibility will be created along with a chart with all solutions so they can be compared.

Analysis of data:
Pictures will be measured to determine which provide the greatest reflected light. The driver responses will be added to the data to account for "human factor" and perception. The optimum solution will provide the best combination of results. The picture analysis will count for 50% of the score, light detection at 100 feet will account for 25% of the final result and the driver reactions to what they observed while driving will count for other 25%.

Conclusion:
We hope that the combination of test results will provide us with the best possible solution to recommend. A major component of the engineering report will be based upon the results of the testing and anecdotal reporting on surveys.

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Decision Matrix

When the list of options needs to be limited to one choice, design engineers sometimes use a decision matrix based upon weighted priorities and available information. It is easier to make decisions if they are based upon the protocol you set up. The decision with the highest score is the one to begin with.

General steps in the process are -

1. *Define the ideal solution*: Members define all the characteristics that are important for the decision. There is usually a brainstorming session to define the criteria for inclusion or exclusion.
2. *Establish Priorities*: From all the characteristics listed which are the most important or least. The examples below rate the weight as 1-10
3. *Place these in a matrix form*.
4. *Assign values for each choice*: Each characteristic is compared to the ideal and rated on a scale. These examples use a 1-5 scale but any scale is posible. (1 through 5 is ideal)
5. *Calculate weighted scores*: The rating on each characteristic times the weighting
6. *Summation of the scores*: Consider using Microsoft Excel for developing the matrix and formatting the document to calculate the scores automatically.

Sample Decision Matrix

What is the best social media for our business?

Characteristic	**Weight**	**Website**		**Blog**		**LinkedIn**		**Twitter**	
		Raw	**Total**	**Raw**	**Total**	**Raw**	**Total**	**Raw**	**Total**
Generate new customers	**9**	5	45	5	45	2	18	1	0
Improve networking and making connections with new and old customers	**7**	3	21	2	14	5	35	4	28

Deepen existing connections with my customers	**8**	3	24	4	32	4	32	4	32
Receive customer feedback	**6**	2	12	0	0	0	0	1	6
Increase the visibility of my business to the public	**9**	4	36	5	45	4	36	3	27
Increase on-line sales	**9**	5	45	2	18	0	0	0	0
Totals	**---**	**---**	**183**	**---**	**154**	**---**	**121**	**---**	**93**

Matrix for siting a plant

		City 1		**City 2**		**City 3**		**City 4**	
Characteristics	Weight	Raw Score	Total Score	Raw Score	Total Score	Raw Score	Total Score	Raw Score	Total Score
Proximity of the plant to the market	6	3	18	4	24	2	12	5	30
Proximity to raw materials	2	5	10	1	2	4	8	1	2
Proximity to Transportation	9	1	9	2	18	3	27	5	45
Local Labor costs	4	2	8	5	20	4	16	2	8
Labor force education	7	2	14	4	28	3	21	5	35
Community attitude	4	4	16	3	12	2	8	3	12
Availability of supporting industries	6	3	18	2	12	3	18	5	30
Suitability of land	6	5	30	2	12	5	30	4	24
Cost of Land	4	3	12	3	12	5	20	1	4
Community regulations	8	3	24	4	32	4	32	2	16
Communication infrastructure	3	4	12	5	15	2	6	5	15
Utility infrastructure	7	4	28	5	35	2	14	5	35
Community resources for workforce	2	5	10	4	8	2	4	5	10
Total Score			209		230		216		266

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Engineering Report

Good report organization should promote readability and reflect the scientific method, which proceeds with objective, method, results, and conclusions. It is logical to report a project in the sequence in which it is done. Many engineering reports are organized on this basis. Two improvements to the logical sequence are the addition of an abstract or executive summary and the insertion of headlines. These two features facilitate "scanning" of the report. Thus, a busy executive or engineer may quickly assess the major findings and conclusions of the report, and then easily find further details as required.

Sections that should be included:

- Title Page. Identify the group members, project, dates and timeframe.
- Summary or Abstract (Executive Summary)
- Nomenclature. Students need to list and define all science and engineering terms and measurements used in the report.
- Introduction. This should include the entire project description.
- Theory and Analysis
- Experimental Procedures
- Results and Discussion
- Conclusions and Recommendations
- Acknowledgments
- Literature Cited
- Appendix

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Assessment Rubrics

Assessment comes in both formative and summative. It is an integral part of quality instruction. During the course of the projects one of the teacher's main functions is to work with student groups, keeping track of progress and providing formative assessment in the form of feedback and promoting reflection on the part of students. The focus should be on lifetime and 21st century skills. The goal of instruction is to promote abilities in research, problem solving, design, experimenting, testing and collecting data.

Rubrics are used in the assessment process to communicate expectations of quality of a task. Rubrics should be shared with students at the beginning of a project so they can clarify any misconceptions before beginning work. They can then build the skills and gather knowledge to solve the problem presented to the expectations of excellence described.

General Rubrics for Literacy tasks

Individual Project Rubrics

Quarter 1

Quarter 2 Projects

Quarter 3 Projects

- Bathroom Door Latch Rubric
- Nut Cracker Rubric
- Ball Launcher Rubric
- Differential Gear Design Rubric
- Merry-Go-Round Rubric

Quarter 4 Projects

- Truss System Rubric
- Hybrid Toy Connector Rubric
- Playground Design Rubric
- Centrifugal Pump Rubric
- Automatic Training Wheels Rubric
- Mechanical Bank Rubric
- Glider Rubric
- Childs Toy Rubric

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Literacy Rubric for Argumentative or Persuasive Project				
	Not Yet	**Getting There**	**Meets Expectations**	**Exceeds Expectations**
	1	**2**	**3**	**4**
Focus	An attempt to answer the problem, but the response lacks focus.	Answers the problem and states a position but the focus is varying or weak.	Fully answers the problem keeping a clear focus. Argument is generally convincing.	Fully answers the problem keeping a very clear focus and strong, convincing argument.
Main Idea	Attempts to create a main idea but lacks focus and clarity. No mention of argument other than their own.	Creates an argument and makes note of claims of other than their own.	Creates a convincing argument; develops and presents argument and counter argument fairly.	Creates a convincing and meaningful argument; develops and presents argument and counter arguments fairly and fully.
Reading & Research	Tries to present information but does not connect it to the problem.	Presents information from research that addresses the problem with only small errors.	Presents accurate and relevant information from research that helps develop their argument	Effectively presents accurate and relevant information from research that develops a strong argument.
Development	Tries to give details but they are poorly written or do not apply to the problem. They make no claim, or make an irrelevant claim	Gives details to support their main idea with only minor weaknesses in reasoning. Makes a weak claim.	Gives details that fully support the main idea and answer the problem. Gives an example that helps clarify the claim.	Gives thorough details that fully support the main idea and strongly answer the problem. Makes strong connections to their argument that clarifies and helps the reader understand the

				claim.
Organization	Tries to organize ideas but lacks structure.	Organizes ideas to fulfill requirements, with some gaps in structure.	Organizes response to meet all requirements of the problem. Organization reveals the reasoning behind the claim.	Organizes response in a way that enhances the information given in response to the problem. Organization reveals the reasoning behind the argument and creates more support for it.
Conventions of English	Writes response with many errors in grammar, usage and writing mechanics. Sources of research are not cited.	Is inconsistent with grammar, usage, and mechanics; uses tone and language inappropriate to audience or topic. Only some sources are cited.	Work has very few errors in grammar, usage, and mechanics; tone and language are appropriate to the project and audience. Few errors in citation formatting.	Demonstrates a full command of the conventions of English; tone and language enhance the response. Consistently and correctly cites sources.
Understanding of Content	Tries to show understanding of content but knowledge is weak or incorrect.	Connects basic knowledge of content to problem, shows minor errors in understanding.	Presents full factual understanding of content as it applies to the project.	Presents in-depth understanding of content that applies to, and enhances, the response to the project.

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Informational Explanatory Rubric				
	Not Yet	**Getting There**	**Meets Expectations**	**Exceeds Expectations**
	1	**2**	**3**	**4**
Focus	An attempt to answer the problem, but response lacks focus.	Answers the problem but the focus is varied or distracted.	Fully answers the problem keeping a clear focus.	Fully answers the problem keeping a very well developed and clear focus.
Main Idea	Attempts to create a main idea but lacks focus and clarity.	Creates a basic main idea with general purpose.	Creates a main idea with a clear purpose that is carried though the piece.	Creates a strong main idea with a clear purpose that guides the response throughout the piece.
Reading & Research	Tries to present information but does not connect it to the problem. Does not evaluate the integrity of sources.	Presents information from research that addresses the problem with only small errors Starts to evaluate the integrity of sources.	Presents detailed information from research that helps answer the problem. Evaluates the integrity of sources.	Selectively presents detailed information that helps answer all parts of the problem. Evaluates the integrity of sources and identifies credible sources.
Development	Tries to give details but they are poorly written or do not apply to the problem. Does not address implication of project, or it is irrelevant. Does not address	Gives details to support the main idea and answer the problem. Mentions implications of project or an unanswered question.	Gives details that fully support the main idea and answer the problem. Explains the implications of project and an unanswered question.	Gives thorough details that fully support the main idea and strongly answer the problem. Entirely explains the implications of project and one or more unanswered questions.

	unanswered questions.			
Organization	Tries to organize ideas but lacks structure.	Organizes ideas to fulfill requirements, with some gaps in structure.	Organizes response to meet all requirements of the problem.	Organizes response in a way that enhances the information given in response to the problem.
Conventions of English	Writes response with many errors in grammar, usage and writing mechanics. Sources of research are not cited.	Is inconsistent with grammar, usage, and mechanics; uses tone and language inappropriate to audience or topic. Only some sources are cited.	Work has very few errors in grammar, usage, and mechanics; tone and language are appropriate to the project and audience. Few errors in citation formatting.	Demonstrates a full command of the conventions of English; tone and language enhance the response. Consistently and correctly cites sources.
Understanding of Content	Tries to show understanding of content but knowledge is weak or incorrect.	Connects basic knowledge of content to problem, shows minor errors in understanding.	Presents full factual understanding of content as it applies to the project.	Presents in-depth understanding of content that applies to, and enhances, the response to the project.

Comments: **Total---->**

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Sketching and Documentation Rubric

Criteria	Novice-1	Apprentice-2	Proficient-3	Expert-4	
Engineering Notebook	No evidence of notes, sketches or research	Shows some evidence of notes, sketches and research	Evidence of most notes, sketches and research	Clear notes and sketches with all research documented and signed	
Cooperative Group Work	One student did all or most of the work in the group	Most team members did some work but workload varied	All team members did some work but workload varied	Workload is divided and shared equally by all group members	
Project Design	The sketches are incomplete or poorly drawn. They are hard to read	The sketches are complete , but design is poor and will not link to other blocks	The project is complete, well constructed and will link to other blocks	The project is complete, well planned, always works and is easily adaptable to the set.	
Presentation	Some difficulty communicating ideas. 1 member presents to class	Good communication. 1 member presents to class	Group communicates well and all members present to class.	Entire group communicates with enthusiasm. All members contribute and know their responsibilities	
Completeness of requirements	Less than 60% of the requirements are met	Between 60 and 80% of the requirements are met	Between 81 and 99% of the requirements are met	Total inclusion of all tasks. 100% of requirements are met	
				Total---->	

Comments:

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Name Plate Holder Rubric

Criteria	Novice-1	Apprentice-2	Proficient-3	Expert-4	
Engineering Notebook	No evidence of notes, sketches or research	Shows some evidence of notes, sketches and research	Evidence of most notes, sketches and research	Clear notes and sketches with all research documented and signed	
Cooperative Group Work (As Needed)	One student did all or most of the work in the group	Most team members did some work but workload varied	All team members did some work but workload varied	Workload is divided and shared equally by all group members	
Project Design	The project is incomplete or partially designed.	The project is complete, but design is poor and will not work	The project is complete, well constructed	The project is complete, well planned, always works and is greatly improved.	
Presentation	Some difficulty communicating ideas. Drawings are hard to read	Reasonable communication. Tough to follow at times. Fair drawings	Communicates very well and easy to follow. Good drawings	Communicates with enthusiasm, well prepared and well spoken. Exceptional drawings	
Completeness of requirements	Less than 60% of the requirements are met	Between 60 and 80% of the requirements are met	Between 81 and 99% of the requirements are met	Total inclusion of all tasks. 100% of requirements are met	
				Total---->	

Comments:

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Sport Drink Container Rubric

Criteria	Novice-1	Apprentice-2	Proficient-3	Expert-4	
Engineering Notebook	No evidence of notes , sketches or research	Shows some evidence of notes, sketches and research	Evidence of most notes, sketches and research	Clear notes and sketches with all research documented and signed	
Cooperative Group Work (As Needed)	One student did all or most of the work in the group	Most team members did some work but workload varied	All team members did some work but workload varied	Workload is divided and shared equally by all group members	
Project Design	The project is incomplete or poorly created. Drawings are hard to read	The project is complete, but design is poor and did not meet original criteria	The project is complete, well-constructed and meets requirements	The project is complete, well planned, always works and is easily adaptable to many situations	
Presentation	Some difficulty communicating ideas.	Reasonable communication and tough to follow at times	Communicates very well and easy to follow	Communicates with enthusiasm, well prepared and well spoken.	
Completeness of requirements	Less than 60% of the requirements are met	Between 60 and 80% of the requirements are met	Between 81 and 99% of the requirements are met	Total inclusion of all tasks. 100% of requirements are met	
				Total---->	

Comments:

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Kitchen Tool Design Rubric

Criteria	Novice-1	Apprentice-2	Proficient-3	Expert-4	
Engineering Notebook	No evidence of notes, sketches or research	Shows some evidence of notes, sketches and research	Evidence of most notes, sketches and research	Clear notes and sketches with all research documented and signed	
Cooperative Group Work (As Needed)	One student did all or most of the work in the group	Most team members did some work but workload varied	All team members did some work but workload varied	Workload is divided and shared equally by all group members	
Project Design	The project is incomplete or partially designed.	The project is complete, but design is poor.	The project is complete, well-constructed.	The project is complete, well planned, always works and is greatly improved.	
Presentation	Some difficulty communicating ideas. Poor drawings	Reasonable communication. Tough to follow at times. Fair drawings	Communicates very well and easy to follow. Good drawings	Communicates with enthusiasm, well prepared and well spoken. Exceptional drawing techniques.	
Completeness of requirements	Less than 60% of the requirements are met	Between 60 and 80% of the requirements are met	Between 81 and 99% of the requirements are met	Total inclusion of all tasks. 100% of requirements are met	
				Total---->	

Comments:

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Chess Set Rubric

Criteria	Novice-1	Apprentice-2	Proficient-3	Expert-4	
Engineering Notebook	No evidence of notes , sketches or research	Shows some evidence of notes, sketches and research	Evidence of most notes, sketches and research	Clear notes and sketches with all research documented and signed	
Cooperative Group Work (As Needed)	One student did all or most of the work in the group	Most team members did some work but workload varied	All team members did some work but workload varied	Workload is divided and shared equally by all group members	
Project Design	The project is incomplete or poorly created. Drawings are hard to read	The project is complete, but design is poor and did not meet original criteria	The project is complete, well-constructed and meets requirements.	The project is complete, well planned, always works and is easily adaptable to several sets.	
Presentation	Some difficulty communicating ideas.	Reasonable communication and tough to follow at times	Communicates very well and easy to follow.	Communicates with enthusiasm, well prepared and well spoken.	
Completeness of requirements	Less than 60% of the requirements are met	Between 60 and 80% of the requirements are met	Between 81 and 99% of the requirements are met	Total inclusion of all tasks. 100% of requirements are met	
				Total---->	

Comments:

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Shower Caddy Rubric

Criteria	Novice-1	Apprentice-2	Proficient-3	Expert-4	
Engineering Notebook	No evidence of notes, sketches or research	Shows some evidence of notes, sketches and research	Evidence of most notes, sketches and research	Clear notes and sketches with all research documented and signed	
Cooperative Group Work (As Needed)	One student did all or most of the work in the group	Most team members did some work but workload varied	All team members did some work but workload varied	Workload is divided and shared equally by all group members	
Project Design	The project is incomplete or partially designed.	The project is complete, but design is poor and will not work with original requirements	The project is complete, well-constructed and meets requirements	The project is complete, well planned, always works and is an innovative solution.	
Presentation	Some difficulty communicating ideas. Drawings are hard to read	Reasonable communication. Tough to follow at times. Fair Drawings	Communicates very well and easy to follow. Good Drawings	Communicates with enthusiasm, well prepared and well spoken. Exceptional Drawings	
Completeness of requirements	Less than 60% of the requirements are met	Between 60 and 80% of the requirements are met	Between 81 and 99% of the requirements are met	Total inclusion of all tasks. 100% of requirements are met	
				Total---->	

Comments:

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Table Driven Kitchen Measuring Instruments Rubric

Criteria	Novice-1	Apprentice-2	Proficient-3	Expert-4	
Engineering Notebook	No evidence of notes, sketches or research	Shows some evidence of notes, sketches and research	Evidence of most notes, sketches and research	Clear notes and sketches with all research documented and signed	
Cooperative Group Work (As Needed)	One student did all or most of the work in the group	Most team members did some work but workload varied	All team members did some work but workload varied	Workload is divided and shared equally by all group members	
Project Design	The project is incomplete or partially designed.	The project is complete, but design is poor and will not work with original constraints	The project is complete, well-constructed and will work	The project is complete, well planned, always works and is easily adaptable	
Presentation	Some difficulty communicating ideas. Poor drawings	Reasonable communication. Tough to follow at times. Several mistakes on drawings	Communicates very well and easy to follow. Few mistakes on drawings	Communicates with enthusiasm, well prepared and well spoken. Exceptional drawings	
Completeness of requirements	Less than 60% of the requirements are met	Between 60 and 80% of the requirements are met	Between 81 and 99% of the requirements are met	Total inclusion of all tasks. 100% of requirements are met	
				Total---->	

Comments:

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Packaging Rubric

Criteria	Novice-1	Apprentice-2	Proficient-3	Expert-4	
Engineering Notebook	No evidence of notes , sketches or research	Shows some evidence of notes, sketches and research	Evidence of most notes, sketches and research	Clear notes and sketches with all research documented and signed	
Cooperative Group Work (As Needed)	One student did all or most of the work in the group	Most team members did some work but workload varied	All team members did some work but workload varied	Workload is divided and shared equally by all group members	
Project Design	The project is incomplete or poorly made.	The project is complete, but design is poor and will not contain an object	The project is complete, well-constructed and will hold an object	The project is complete, well planned, always works and is easily adaptable to different objects.	
Presentation	Some difficulty communicating ideas.	Reasonable communication, tough to follow at times.	Communicates very well and easy to follow.	Communicates with enthusiasm, well prepared and well spoken.	
Completeness of requirements	Less than 60% of the requirements are met	Between 60 and 80% of the requirements are met	Between 81 and 99% of the requirements are met	Total inclusion of all tasks. 100% of requirements are met	
				Total---->	

Comments: **Total---->**

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3D Puzzle Rubric

Criteria	Novice-1	Apprentice-2	Proficient-3	Expert-4	
Engineering Notebook	No evidence of notes, sketches or research	Shows some evidence of notes, sketches and research	Evidence of most notes, sketches and research	Clear notes and sketches with all research documented and signed	
Cooperative Group Work (As Needed)	One student did all or most of the work in the group	Most team members did some work but workload varied	All team members did some work but workload varied	Workload is divided and shared equally by all group members	
Project Design	The project is incomplete or partially designed.	The project is complete, but design is poor and will not work with original constraints	The project is complete, well-constructed and will work	The project is complete, well planned, always works and is easily adaptable	
Presentation	Some difficulty communicating ideas. Poor drawings	Reasonable communication. Tough to follow at times. Several mistakes on drawings	Communicates very well and easy to follow. Few mistakes on drawings	Communicates with enthusiasm, well prepared and well spoken. Exceptional drawings	
Completeness of requirements	Less than 60% of the requirements are met	Between 60 and 80% of the requirements are met	Between 81 and 99% of the requirements are met	Total inclusion of all tasks. 100% of requirements are met	
Puzzle Characteristics	Puzzle is not complete	Puzzle is complete but does not work	Puzzle is complete and works but fits together poorly	Puzzle is complete, works and fits perfectly	

Comments: **Total---->**

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Mold Design Rubric

Criteria	Novice-1	Apprentice-2	Proficient-3	Expert-4	
Engineering Notebook	No evidence of notes, sketches or research	Shows some evidence of notes, sketches and research	Evidence of most notes, sketches and research	Clear notes and sketches with all research documented and signed	
Cooperative Group Work (As Needed)	One student did all or most of the work in the group	Most team members did some work but workload varied	All team members did some work but workload varied	Workload is divided and shared equally by all group members	
Project Design	The project is incomplete or partially designed.	The project is complete, but design is poor and will not work with original constraints	The project is complete, well-constructed and will work	The project is complete, well planned, always works and is easily adaptable	
Presentation	Some difficulty communicating ideas. Poor drawings	Reasonable communication. Tough to follow at times. Several mistakes on drawings	Communicates very well and easy to follow. Few mistakes on drawings	Communicates with enthusiasm, well prepared and well spoken. Exceptional drawings	
Completeness of requirements	Less than 60% of the requirements are met	Between 60 and 80% of the requirements are met	Between 81 and 99% of the requirements are met	Total inclusion of all tasks. 100% of requirements are met	
Mold Characteristics	Mold is incomplete	Mold is complete but done incorrectly	Mold is complete but is lacking details	Mold is complete, has met all requirements and is ready to cast	

Comments: **Total---->**

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Coaches' Cart Rubric

Criteria	Novice-1	Apprentice-2	Proficient-3	Expert-4	
Engineering Notebook	No evidence of notes, sketches or research	Shows some evidence of notes, sketches and research	Evidence of most notes, sketches and research	Clear notes and sketches with all research documented and signed	
Cooperative Group Work (As Needed)	One student did all or most of the work in the group	Most team members did some work but workload varied	All team members did some work but workload varied	Workload is divided and shared equally by all group members	
Project Design	The project is incomplete or partially designed.	The project is complete, but design is poor and will not work with original constraints	The project is complete, well-constructed and will work	The project is complete, well planned, always works and is easily adaptable	
Presentation	Some difficulty communicating ideas. Poor drawings	Reasonable communication. Tough to follow at times. Several mistakes on drawings	Communicates very well and easy to follow. Few mistakes on drawings	Communicates with enthusiasm, well prepared and well spoken. Exceptional drawings	
Completeness of requirements	Less than 60% of the requirements are met	Between 60 and 80% of the requirements are met	Between 81 and 99% of the requirements are met	Total inclusion of all tasks. 100% of requirements are met	
				Total---->	

Comments: **Total---->**

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Reverse Engineering Rubric

Criteria	Novice-1	Apprentice-2	Proficient-3	Expert-4	
Engineering Notebook	No evidence of notes , sketches or research	Shows some evidence of notes, sketches and research	Evidence of most notes, sketches and research	Clear notes and sketches with all research documented and signed	
Cooperative Group Work (As Needed)	One student did all or most of the work in the group	Most team members did some work but workload varied	All team members did some work but workload varied	Workload is divided and shared equally by all group members	
Project Design	The project is incomplete or partially designed. Drawings are hard to read	The project is complete, but design is poor and will not work with original parts	The project is complete, well constructed and will link to other parts	The project is complete, well planned, always works and is improved over the original parts.	
Presentation	Some difficulty communicating ideas. Poor construction	Reasonable communication. Tough to follow at times. Fair construction	Communicates very well and easy to follow. Good construction	Communicates with enthusiasm, well prepared and well spoken. Exceptional construction	
Completeness of requirements	Less than 60% of the requirements are met	Between 60 and 80% of the requirements are met	Between 81 and 99% of the requirements are met	Total inclusion of all tasks. 100% of requirements are met	
				Total---->	

Comments: **Total---->**

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Bathroom Door Latch Rubric

Criteria	Novice-1	Apprentice-2	Proficient-3	Expert-4	
Engineering Notebook	No evidence of notes, sketches, research and calculations	Shows some evidence of notes, sketches, research and calculations	Evidence of most notes, sketches, research and calculations	Clear notes, calculations and sketches with all research documented and signed	
Cooperative Group Work	One student did all or most of the work in the group	Most team members did some work but workload varied	All team members did some work but workload varied	Workload is divided and shared equally by all group members	
Solid Modeling Design	is incomplete or partially designed.	is complete, but design is poor and will not work with original constraints	is completed, well-assembled and will work	is completed, well planned, always works and is easily adaptable	
Presentation	Some difficulty communicating ideas. Poor drawings	Reasonable communication. Tough to follow at times. Several mistakes on drawings	Communicates very well and easy to follow. Few mistakes on drawings	Communicates with enthusiasm, well prepared and well spoken. Exceptional drawings	
Completeness of requirements	Less than 60% of the requirements are met	Between 60 and 80% of the requirements are met	Between 81 and 99% of the requirements are met	Total inclusion of all tasks. 100% of requirements are met	
Door Latch characteristics	Project Is not complete	Project is complete but does not function	Project is complete and works most of the time	Project is complete, works all of the time	

Comments: **Total---->**

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Nutcracker Rubric

Criteria	Novice-1	Apprentice-2	Proficient-3	Expert-4	
Engineering Notebook	No evidence of notes, sketches, research and calculations	Shows some evidence of notes, sketches, research and calculations	Evidence of most notes, sketches, research and calculations	Clear notes, calculations and sketches with all research documented and signed	
Cooperative Group Work (As Needed)	One student did all or most of the work in the group	Most team members did some work but workload varied	All team members did some work but workload varied	Workload is divided and shared equally by all group members	
Solid Modeling Design	Is incomplete or partially designed.	Is complete, but design is poor and will not work with original constraints	Is complete, well-assembled and will work	Is complete, well planned, always works and is easily adaptable	
Presentation	Some difficulty communicating ideas. Poor drawings	Reasonable communication. Tough to follow at times. Several mistakes on drawings	Communicates very well and easy to follow. Few mistakes on drawings	Communicates with enthusiasm, well prepared and well spoken. Exceptional drawings	
Completeness of requirements	Less than 60% of the requirements are met	Between 60 and 80% of the requirements are met	Between 81 and 99% of the requirements are met	Total inclusion of all tasks. 100% of requirements are met	
Nut Cracker characteristics	Project Is not complete	Project is complete but does not function	Project is complete and works some of the time	Project is complete, works all of the time	

Comments: **Total---->**

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Ball Launcher Rubric

Criteria	Novice-1	Apprentice-2	Proficient-3	Expert-4	
Engineering Notebook	No evidence of notes, sketches or research	Shows some evidence of notes, sketches and research	Evidence of most notes, sketches and research	Clear notes and sketches with all research documented and signed	
Cooperative Group Work	One student did all or most of the work in the group	Most team members did some work but workload varied	All team members did some work but workload varied	Workload is divided and shared equally by all group members	
Project Design	The project is incomplete or partially designed.	The project is complete, but design is poor and will not work with original constraints	The project is complete, well-constructed and will work	The project is complete, well planned, always works and is easily adaptable	
Presentation	Some difficulty communicating ideas. Poor drawings	Reasonable communication. Tough to follow at times. Several mistakes on drawings	Communicates very well and easy to follow. Few mistakes on drawings	Communicates with enthusiasm, well prepared and well spoken. Exceptional drawings	
Completeness of requirements	Less than 60% of the requirements are met	Between 60 and 80% of the requirements are met	Between 81 and 99% of the requirements are met	Total inclusion of all tasks. 100% of requirements are met	
Launcher characteristics	Project Is not complete	Project is complete but does not launch	Project is complete and launches. Hits targets most of time	Project is complete, hits targets accurately all of the time	

Comments: **Total---->**

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Differential Gear Design Rubric

Criteria	Novice-1	Apprentice-2	Proficient-3	Expert-4	
Engineering Notebook	No evidence of notes, sketches, research and calculations	Shows some evidence of notes, sketches, research and calculations	Evidence of most notes, sketches, research and calculations	Clear notes, calculations and sketches with all research documented and signed	
Cooperative Group Work (As Needed)	One student did all or most of the work in the group	Most team members did some work but workload varied	All team members did some work but workload varied	Workload is divided and shared equally by all group members	
Solid Modeling Design	Is incomplete or partially designed.	Is complete, but design is poor and will not work with original constraints	Is complete, well-assembled and will work	Is complete, well planned, always works and is easily adaptable	
Presentation	Some difficulty communicating ideas. Poor drawings	Reasonable communication. Tough to follow at times. Several mistakes on drawings	Communicates very well and easy to follow. Few mistakes on drawings	Communicates with enthusiasm, well prepared and well spoken. Exceptional drawings	
Completeness of requirements	Less than 60% of the requirements are met	Between 60 and 80% of the requirements are met	Between 81 and 99% of the requirements are met	Total inclusion of all tasks. 100% of requirements are met	
Differential characteristics	Project Is not complete	Project is complete but does not function	Project is complete and works some of the time	Project is complete, works all of the time	

Comments: **Total---->**

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Merry-Go-Round Rubric

Criteria	Novice-1	Apprentice-2	Proficient-3	Expert-4	
Engineering Notebook	No evidence of notes, sketches, research and calculations	Shows some evidence of notes, sketches, research and calculations	Evidence of most notes, sketches, research and calculations	Clear notes, calculations and sketches with all research documented and signed	
Cooperative Group Work (As Needed)	One student did all or most of the work in the group	Most team members did some work but workload varied	All team members did some work but workload varied	Workload is divided and shared equally by all group members	
Solid Modeling Design	Is incomplete or partially designed.	Is complete, but design is poor and will not work with original constraints	Is complete, well-assembled and will work	Is complete, well planned, always works and is easily adaptable	
Presentation	Some difficulty communicating ideas. Poor drawings	Reasonable communication. Tough to follow at times. Several mistakes on drawings	Communicates very well and easy to follow. Few mistakes on drawings	Communicates with enthusiasm, well prepared and well spoken. Exceptional drawings	
Completeness of requirements	Less than 60% of the requirements are met	Between 60 and 80% of the requirements are met	Between 81 and 99% of the requirements are met	Total inclusion of all tasks. 100% of requirements are met	
Merry Go Round characteristics	Project Is not complete	Project is complete but does not function	Project is complete and works some of the time	Project is complete, works all of the time	

Comments: **Total---->**

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Truss System Rubric

Criteria	Novice-1	Apprentice-2	Proficient-3	Expert-4	
Engineering Notebook	No evidence of notes, sketches, research and calculations	Shows some evidence of notes, sketches, research and calculations	Evidence of most notes, sketches, research and calculations	Clear notes, calculations and sketches with all research documented and signed	
Cooperative Group Work (As Needed)	One student did all or most of the work in the group	Most team members did some work but workload varied	All team members did some work but workload varied	Workload is divided and shared equally by all group members	
Solid Modeling Design	Is incomplete or partially designed.	Is complete, but design is poor and will not work with original constraints	Is complete, well-assembled and will work	Is complete, well planned, always works and is easily adaptable	
Presentation	Some difficulty communicating ideas. Poor drawings	Reasonable communication. Tough to follow at times. Several mistakes on drawings	Communicates very well and easy to follow. Few mistakes on drawings	Communicates with enthusiasm, well prepared and well spoken. Exceptional drawings	
Completeness of requirements	Less than 60% of the requirements are met	Between 60 and 80% of the requirements are met	Between 81 and 99% of the requirements are met	Total inclusion of all tasks. 100% of requirements are met	
Truss characteristics	Project Is not complete	Project is complete but does not function	Project is complete and works some of the time	Project is complete, works all of the time	

Comments: **Total---->**

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Ingenuity for life

Hybrid Toy Connector Rubric

Criteria	Novice-1	Apprentice-2	Proficient-3	Expert-4	
Engineering Notebook	No evidence of notes, sketches, research and calculations	Shows some evidence of notes, sketches, research and calculations	Evidence of most notes, sketches, research and calculations	Clear notes, calculations and sketches with all research documented and signed	
Cooperative Group Work (As Needed)	One student did all or most of the work in the group	Most team members did some work but workload varied	All team members did some work but workload varied	Workload is divided and shared equally by all group members	
Solid Modeling Design	Is incomplete or partially designed.	Is complete, but design is poor and will not work with original constraints	Is complete, well-assembled and will work	Is complete, well planned, always works and is easily adaptable	
Presentation	Some difficulty communicating ideas. Poor drawings	Reasonable communication. Tough to follow at times. Several mistakes on drawings	Communicates very well and easy to follow. Few mistakes on drawings	Communicates with enthusiasm, well prepared and well spoken. Exceptional drawings	
Completeness of requirements	Less than 60% of the requirements are met	Between 60 and 80% of the requirements are met	Between 81 and 99% of the requirements are met	Total inclusion of all tasks. 100% of requirements are met	
Hybrid Toy characteristics	Project Is not complete	Project is complete but does not function	Project is complete and works some of the time	Project is complete, works all of the time	

Comments: **Total---->**

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Ingenuity for life

Playground Design Rubric

Criteria	Novice-1	Apprentice-2	Proficient-3	Expert-4	
Engineering Notebook	No evidence of notes, sketches, research and calculations	Shows some evidence of notes, sketches, research and calculations	Evidence of most notes, sketches, research and calculations	Clear notes, calculations and sketches with all research documented and signed	
Cooperative Group Work (As Needed)	One student did all or most of the work in the group	Most team members did some work but workload varied	All team members did some work but workload varied	Workload is divided and shared equally by all group members	
Solid Modeling Design	Is incomplete or partially designed.	Is complete, but design is poor and will not work with original constraints	Is complete, well-assembled and will work	Is complete, well planned, always works and is easily adaptable	
Presentation	Some difficulty communicating ideas. Poor drawings	Reasonable communication. Tough to follow at times. Several mistakes on drawings	Communicates very well and easy to follow. Few mistakes on drawings	Communicates with enthusiasm, well prepared and well spoken. Exceptional drawings	
Completeness of requirements	Less than 60% of the requirements are met	Between 60 and 80% of the requirements are met	Between 81 and 99% of the requirements are met	Total inclusion of all tasks. 100% of requirements are met	
Playground characteristics	Project Is not complete	Project is complete but does not function	Project is complete and works some of the time	Project is complete, works all of the time	

Comments: **Total---->**

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Ingenuity for life

Centrifugal Pump Rubric

Criteria	Novice-1	Apprentice-2	Proficient-3	Expert-4	
Engineering Notebook	No evidence of notes, sketches, research and calculations	Shows some evidence of notes, sketches, research and calculations	Evidence of most notes, sketches, research and calculations	Clear notes, calculations and sketches with all research documented and signed	
Cooperative Group Work (As Needed)	One student did all or most of the work in the group	Most team members did some work but workload varied	All team members did some work but workload varied	Workload is divided and shared equally by all group members	
Solid Modeling Design	Is incomplete or partially designed.	Is complete, but design is poor and will not work with original constraints	Is complete, well-assembled and will work	Is complete, well planned, always works and is easily adaptable	
Presentation	Some difficulty communicating ideas. Poor drawings	Reasonable communication. Tough to follow at times. Several mistakes on drawings	Communicates very well and easy to follow. Few mistakes on drawings	Communicates with enthusiasm, well prepared and well spoken. Exceptional drawings	
Completeness of requirements	Less than 60% of the requirements are met	Between 60 and 80% of the requirements are met	Between 81 and 99% of the requirements are met	Total inclusion of all tasks. 100% of requirements are met	
Pump characteristics	Project Is not complete	Project is complete but does not function	Project is complete and works some of the time	Project is complete, works all of the time	

Comments: **Total---->**

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Automatic Training Wheels Rubric

Criteria	Novice-1	Apprentice-2	Proficient-3	Expert-4	
Engineering Notebook	No evidence of notes, sketches, research and calculations	Shows some evidence of notes, sketches, research and calculations	Evidence of most notes, sketches, research and calculations	Clear notes, calculations and sketches with all research documented and signed	
Cooperative Group Work (As Needed)	One student did all or most of the work in the group	Most team members did some work but workload varied	All team members did some work but workload varied	Workload is divided and shared equally by all group members	
Solid Modeling Design	Is incomplete or partially designed.	Is complete, but design is poor and will not work with original constraints	Is complete, well-assembled and will work	Is complete, well planned, always works and is easily adaptable	
Presentation	Some difficulty communicating ideas. Poor drawings	Reasonable communication. Tough to follow at times. Several mistakes on drawings	Communicates very well and easy to follow. Few mistakes on drawings	Communicates with enthusiasm, well prepared and well spoken. Exceptional drawings	
Completeness of requirements	Less than 60% of the requirements are met	Between 60 and 80% of the requirements are met	Between 81 and 99% of the requirements are met	Total inclusion of all tasks. 100% of requirements are met	
Training wheels characteristics	Project Is not complete	Project is complete but does not function	Project is complete and works some of the time	Project is complete, works all of the time	

Comments: **Total---->**

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Ingenuity for life

Mechanical Bank Rubric

Criteria	Novice-1	Apprentice-2	Proficient-3	Expert-4	
Engineering Notebook	No evidence of notes, sketches, research and calculations	Shows some evidence of notes, sketches, research and calculations	Evidence of most notes, sketches, research and calculations	Clear notes, calculations and sketches with all research documented and signed	
Cooperative Group Work (As Needed)	One student did all or most of the work in the group	Most team members did some work but workload varied	All team members did some work but workload varied	Workload is divided and shared equally by all group members	
Solid Modeling Design	Is incomplete or partially designed.	Is complete, but design is poor and will not work with original constraints	Is complete, well-assembled and will work	Is complete, well planned, always works and is easily adaptable	
Presentation	Some difficulty communicating ideas. Poor drawings	Reasonable communication. Tough to follow at times. Several mistakes on drawings	Communicates very well and easy to follow. Few mistakes on drawings	Communicates with enthusiasm, well prepared and well spoken. Exceptional drawings	
Completeness of requirements	Less than 60% of the requirements are met	Between 60 and 80% of the requirements are met	Between 81 and 99% of the requirements are met	Total inclusion of all tasks. 100% of requirements are met	
bank characteristics	Project Is not complete	Project is complete but does not function	Project is complete and works some of the time	Project is complete, works all of the time	

Comments: **Total---->**

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Ingenuity for life

Glider Rubric

Criteria	Novice-1	Apprentice-2	Proficient-3	Expert-4	
Engineering Notebook	No evidence of notes, sketches, research and calculations	Shows some evidence of notes, sketches, research and calculations	Evidence of most notes, sketches, research and calculations	Clear notes, calculations and sketches with all research documented and signed	
Cooperative Group Work (As Needed)	One student did all or most of the work in the group	Most team members did some work but workload varied	All team members did some work but workload varied	Workload is divided and shared equally by all group members	
Solid Modeling Design	Is incomplete or partially designed.	Is complete, but design is poor and will not work with original constraints	Is complete, well-assembled and will work	Is complete, well planned, always works and is easily adaptable	
Presentation	Some difficulty communicating ideas. Poor drawings	Reasonable communication. Tough to follow at times. Several mistakes on drawings	Communicates very well and easy to follow. Few mistakes on drawings	Communicates with enthusiasm, well prepared and well spoken. Exceptional drawings	
Completeness of requirements	Less than 60% of the requirements are met	Between 60 and 80% of the requirements are met	Between 81 and 99% of the requirements are met	Total inclusion of all tasks. 100% of requirements are met	
Glider characteristics	Project Is not complete	Project is complete but does not function	Project is complete and works some of the time	Project is complete, works all of the time and hits target	

Comments: **Total---->**

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Ingenuity for life

Childs Toy Rubric

Criteria	Novice-1	Apprentice-2	Proficient-3	Expert-4	
Engineering Notebook	No evidence of notes, sketches, research and calculations	Shows some evidence of notes, sketches, research and calculations	Evidence of most notes, sketches, research and calculations	Clear notes, calculations and sketches with all research documented and signed	
Cooperative Group Work (As Needed)	One student did all or most of the work in the group	Most team members did some work but workload varied	All team members did some work but workload varied	Workload is divided and shared equally by all group members	
Solid Modeling Design	Is incomplete or partially designed.	Is complete, but design is poor and will not work with original constraints	Is complete, well-assembled and will work	Is complete, well planned, always works and is easily adaptable	
Presentation	Some difficulty communicating ideas. Poor drawings	Reasonable communication. Tough to follow at times. Several mistakes on drawings	Communicates very well and easy to follow. Few mistakes on drawings	Communicates with enthusiasm, well prepared and well spoken. Exceptional drawings	
Completeness of requirements	Less than 60% of the requirements are met	Between 60 and 80% of the requirements are met	Between 81 and 99% of the requirements are met	Total inclusion of all tasks. 100% of requirements are met	
Toy characteristics	Project Is not complete	Project is complete but does not function	Project is complete and works some of the time	Project is complete, works all of the time	

Comments: **Total---->**

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Solid Edge Resources

To gain access to the resources listed here and other videos about Solid Edge students and teachers must register at the Siemens Learning Center. The link to instructions for creating your account is https://solidedge.siemens.com/en/resource/video/siemens-learning-center/. Follow the instructions in the video and create your account. Use your account to sign into the dashboard https://learn.sw.siemens.com/dashboard. The dashboard will provide access to all kinds of resources. Selected resources which support the projects are sorted by subject. Follow the links to access the video tutorials for desired topics.

User Interface

Basic Introduction

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-quick-start/Ey8QWFP7d/chapters/solid-edge-quick-start/Nk1aTuvXd?topic=0

Controls and View Orientation

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-01-fundamentals-of-3-d-modelling/E1NPKx5pP?topic=2

Selecting Templates

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-03-user-interface/4kozzZqTv?topic=0

Work Environment

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-03-user-interface/4kozzZqTv?topic=1

Command Finder

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-03-user-interface/4kozzZqTv?topic=2

Feature Tree

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-03-user-interface/4kozzZqTv?topic=3

Prompt Bar

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-03-user-interface/4kozzZqTv?topic=4

View Styles

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-06-cube-cutouts/EJu1wW96D?topic=9

Quick View Cube

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=2

Steering Wheel

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=34
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-01-fundamentals-of-3-d-modelling/E1NPKx5pP?topic=12
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-01-fundamentals-of-3-d-modelling/E1NPKx5pP?topic=13

Sketching

Introduction

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=3
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=4
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=9
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=10
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-quick-start/Ey8QWFP7d/chapters/solid-edge-quick-start/Nk1aTuvXd?topic=1
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=22

Draw Commands

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-01-fundamentals-of-3-d-modelling/E1NPKx5pP?topic=4

Trim

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=18

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/introduction-to-solid-edge-2-d-geometry/414vCOk6P/chapters/chapter-01-constraints-and-relationships/VkJ3kKy6w?topic=5
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/introduction-to-solid-edge-2-d-geometry/414vCOk6P/chapters/chapter-01-constraints-and-relationships/VkJ3kKy6w?topic=7

Extend to Next
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/introduction-to-solid-edge-2-d-geometry/414vCOk6P/chapters/chapter-01-constraints-and-relationships/VkJ3kKy6w?topic=22

Line Sketch
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-01-fundamentals-of-3-d-modelling/E1NPKx5pP?topic=5

Axis in the Center
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=15
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-01-fundamentals-of-3-d-modelling/E1NPKx5pP?topic=10

Centering Sketches
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-01-fundamentals-of-3-d-modelling/E1NPKx5pP?topic=6

Selecting Keypoints
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-01-fundamentals-of-3-d-modelling/E1NPKx5pP?topic=11
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/introduction-to-solid-edge-2-d-geometry/414vCOk6P/chapters/chapter-03-creating-shapes-and-patterns/Vyb071ZpP?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/introduction-to-solid-edge-2-d-

geometry/414vCOk6P/chapters/chapter-03-creating-shapes-and-patterns/Vyb071ZpP?topic=2
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/introduction-to-solid-edge-2-d-geometry/414vCOk6P/chapters/chapter-03-creating-shapes-and-patterns/Vyb071ZpP?topic=3

Intellisketch
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=7
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=8

Using the Sketch Lock
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=12
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=13
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/chapters/chapter-02-locking/EkUTlbqpw?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/chapters/chapter-02-locking/EkUTlbqpw?topic=1

Project to Sketch
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=24
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=25

Offset
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-09-bullseye/4ySXy7qTD?topic=1

Text
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-18-practice/E1CNFc96w?topic=0

Crosshatch and Color

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=16
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=11
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/introduction-to-solid-edge-2-d-geometry/414vCOk6P/chapters/chapter-01-constraints-and-relationships/VkJ3kKy6w?topic=8

Copy and Rotate

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=27
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/introduction-to-solid-edge-2-d-geometry/414vCOk6P/chapters/chapter-03-creating-shapes-and-patterns/Vyb071ZpP?topic=7
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/introduction-to-solid-edge-2-d-geometry/414vCOk6P/chapters/chapter-03-creating-shapes-and-patterns/Vyb071ZpP?topic=8
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/introduction-to-solid-edge-2-d-geometry/414vCOk6P/chapters/chapter-03-creating-shapes-and-patterns/Vyb071ZpP?topic=10

Fillet

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/introduction-to-solid-edge-2-d-geometry/414vCOk6P/chapters/chapter-03-creating-shapes-and-patterns/Vyb071ZpP?topic=19

Mirror

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=21
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/introduction-to-solid-edge-2-d-geometry/414vCOk6P/chapters/chapter-03-creating-shapes-and-patterns/Vyb071ZpP?topic=23

Creating Reference Planes

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=17

Visualization: Creating Parts from Engineering Sketches

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-10-engineering-drawings/4yIO-mcaP?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-10-engineering-drawings/4yIO-mcaP?topic=1
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-10-engineering-drawings/4yIO-mcaP?topic=2
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-10-engineering-drawings/4yIO-mcaP?topic=5

Polygons

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/introduction-to-solid-edge-2-d-geometry/414vCOk6P/chapters/chapter-01-constraints-and-relationships/VkJ3kKy6w?topic=17
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/introduction-to-solid-edge-2-d-geometry/414vCOk6P/chapters/chapter-01-constraints-and-relationships/VkJ3kKy6w?topic=18

Constraining Sketches

Geometric Relationships and Constraints

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=5
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=6
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-quick-start/Ey8QWFP7d/chapters/solid-edge-quick-start/Nk1aTuvXd?topic=3
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-quick-start/Ey8QWFP7d/chapters/solid-edge-quick-start/Nk1aTuvXd?topic=4
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/introduction-to-solid-edge-2-d-geometry/414vCOk6P/chapters/chapter-01-constraints-and-relationships/VkJ3kKy6w?topic=0

Line Constraints

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/introduction-to-solid-edge-2-d-geometry/414vCOk6P/chapters/chapter-01-constraints-and-relationships/VkJ3kKy6w?topic=1

Equal Constraint

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/introduction-to-solid-edge-2-d-geometry/414vCOk6P/chapters/chapter-01-constraints-and-relationships/VkJ3kKy6w?topic=2
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/introduction-to-solid-edge-2-d-geometry/414vCOk6P/chapters/chapter-01-constraints-and-relationships/VkJ3kKy6w?topic=5
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/introduction-to-solid-edge-2-d-geometry/414vCOk6P/chapters/chapter-01-constraints-and-relationships/VkJ3kKy6w?topic=9

Horizontal and Vertical

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/introduction-to-solid-edge-2-d-geometry/414vCOk6P/chapters/chapter-01-constraints-and-relationships/VkJ3kKy6w?topic=3

Tangent

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/introduction-to-solid-edge-2-d-geometry/414vCOk6P/chapters/chapter-01-constraints-and-relationships/VkJ3kKy6w?topic=10

Concentric

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/introduction-to-solid-edge-2-d-geometry/414vCOk6P/chapters/chapter-01-constraints-and-relationships/VkJ3kKy6w?topic=11

Parallel

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/introduction-to-solid-edge-2-d-geometry/414vCOk6P/chapters/chapter-01-constraints-and-relationships/VkJ3kKy6w?topic=11
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/introduction-to-solid-edge-2-d-geometry/414vCOk6P/chapters/chapter-01-constraints-and-relationships/VkJ3kKy6w?topic=12

Connect

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/introduction-to-solid-edge-2-d-geometry/414vCOk6P/chapters/chapter-01-constraints-and-relationships/VkJ3kKy6w?topic=11

Perpendicular

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/introduction-to-solid-edge-2-d-geometry/414vCOk6P/chapters/chapter-01-constraints-and-relationships/VkJ3kKy6w?topic=11

Collinear

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/introduction-to-solid-edge-2-d-geometry/414vCOk6P/chapters/chapter-01-constraints-and-relationships/VkJ3kKy6w?topic=14

Dimensions

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=19

Base Features

Base Features introduction

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-quick-start/Ey8QWFP7d/chapters/solid-edge-quick-start/Nk1aTuvXd?topic=2
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-01-fundamentals-of-3-d-modelling/E1NPKx5pP?topic=16

Basic Shapes

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=1
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-01-fundamentals-of-3-d-modelling/E1NPKx5pP?topic=1
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-01-fundamentals-of-3-d-modelling/E1NPKx5pP?topic=8

Using the Steering Wheel

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-01-fundamentals-of-3-d-modelling/E1NPKx5pP?topic=15
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-01-fundamentals-of-3-d-modelling/E1NPKx5pP?topic=14
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-18-practice/E1CNFc96w?topic=6

Extrusion

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-06-cube-cutouts/EJu1wW96D?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-06-cube-cutouts/EJu1wW96D?topic=1
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-06-cube-cutouts/EJu1wW96D?topic=2
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-06-cube-cutouts/EJu1wW96D?topic=5
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-06-cube-cutouts/EJu1wW96D?topic=6
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-06-cube-cutouts/EJu1wW96D?topic=7
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-06-cube-cutouts/EJu1wW96D?topic=8

Round Command

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-07-rounding/EJl7pZ5TD?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-07-rounding/EJl7pZ5TD?topic=1

Thin Wall

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-12-thinwall/Ny6wHXcaw?topic=0

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-12-thinwall/Ny6wHXcaw?topic=1
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-12-thinwall/Ny6wHXcaw?topic=2
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-12-thinwall/Ny6wHXcaw?topic=3
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-12-thinwall/Ny6wHXcaw?topic=4

Loft

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-14-loft/Ektxjm9Tv?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-14-loft/Ektxjm9Tv?topic=1

Revolve

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=29
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-16-revolve/4y6GdN9pP?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-16-revolve/4y6GdN9pP?topic=1
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-16-revolve/4y6GdN9pP?topic=2
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-16-revolve/4y6GdN9pP?topic=3
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-16-revolve/4y6GdN9pP?topic=4
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-16-revolve/4y6GdN9pP?topic=5
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-16-revolve/4y6GdN9pP?topic=7

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-16-revolve/4y6GdN9pP?topic=8
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-16-revolve/4y6GdN9pP?topic=9
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=31

Sweep

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-17-sweep/VydMvq5aw?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-17-sweep/VydMvq5aw?topic=1

Pattern

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=28

Analysis of Parts

Area

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=20
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=14
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-11-area/VkAAEQ9Tw?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-11-area/VkAAEQ9Tw?topic=1
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/introduction-to-solid-edge-2-d-geometry/414vCOk6P/chapters/chapter-02-finding-angle-length-and-area/V19eZkWaw?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/introduction-to-solid-edge-2-d-geometry/414vCOk6P/chapters/chapter-02-finding-angle-length-and-area/V19eZkWaw?topic=1

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/introduction-to-solid-edge-2-d-geometry/414vCOk6P/chapters/chapter-02-finding-angle-length-and-area/V19eZkWaw?topic=2

Measure Minimum Distance

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=38
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/introduction-to-solid-edge-2-d-geometry/414vCOk6P/chapters/chapter-02-finding-angle-length-and-area/V19eZkWaw?topic=7

Mass Properties

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=23
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-18-practice/E1CNFc96w?topic=4

Editing Dimensions and parts

Basic modify

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-01-fundamentals-of-3-d-modelling/E1NPKx5pP?topic=3

Steering Wheel

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-quick-start/Ey8QWFP7d/chapters/solid-edge-quick-start/Nk1aTuvXd?topic=5

Design Intent

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-09-bullseye/4ySXy7qTD?topic=0

Working Drawings

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=26

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-quick-start/Ey8QWFP7d/chapters/solid-edge-quick-start/Nk1aTuvXd?topic=7

Renderings

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-quick-start/Ey8QWFP7d/chapters/solid-edge-quick-start/Nk1aTuvXd?topic=10

Adding Color to Models

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-01-fundamentals-of-3-d-modelling/E1NPKx5pP?topic=7

Saving Images

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-introduction-to-3-d-design/EkPJgmzTv/chapters/chapter-03-user-interface/4kozzZqTv?topic=5

Creating Movies

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=3
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=7

Editing Imported Parts

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-quick-start/Ey8QWFP7d/chapters/solid-edge-quick-start/Nk1aTuvXd?topic=8

Assembly Modeling

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=35
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=36
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-certification/Nykqp_i6D/chapters/chapter-1-key-concepts-review/N1-L0OjTw?topic=37

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-quick-start/Ey8QWFP7d/chapters/solid-edge-quick-start/Nk1aTuvXd?topic=6

Generative Design

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-quick-start/Ey8QWFP7d/chapters/solid-edge-quick-start/Nk1aTuvXd?topic=11

Engineering References

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1323753:index_xid718565

Mechanical Systems

Introduction to Mechanisms

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-01-introduction/VJ-5mlGyO?topic=1

CAM and Follower

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=1

Beginning CAM Motion

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-02-cam-follower/Vyu1KZMkd?topic=2

Common CAM Types

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=1
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=2

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-03-common-cam-types/41Bc5-zJ_?topic=3

CAM Physical Motion

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-04-cam-vice-lock-scissors/4JThnbf1d?topic=2

Circular vs. Arc

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-04-cam-vice-lock-scissors/4JThnbf1d?topic=3

Four Bar Mechanisms

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=1
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=2
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=3
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=4
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-06-4-bar-mechanisms/NJoFlzzJ_?topic=4

Motion Concepts

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-09-motion-concepts/NytArMfyu?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-09-motion-concepts/NytArMfyu?topic=1

Examples of Mechanisms

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-10-reciprocating-saw/4yAA8Mfyd?topic=0

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-11-slider-crank-mechanism/VyXX_ffJd?topic=0
- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-12-crank-mechanism-modification/VJqNYfMku?topic=0

Scotch Yoke Mechanism

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-13-scotch-yoke-mechanism/NJJrsGzkd?topic=0

Waving Mechanism

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-14-waving-mechanism/NyeShGzJu?topic=0

Hammering Toy Mechanism

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-15-hammering-toy-mechanism/4kBlTGfyd?topic=0

Iris Mechanism

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-robotics-and-mechanisms/NyxzW7fku/chapters/chapter-16-iris-mechanism/VJ6a1QGJ_?topic=0

Structures and Forces

- https://learn.sw.siemens.com/library/solid-edge-for-education-and-community/VyR_oDmjP/learning-paths/solid-edge-quick-start/Ey8QWFP7d/chapters/solid-edge-quick-start/Nk1aTuvXd?topic=9

Tutorial

- https://docs.plm.automation.siemens.com/tdoc/se/2020/se_help#uid:xid1129777:xid1325275:index_sesim:xid1602403:activity1a

Where do you Want to Go?

This page contains links back to the Daily Plan for each project.

Quarter 1

Engineering Design Process

- Introduction to the Engineering Design Process

Sketching

- Sketching and Documentation

3D Solid Modeling/Fabrication and 3D printing

- Name Plate Holder
- Sport Drink Container
- Kitchen Tool Design
- Chess Set

Renderings/Working Drawings/ Design Presentations

- Shower Caddy Rendering
- Table Driven Kitchen Measuring Instruments
- Package Design

Quarter 2

Assembly Modeling/Documentation/Exploded Assemblies/Bill of materials

- 3D Puzzle
- Mold Design
- Coaches' Cart

Reverse Engineering/Engineering Features

- Reverse Engineering Project

Quarter 3

Simple Machines

- Bathroom Door Latch
- Nutcracker
- Ball Launcher

Mechanical Systems

- Differential Gear Design

- Merry-Go-Round

Quarter 4

Structures and Forces

- Truss System
- Playground Design
- Hybrid Toy Connector

Engineering Systems

- Centrifugal Pump
- Automatic Training Wheels
- Mechanical Bank
- Glider
- Child's Toy