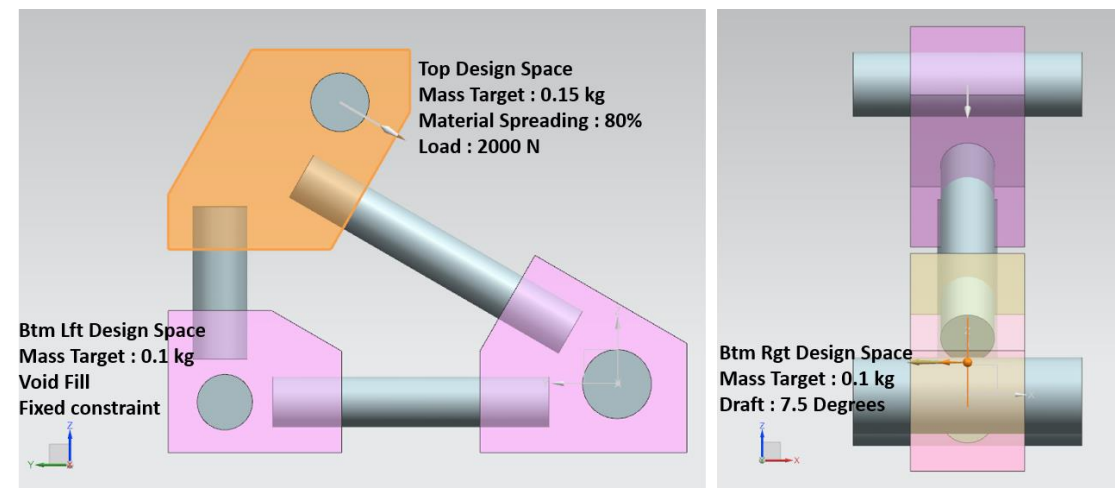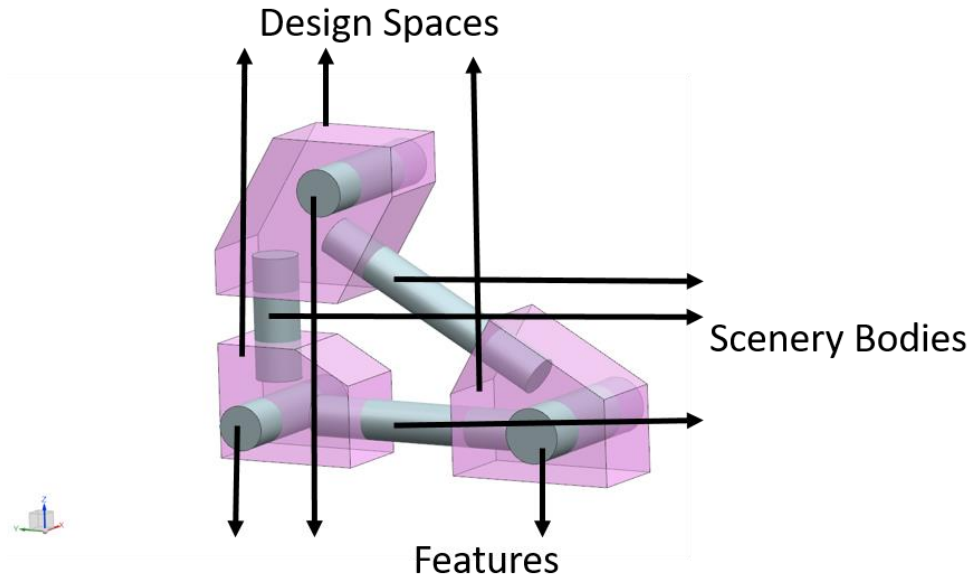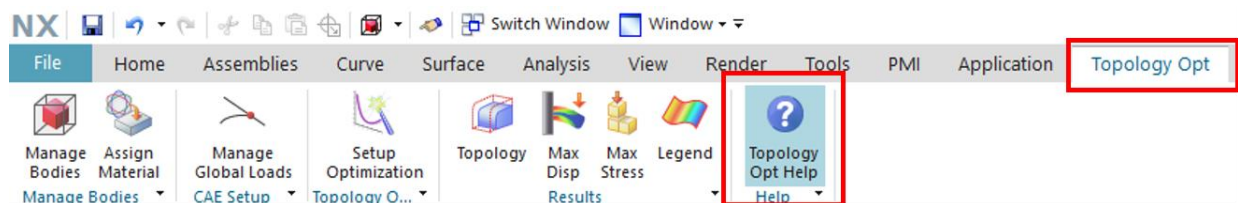# TOPOLOGY OPTIMIZATION

This tutorial shows how to perform **Topology Optimization** on the part shown, with specified loads and constraints

NOTE: To understand the relevant terminology in this tutorial associated with the Topology Optimization workflow, go to **Topology Opt → Topology Opt Help**

<u>**TIP:**</u>

- Each dialog box in the Top Opt workflow may retain dialog memory from previous iterations. If it is found that a certain parameter in a dialog box is already set without the user having assigned a value, the dialog memory needs to be refreshed. Click on ⟳ icon in any dialog box to refresh memory

- If you need to reset the entire Topology Optimization workflow in the **Manage Bodies** dialog box, click on **Reset Topology Optimization workflow**
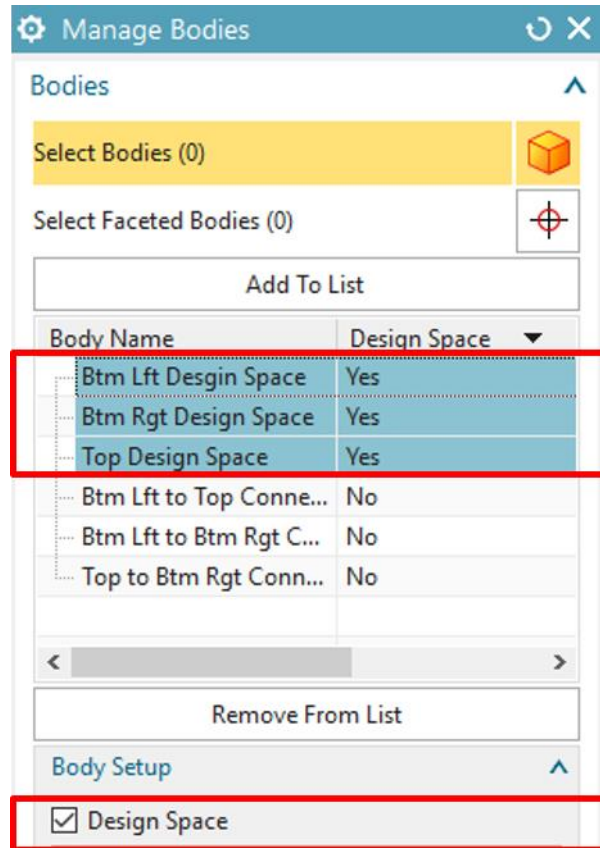
<u>MANAGE BODIES</u>

1. In the Modeling application, select **Topology Opt**
2. In the Ribbon bar, select **Manage Bodies**.

3. In the graphics window, select the Design Spaces and Scenery bodies that need to be optimized.
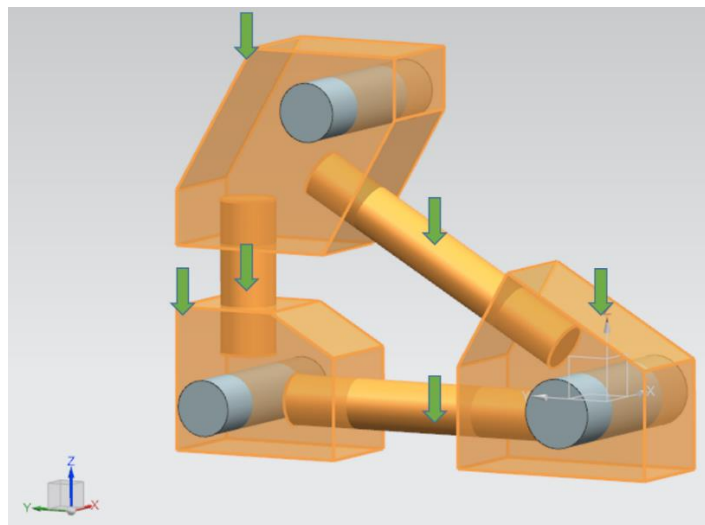
4. In the **Manage Bodies** dialog box, in the **Bodies group,** click **Add To List**
   Notice the selected bodies have been added to the **Bodies list**
5. To assign a body (or bodies using **Ctrl** button) from the **Bodies list** as design space, select body from the list and activate the **Design Space** checkbox

Notice the bodies assigned as 'Design Space' have changed to **'Yes'**

NOTE: For more information on 'Design Space' and 'Scenery Body' refer **Topology Opt Help | Manage Bodies | Bodies**

CONNECTIONS

NOTE: For more information on 'Connections' refer **Topology Opt Help | Manage Bodies | Bodies | Connections**

1. To make connections among design spaces, select a Design space and a Scenery body from the list (2 bodies need to be selected; use **Ctrl** button)

2. In the **Connections** group, click **Add (Select Two Bodies)**
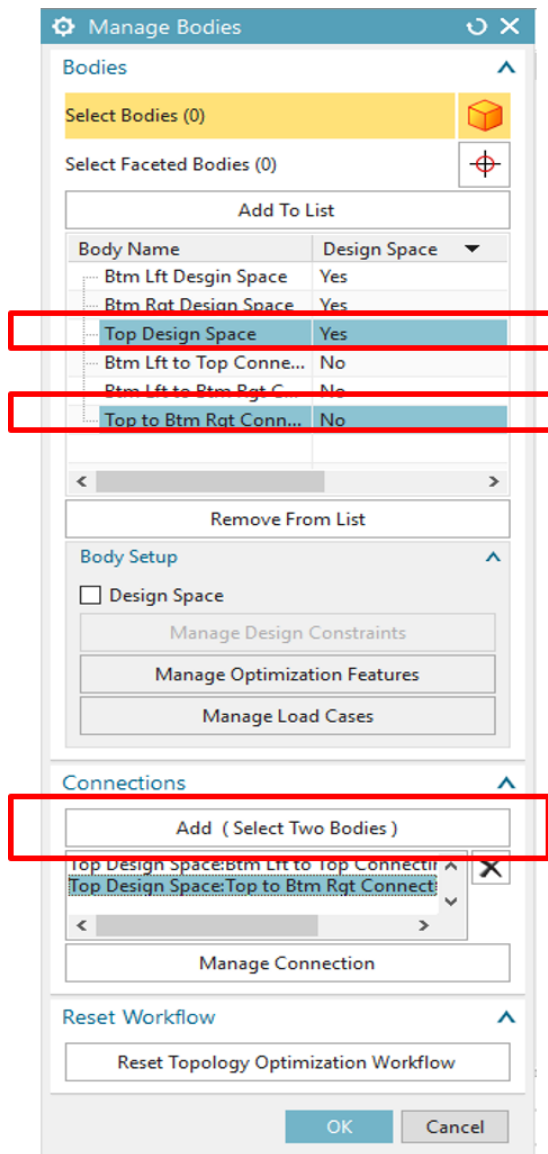
Notice the updated **Connections** list

3. Make all relevant connections (as shown in graphics)
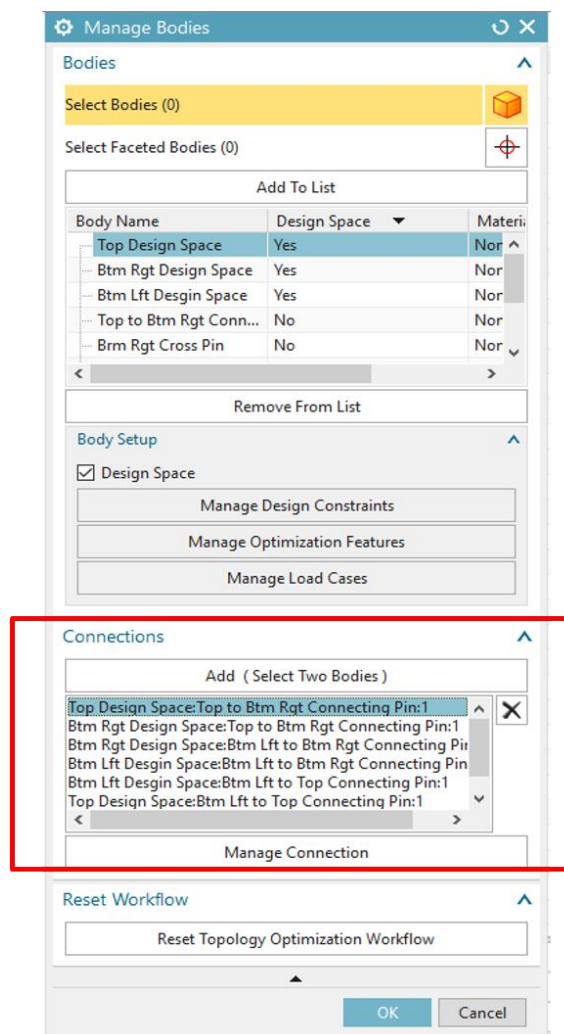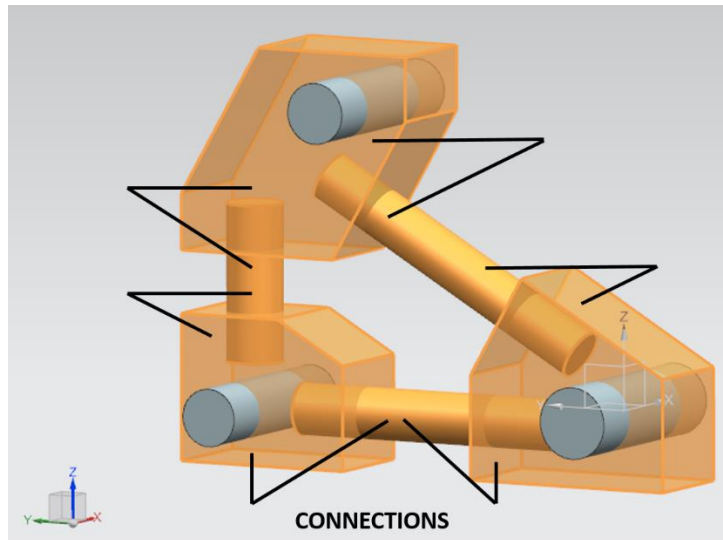
CONNECTIONS

Notice the updated **Connections** list

MANAGE DESIGN CONSTRAINTS

1. Select a Design Space from the **Bodies** list, click **Manage Design Constraints**
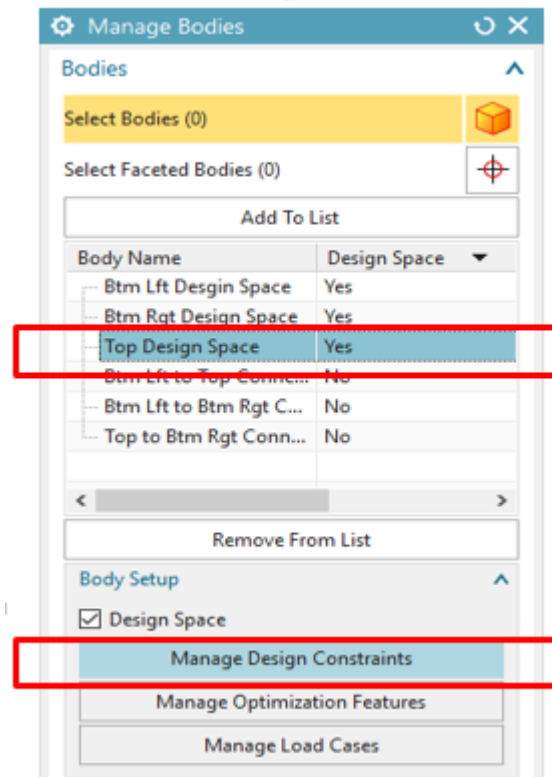
2. In **Manage Design Constraints** dialog box, from the **Constraints Type** drop down list, choose a constraint
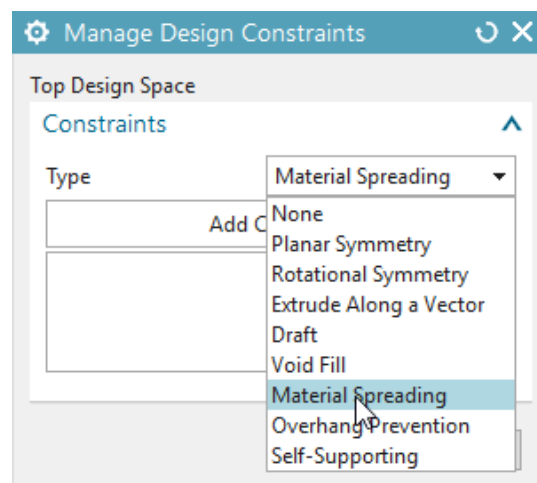
3. Click **Add Constraint**

Notice the updated **Constraints** list

4. Select the constraint and set/define the constraint parameters
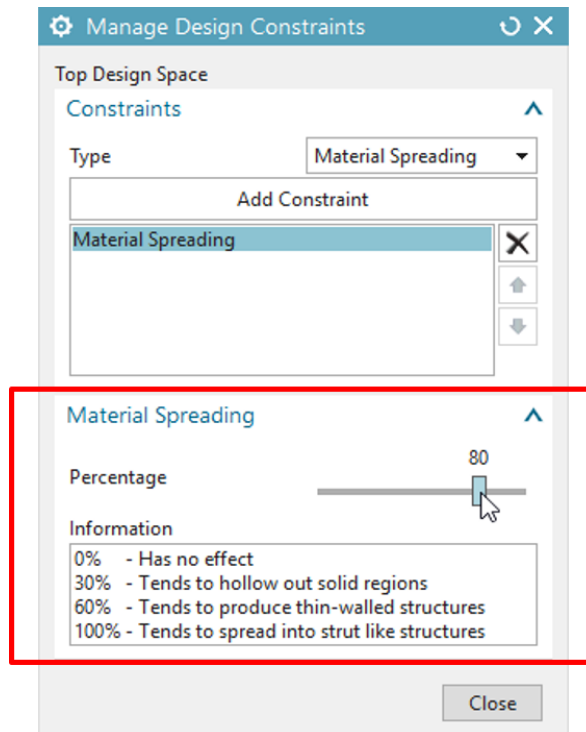
Notice the Material Spreading Percentage has been set to 80%

Manage the Design Constraints for each Design Space according to the table

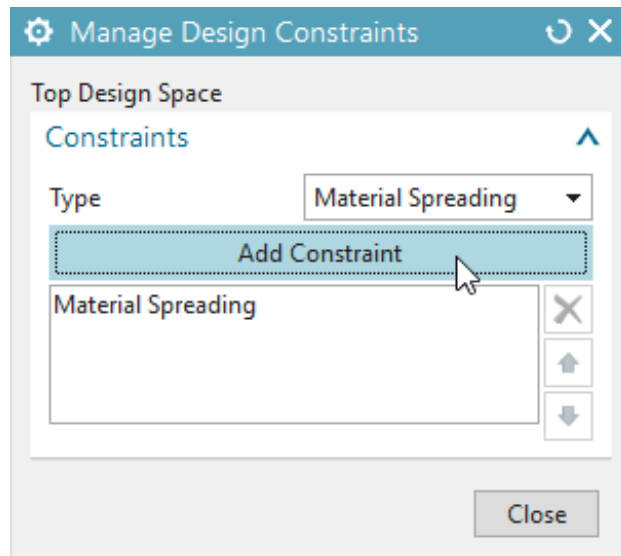| Design Space	List of Design Constraints	Constraint parameters
Btm Lft Design Space	Void Fill	Checkbox : Enable
Top Design Space	Material Spreading	Percentage : 80%
Btm Rgt Design Space	Draft	Parting surface type : Plane Plane definition : Bisector Draft Angle : 7.5 degrees
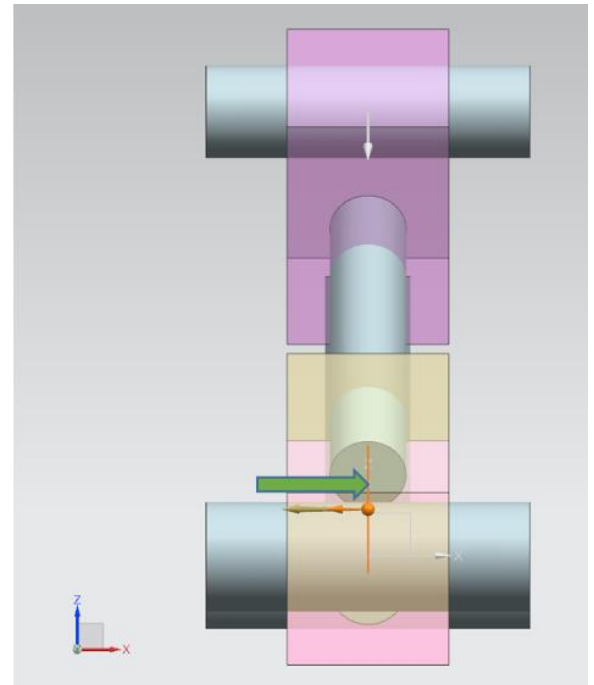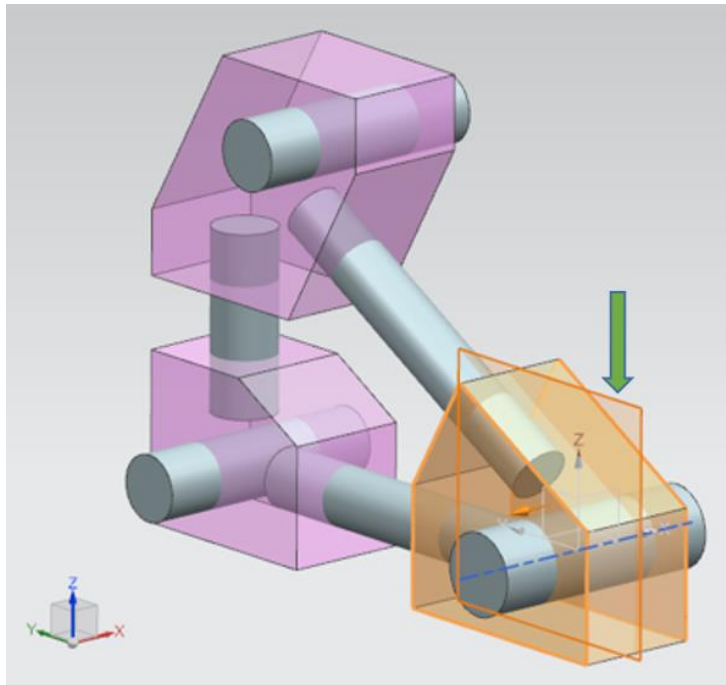
This graphic shows the Draft plane for Btm Rgt Design Space

MANAGE OPTIMIZATION FEATURES

1. In the **Manage Bodies** dialog box, select a Design space from the list, click **Manage Optimization Features**

2. In the **Manage Optimization Features** dialog box, to add a feature body to the **Feature list**, click on ⊕ symbol, select solid body from the graphics window, then click OK. (see tables below)
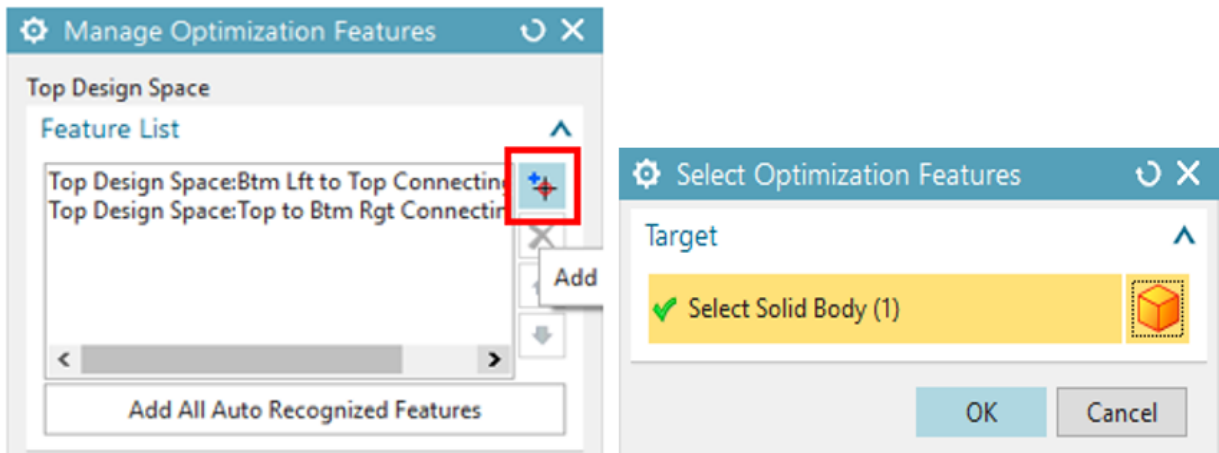
3. From the **Feature list** select a feature
4. In **Feature Properties** group specify **Geometry** parameters for each feature. (see tables below)
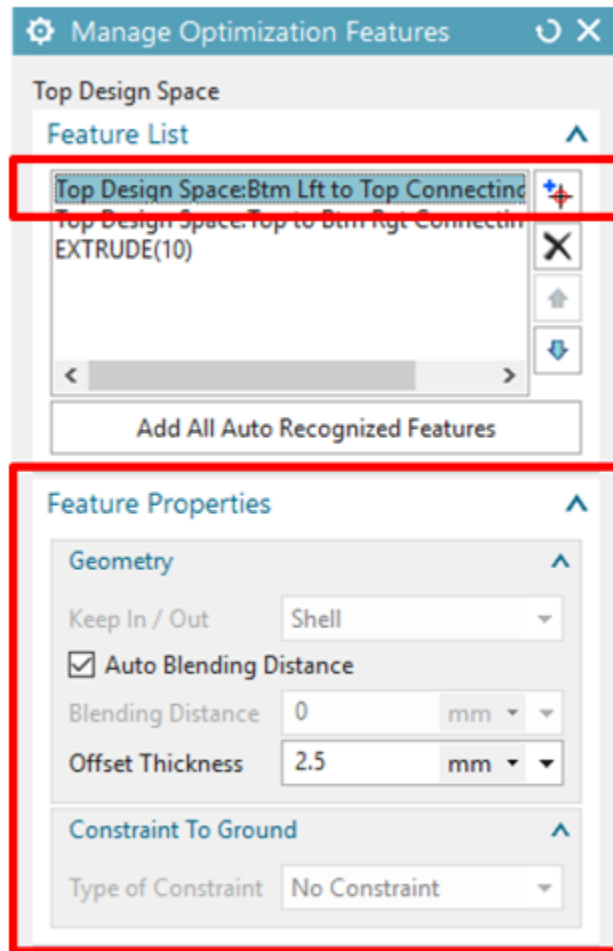
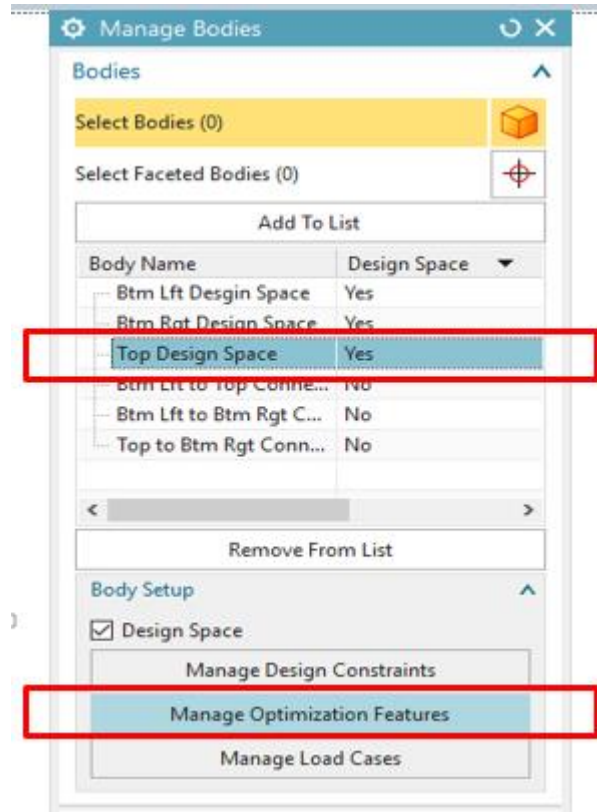Manage the Optimization Features for each Design Space according to the table using the steps outlined above

Design Space	Feature List	Feature Properties	Maximum Displacement
Top Design Space	Top Design Space : Btm Lft to Top Connecting Pin : 1	• Keep In / Out : Shell • Blending Distance : Auto • Offset Thickness : 2.5 mm • Type of Constraint : No Constraint	Disabled
	Top Design Space : Top to Btm Rgt Connecting Pin : 1	• Keep In / Out : Shell • Blending Distance : Auto • Offset Thickness : 2.5 mm • Type of Constraint : No Constraint	Disabled
	EXTRUDE(10)	• Keep In / Out : Shell • Blending Distance : Auto • Offset Thickness : 2.5 mm • Type of Constraint : No Constraint	Disabled

Design Space	Feature List	Feature Properties	Maximum Displacement
Btm Rgt Design Space	Btm Rgt Design Space : Lft to Btm Rgt Connecting Pin : 1	• Keep In / Out : Shell • Blending Distance : Auto • Offset Thickness : 2.5 mm • Type of Constraint : No Constraint	Disabled
	Btm Rgt Design Space : Top to Btm Rgt Connecting Pin : 1	• Keep In / Out : Shell • Blending Distance : Auto • Offset Thickness : 2.5 mm • Type of Constraint : No Constraint	Disabled
	EXTRUDE(8)	• Keep In / Out : Shell • Blending Distance : Auto • Offset Thickness : 2.5 mm • Type of Constraint : No Constraint	Disabled

Design Space	Feature List	Feature Properties	Maximum Displacement
Btm Lft Design Space	Btm Lft Design Space : Btm Lft to Top Connecting Pin : 1	• Keep In / Out : Shell • Blending Distance : Auto • Offset Thickness : 2.5 mm • Type of Constraint : No Constraint	Disabled
	Btm Lft Design Space : Btm Lft to Btm Rgt Connecting Pin : 1	• Keep In / Out : Shell • Blending Distance : Auto • Offset Thickness : 2.5 mm • Type of Constraint : No Constraint	Disabled
	EXTRUDE(11)	• Keep In / Out : Shell • Blending Distance : Auto • Offset Thickness : 2.5 mm • Type of Constraint : Fixed	Disabled

NOTE:

- For detailed information on the effect of a feature property on the result, refer **Topology Opt Help | Manage Bodies | Bodies| Manage Optimization Features**
- For information on '**Add All Auto Recognized Features',** go to **Topology Opt Help | Manage Bodies | Bodies | Manage Optimization Features**

MANAGE LOAD CASES

1. In the **Manage Bodies** dialog box, select a Design space from the list, click **Manage Load Cases**
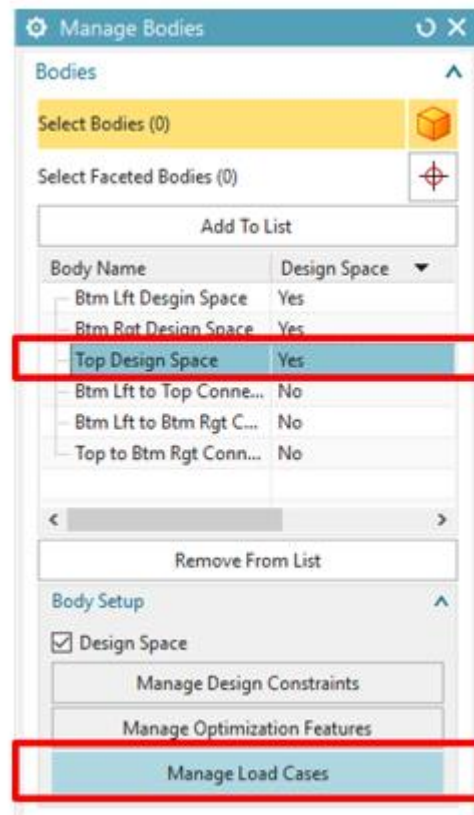
2. In the **Manage Load Cases** dialog box, in **Features** group, the list of features is auto populated
3. From the **Features** list select a feature
4. In the **Loads group -**
- Select the load **Type** to be applied from the drop-down list
- Specify the magnitude and direction of the load
  NOTE: For detailed information on different types of loads, refer **Topology Opt Help | Manage Bodies | Bodies | Manage Load Cases | Load Type**
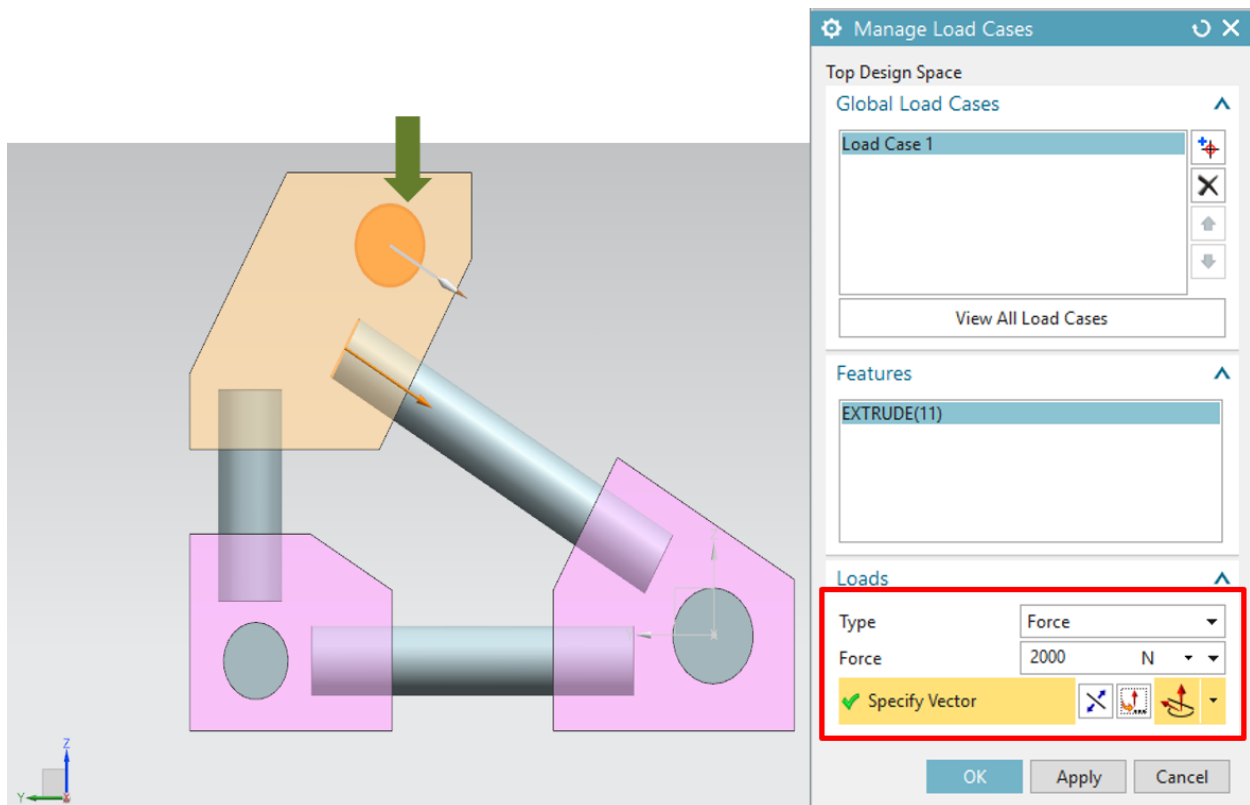
Notice in the graphics window, the direction of load on highlighted feature

NOTE: In the **Global Load Cases group,** click on **View All Load Cases** to view the type, magnitude and direction of loads applied on all features in all load cases. There is always a single load case (**Load Case 1**) by default

Manage Load Cases

Btm Rgt Design Space

Global Load Cases

Load Case 1

View All Load Cases

Features

EXTRUDE(8)

Loads

| Type | Force |
| Force | 0 N |

Specify Vector

OK | Apply | Cancel

Information

Type	Load Case 1	Load	Vector
Force	EXTRUDE(8)	0.000E+00 N	[0.0,0.0,0.0]

Manage Load Cases

Btm Lft Desgin Space

Global Load Cases

Load Case 1

View All Load Cases

Features

EXTRUDE(11) - (Fixed)

Loads

| Type | Force |
| Force | 0 N |

Specify Vector

OK | Apply | Cancel

Information

Type	Load Case 1	Load	Vector
	EXTRUDE(11)	Fixed	-

MANAGE ASSEMBLY CONNECTION

1. In the **Manage Bodies** dialog box, from the **Connections** list, select a connection, click **Manage Connection**
2. In the **Manage Assembly Connection** dialog box, select the **Type of Connection** (Glue)
3. In **Manage Overlaps** group, define **Behavior** from the dropdown list.
   NOTE: For more information on 'Behavior' refer **Topology Opt Help | Manage Bodies | Bodies | Connections**
4. In this case, we subtract the connecting pin from the design space. Hence, **Subtract B from A**
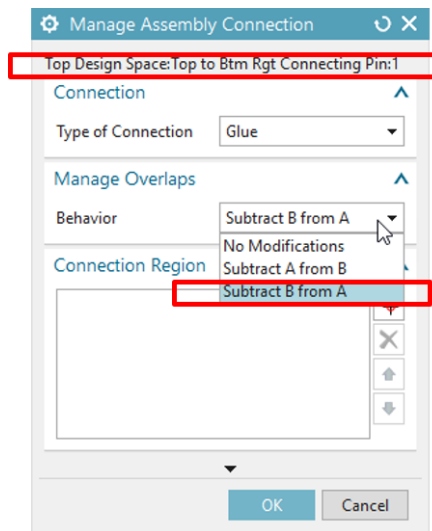
Manage the connections between bodies according to the table using the steps outlined above

First Body (A)	Second Body (B)	Connection Type	Behavior
Top Design Space	Top to Btm Rgt Connecting Pin	Glue	Subtract B from A
Btm Rgt Design Space	Top to Btm Rgt Connecting Pin	Glue	Subtract B from A
Btm Rgt Design Space	Btm Lft to Btm Rgt Connecting Pin	Glue	Subtract B from A
Btm Lft Design Space	Btm Lft to Btm Rgt Connecting Pin	Glue	Subtract B from A
Btm Lft Design Space	Btm Lft to Top Connecting Pin	Glue	Subtract B from A
Top Design Space	Btm Lft to Top Connecting Pin	Glue	Subtract B from A

5. Click **OK** to close the **Manage Assembly Connection** dialog box

ASSIGN MATERIAL

1. Each body in the **Bodies** list needs to be assigned a material. In the Modeling application, select **Topology Opt**
2. In the Ribbon bar, select **Assign Material**
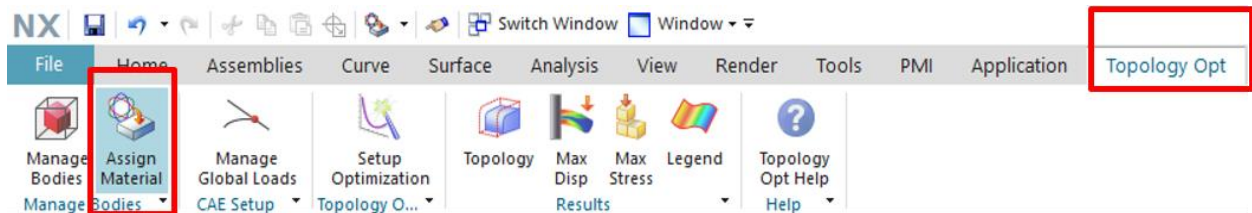
3. In the graphics window, select all the bodies to which a material is to be assigned
4. In the **Assign Material** dialog box, under **Material List** group**,** select a material from the **Materials** list
5. In the **New Material** group**,** from the drop-down list of material properties, select a **Type;** click **Apply/OK**
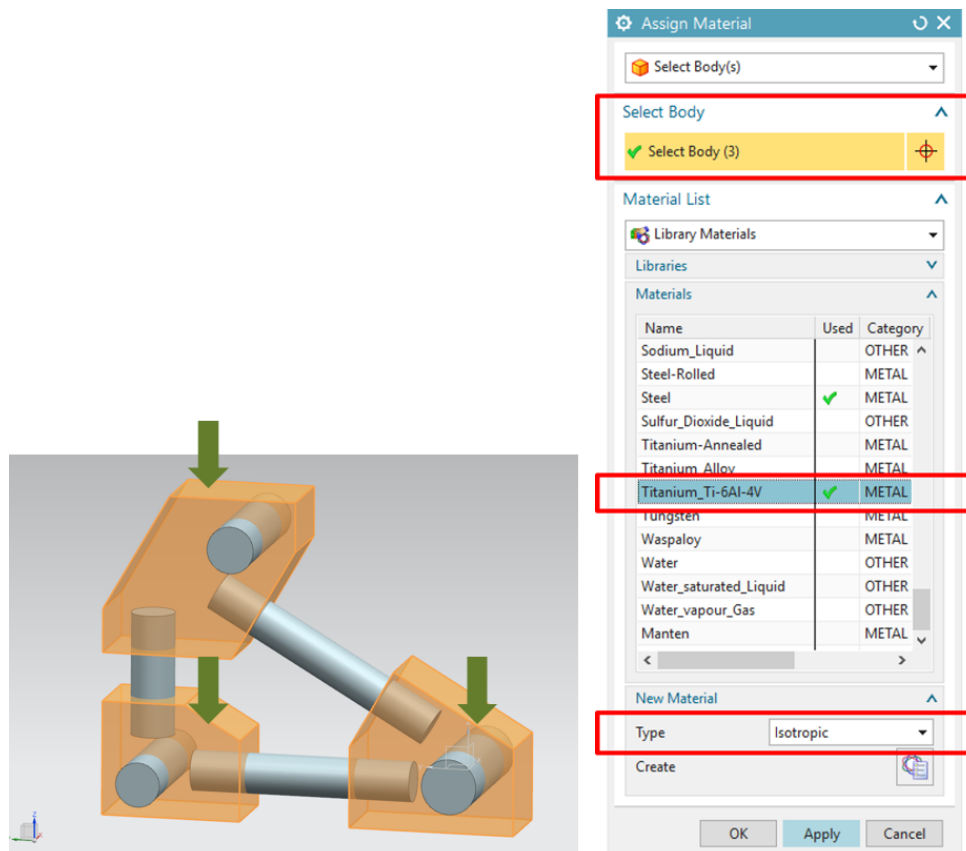
Notice in the graphics window, the design spaces selected

The table below illustrates the material assigned to each body in the Bodies list

| Bodies	Assigned Library Material
Top Design Space Btm Rgt Design Space Btm Lft Design Space	Titanium_Ti-6Al-4V
Top to Btm Rgt Connecting Pin Btm Lft to Btm Rgt Connecting Pin Btm Lft to Top Connecting Pin	Steel

<u>SETUP OPTIMIZATION</u>

1. In the Modeling application, select **Topology Optimization**
2. In the Ribbon bar, select **Setup Optimization**
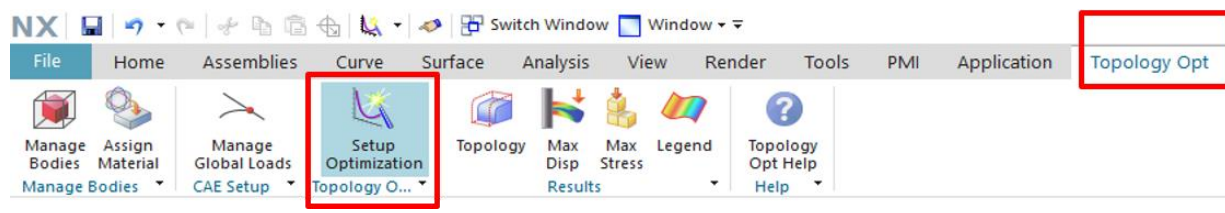
3. In **Setup Optimization** dialog box, **Parameters** tab, under **Optimization group,** select the optimization type from the drop-down list
4. In **Select Global Resolution** group**,** move the slider to select either a fast & coarse or a slow & fine optimization.
5. Click **Estimate Optimization Parameters.** The values under **Optimization Parameters** are determined
6. Select each design space from the list of **Design Spaces,** under **Optimization Constraints group,** enter a numeric value for **Mass Target**
7. Click **Run Optimization**

The table below illustrates the Mass Target for each Design Space

| Design Spaces	Optimization Constraints (Mass Target)
Top Design Space	0.15 kg
Btm Rgt Design Space	0.1 kg
Btm Lft Design Space	0.1 kg
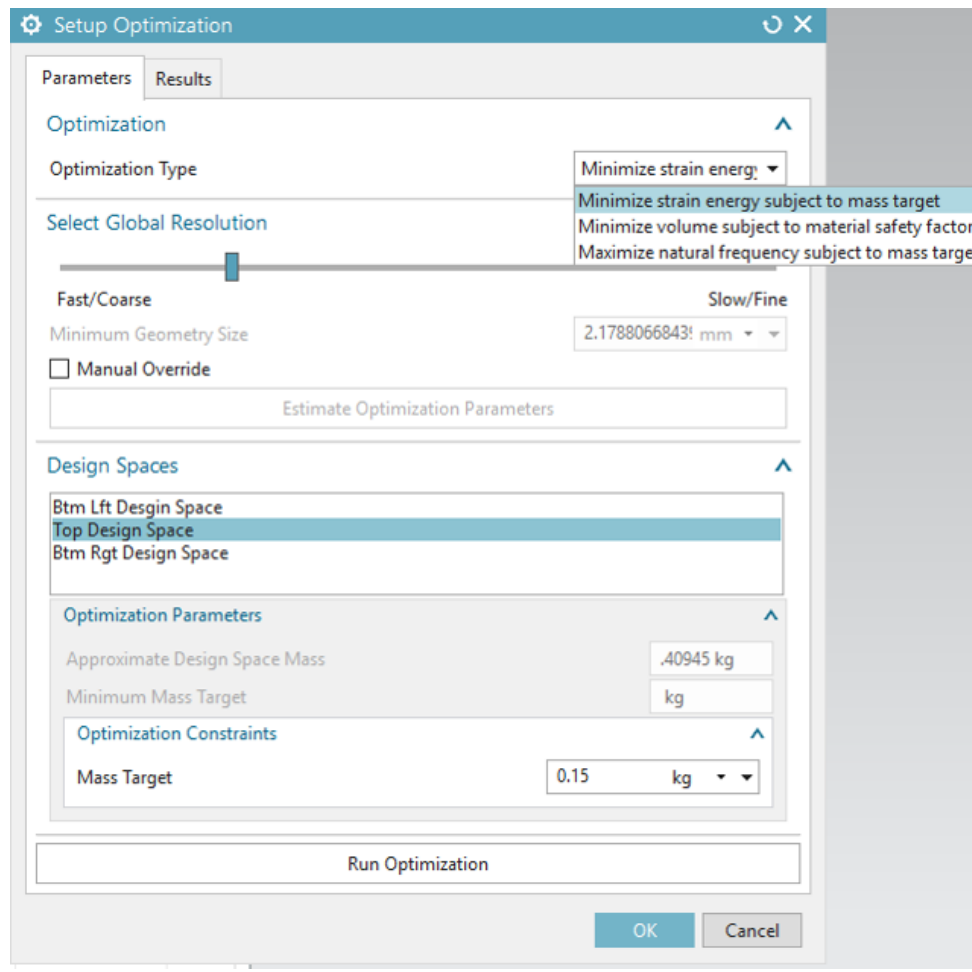
RESULTS

1. As the optimization runs, the **Results** tab displays-
2. **Diagram of Convergence :** This shows the progress of the optimization in two stages of convergence to the optimal design

3. **Log:** The log displays any **errors** found in the optimization setup and the **displacement** and **stress** results of the optimization. It also displays the time taken after the optimization is complete.
4. **Status :** The status shows whether the optimization is **Running** or **Finished**

⚙ Setup Optimization   ↻ ✕

Parameters | Results

Diagram of Convergence   ∧

Log

Approximate results for [Top Design Space]:
    Max Disp (mm)   Max VM Stress (MPa)
LC 1   0.145   39.3
Max   0.145   39.3
Approximate results for [Btm Rgt Design Space]:
    Max Disp (mm)   Max VM Stress (MPa)
LC 1   0.147   46.7
Max   0.147   46.7
Approximate results for [Btm Lft Desgin Space]:
    Max Disp (mm)   Max VM Stress (MPa)
LC 1   0.0108   50.8
Max   0.0108   50.8
Approximate results for [Top to Btm Rgt Connecting Pin]:
    Max Disp (mm)   Max VM Stress (MPa)
LC 1   0.119   101
Max   0.119   101
Approximate results for [Btm Lft to Btm Rgt Connecting Pin]:
    Max Disp (mm)   Max VM Stress (MPa)
LC 1   0.103   98.6
Max   0.103   98.6
Approximate results for [Btm Lft to Top Connecting Pin]:
    Max Disp (mm)   Max VM Stress (MPa)
LC 1   0.0528   107

Status   Finished!

OK   Cancel

5. In **Topology Opt → Results group,** toggle through the **Topology, Max Disp, Max Stress** to view simulation results of the optimized geometry
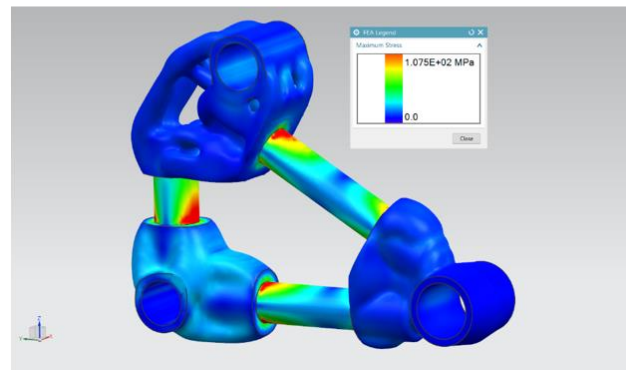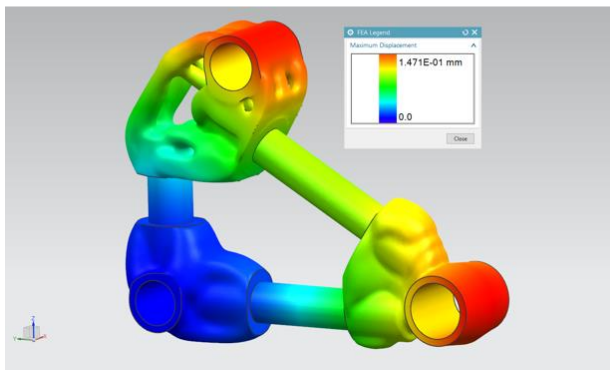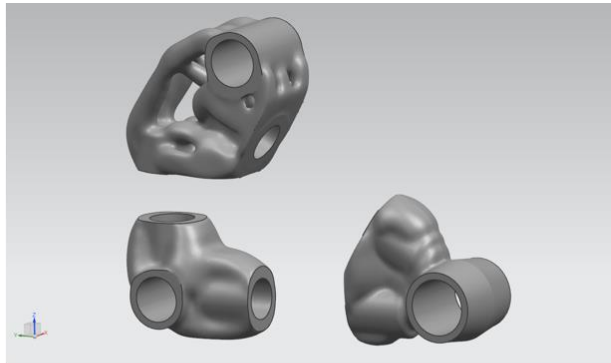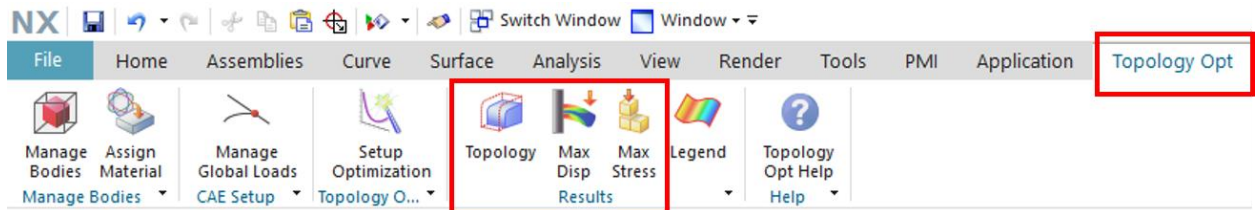
NOTE: For more information on **Setup Optimization** criteria and analysis of top opt results, refer **Topology Opt | Manage Bodies | Setup Optimization**