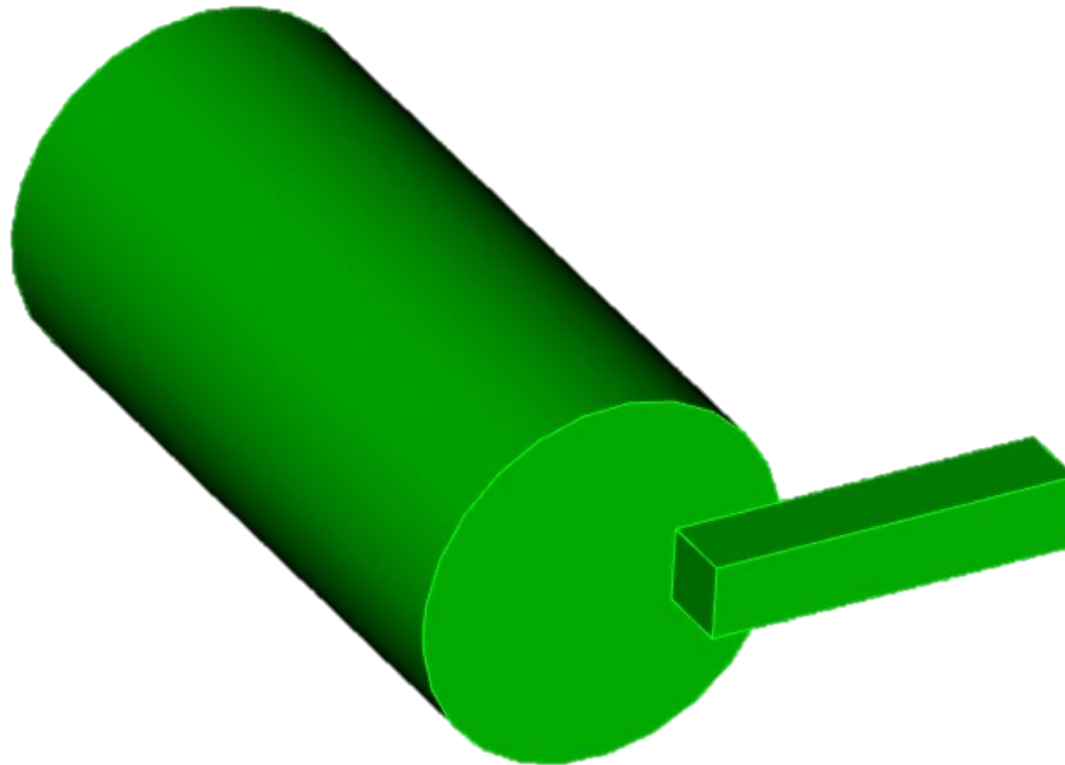


Prune and Refine Tutorial

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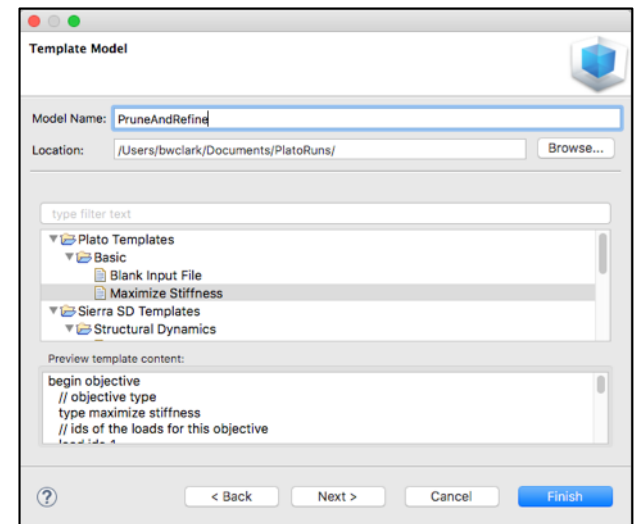
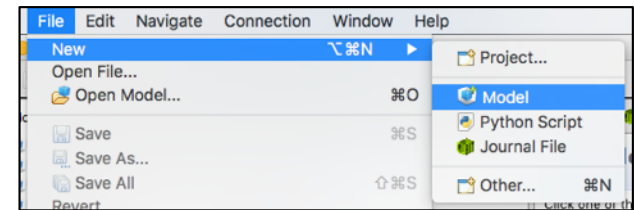
Problem Description

The problem will be a cylinder under a torsional-type loading condition using the geometry shown below as the design domain.



Create a New Model

- Choose **File->New->Model** in the menu
- Choose **New Model** then **Next**
- Choose **Create From Template** then **Next**
- Enter **PruneAndRefine** as the **Model Name**
- Choose the **Plato Templates->Basic->Maximize Stiffness** template and then **Finish**



Create the Design Domain

- At the **CUBIT** command prompt copy and paste the following commands (see Hint on next slide):

cylinder radius 5 height 20

brick x 10 y 2 z 2

vol 2 move 7 0 11

unite all

webcut volume 1 with sheet extended from surface 1

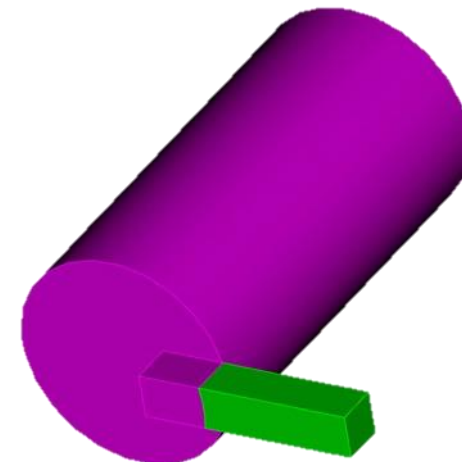
imprint all

merge all

```

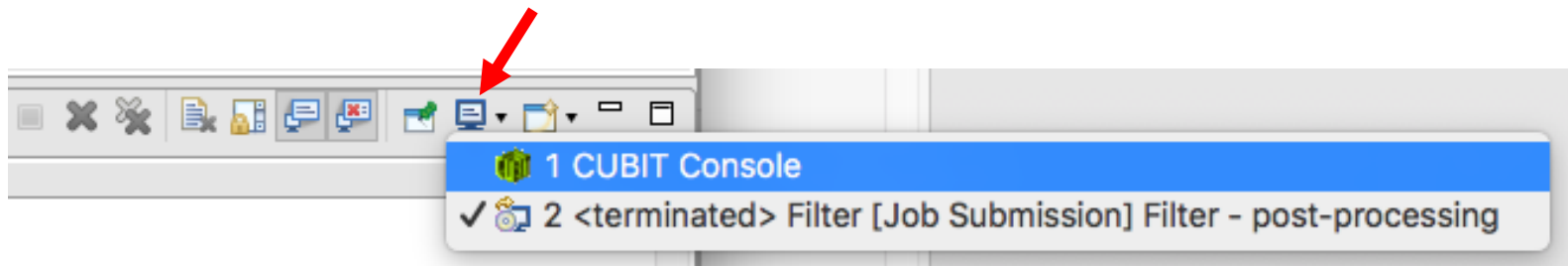
CUBIT Console
CUBIT> cylinder radius 5 height 20
brick x 10 y 2 z 2
vol 2 move 7 0 11
unite all
webcut volume 1 with sheet extended from surface 1
imprint all
merge allSuccessfully created cylinder volume 1
Journaled Command: cylinder radius 5 height 20

Successfully created brick volume 2
Journaled Command: brick x 10 y 2 z 2
  
```



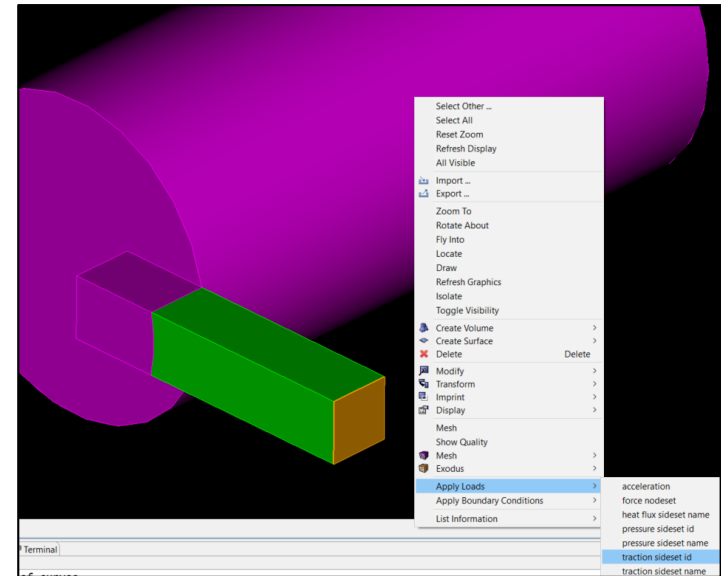
Hint: Cubit Console

- If you don't see the **CUBIT>** prompt in the console window you are just looking at the wrong console (there may be multiple to choose from loaded in Plato that use the single console window). Click on the icon at the top right of the console window that looks like a computer screen to toggle through the different consoles that are currently loaded. Or you can click on the down arrow next to the computer screen icon to see all of the currently loaded consoles and choose one from the list.



Apply a Traction Load

- Select and right-click the surface (see Hint on next slide) on the end of the rectangular arm and choose **Apply Loads->traction sideset id** (Surface is highlighted in orange).
- In the **Settings** panel enter “0 -1e5 0” in the “**value**” box and hit the tab key. Then enter “1” in the “**load id**” box and hit the return key.



traction sideset

Summary

1

value

0 -1e5 0

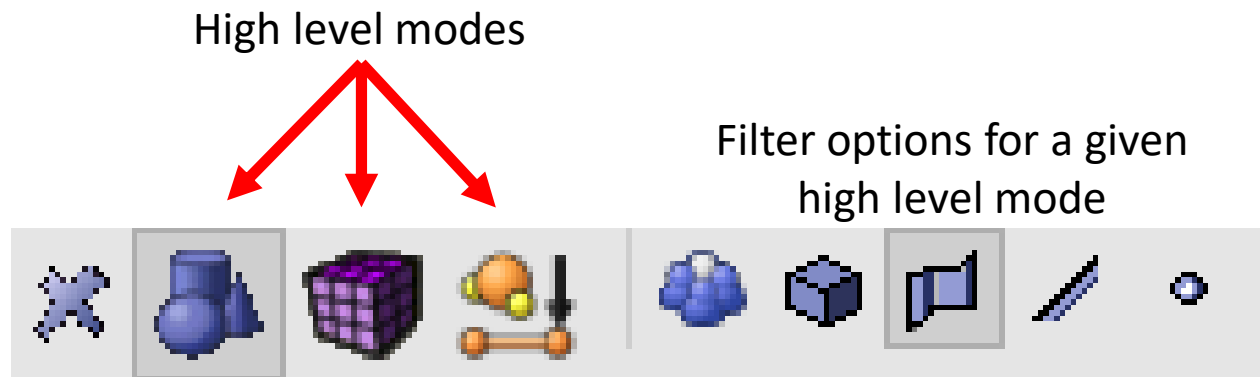
load id

1

Located in: loads

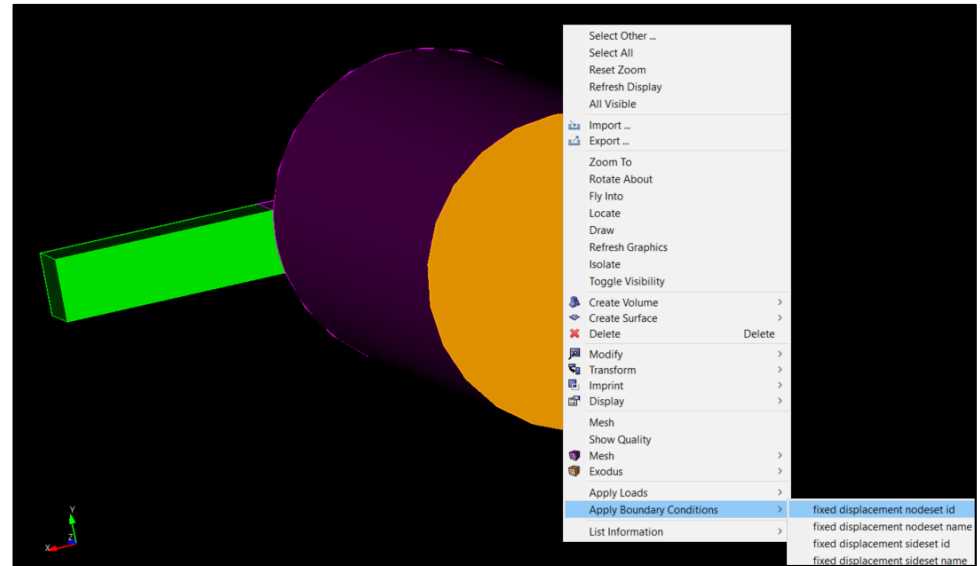
Hint: Entity Selection

- The selection filter toolbar is at the bottom left of the graphics window.
- There are 3 high level modes: Geometry, Mesh, and Exodus
- Within each high level mode there are various options for filtering what will get selected by clicks in the graphics window.



Create a Fixed BC

- Select the circular surface on the end of the cylinder that doesn't have the load applied. Right-click and choose **Apply Boundary Conditions->fixed displacement nodeset id**
- In the **Settings** panel enter “1” in the “bc id” box and hit return.



fixed displacement nodeset

Summary

1

☐

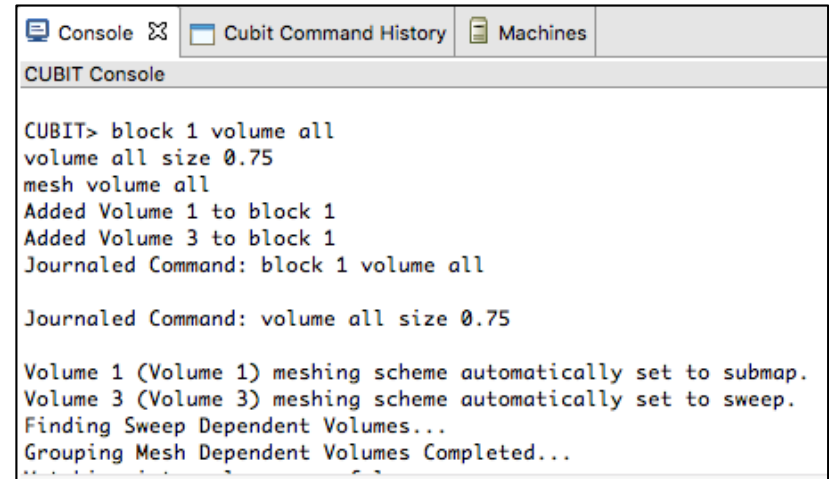
bc id

1

Located in: boundary conditions

Define Blocks and Mesh Domain

- At the **CUBIT** prompt copy and paste the following commands:
 block 1 volume all
 volume all size 0.75
 mesh volume all
- Click on **Geometry/Mesh** node in the tree and then click the **Save** icon in the toolbar to save the model

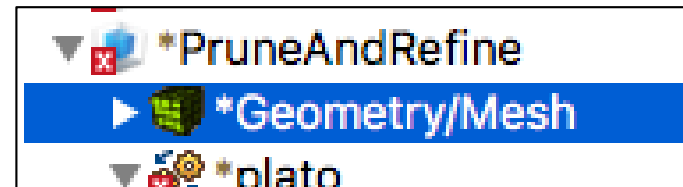


The screenshot shows the CUBIT Console window with the following text:

```
CUBIT> block 1 volume all
volume all size 0.75
mesh volume all
Added Volume 1 to block 1
Added Volume 3 to block 1
Journaled Command: block 1 volume all

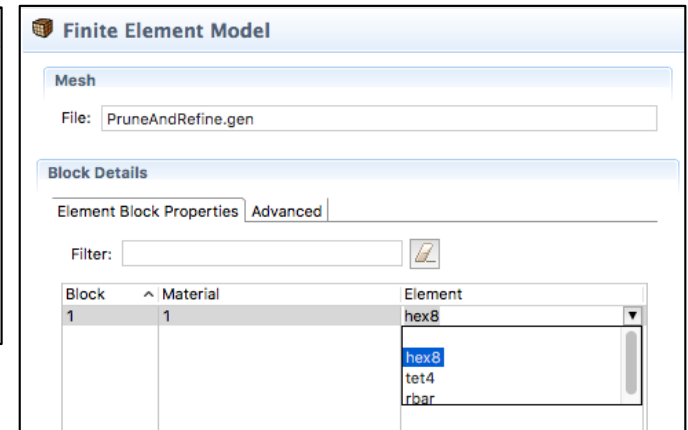
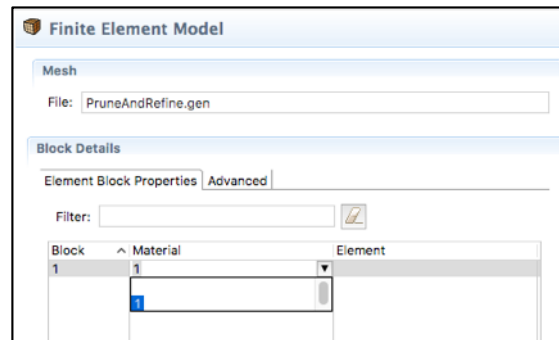
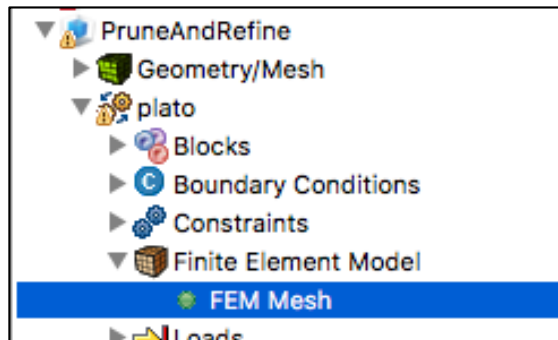
Journaled Command: volume all size 0.75

Volume 1 (Volume 1) meshing scheme automatically set to submap.
Volume 3 (Volume 3) meshing scheme automatically set to sweep.
Finding Sweep Dependent Volumes...
Grouping Mesh Dependent Volumes Completed...
```



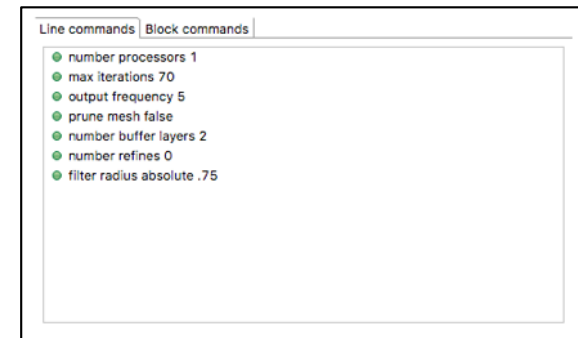
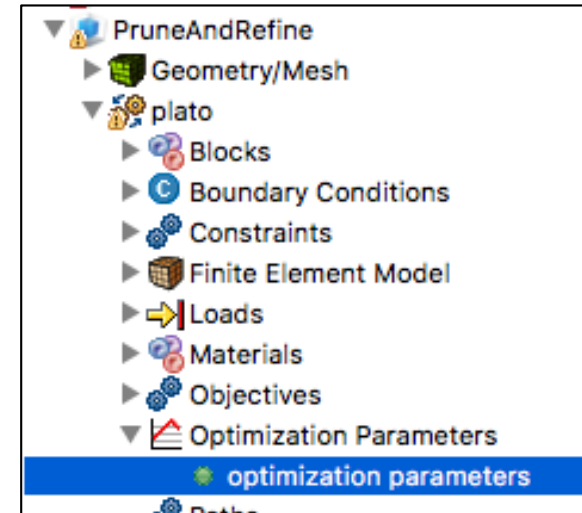
Assign Material and Element Type

- Click on the **FEM Mesh** node in the tree under **plato->Finite Element Model**
- In the **Settings** panel click in the **Material** area next to Block 1 and select **1** from the dropdown list
- Then click in the **Element** area next to Block 1 and select **hex8** from the dropdown list



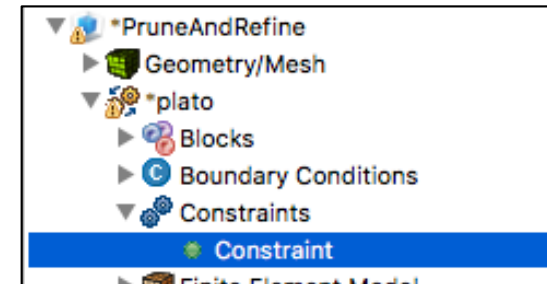
Set the Top. Opt. Parameters

- Click on the **Optimization Parameters**-> **optimization parameters** node in the tree
- In the **Settings** panel right-click in the **Parameters** area and **Add** the parameter **filter radius absolute**. We will use the absolute filter radius value so that we can specify the radius as an absolute value rather than a scale of the average mesh edge size. We do this because when we refine the mesh our average mesh edge size will change and we want the filter radius value to stay constant.
- In the **Settings** panel delete **filter radius scale** by right-clicking on it and choosing **Delete**.
- Set the following parameter values by clicking on them and then entering the value in the edit field.
 - **filter radius absolute** = .75
 - **max iterations** = 70



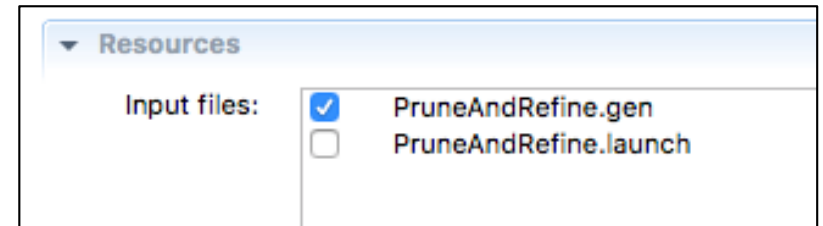
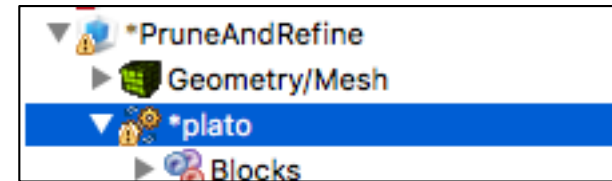
Set the Target Volume

- Click on the **Constraints->Constraint** node in the tree
- In the **Settings** panel right-click in the **Parameters** area and **Add** the parameter **volume absolute**. We will use this parameter to specify an absolute target value rather than a percentage of the original design domain volume. We do this because when we prune the mesh the starting domain volume will change and we want our target volume to stay constant.
- In the **Settings** panel delete **volume fraction** by right-clicking on it and choosing **Delete**.
- Set **volume absolute** to 100. Just for reference our starting design domain volume is about 1605 so we are asking for a small fraction of that.



Run the Optimization

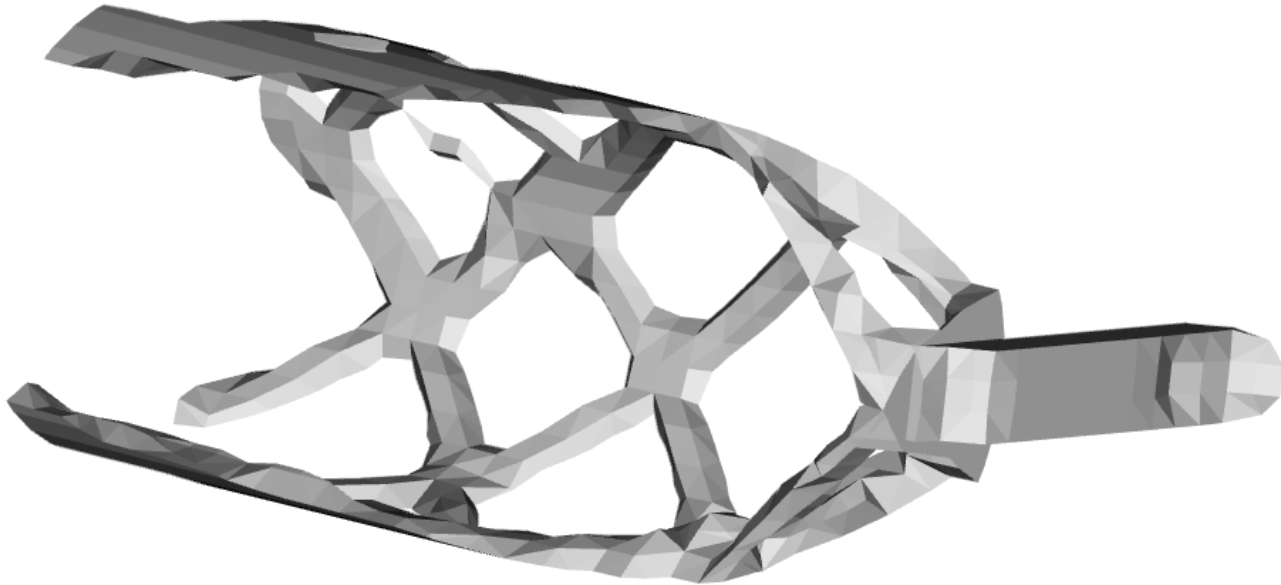
- Click on the **plato** node in the tree to bring up the job submission panel in the **Settings** view
- Choose **Plato** as the code and then choose the machine and execution template you want to use



- In the **Resources** area make sure **PruneAndRefine.gen** is checked so that this file gets pushed to the working directory.
- In the **Prune and Refine** area make sure **Prune Mesh** is unchecked and **Number Refines** is **0**. For this first run we won't be doing any pruning or refining.
- Choose any other preferences and launch the job by clicking on **Submit Simulation Job** toward the top of the panel

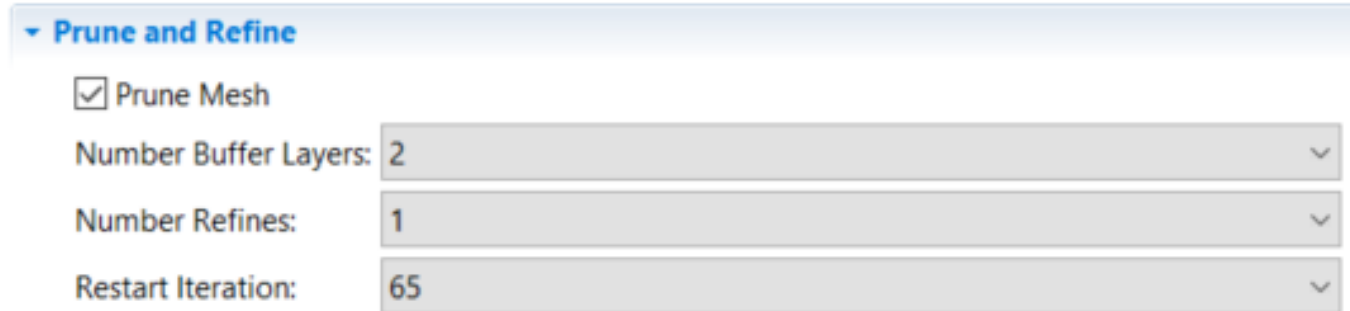
Initial Result

The initial results should look something like that shown below. Note how rough the results look because of the coarse mesh we used. Next, we will use pruning and refining to run with a finer mesh so that we get smoother features while still keeping the problem size reasonable.



Launch the Restart Run

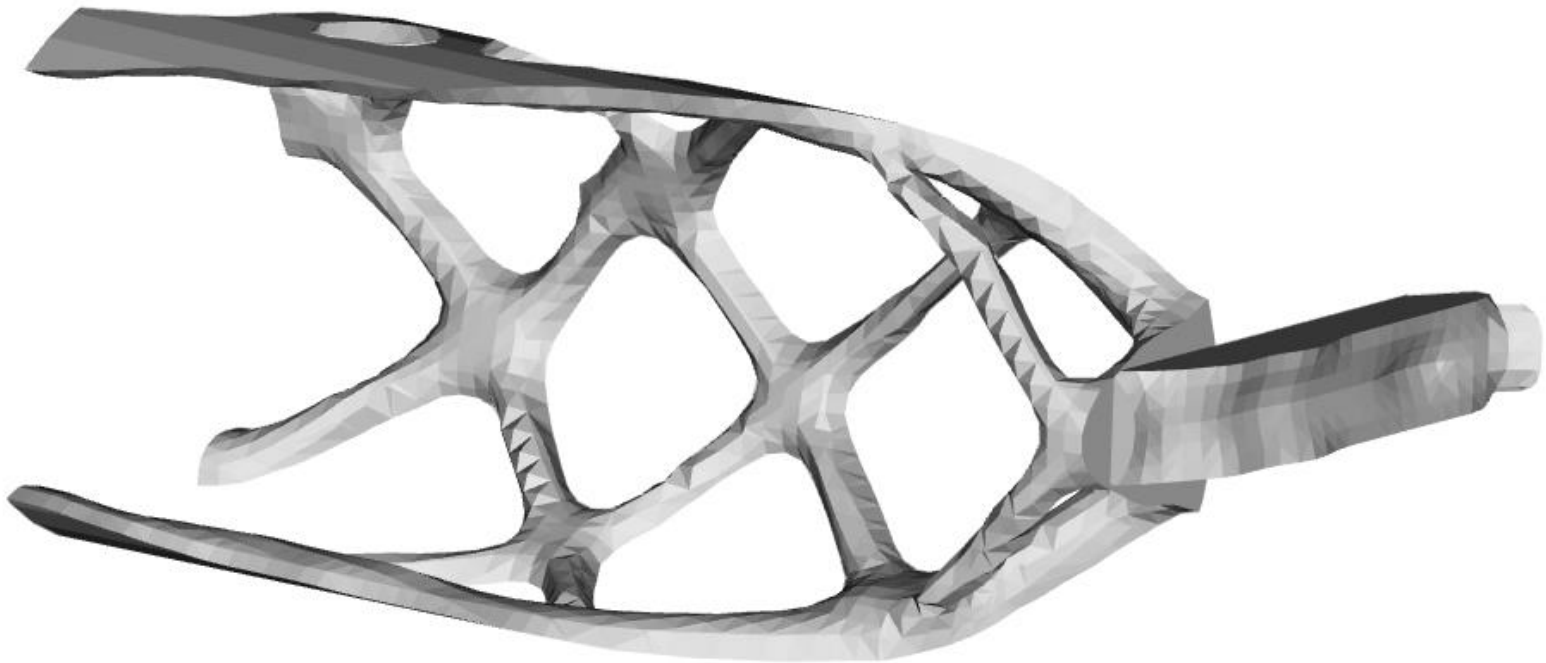
- Bring up the job submission panel by clicking on the **plato** node in the tree.
- Under the **Prune and Refine** area check the **Prune Mesh** box, set the **Number Buffer Layers** to **2**, **Number Refines** to **1**, and **Restart Iteration** to **65**. Plato will prune away the mesh not touched by the results in Iteration 65, leaving 2 additional buffer layers of hexes around the pruned mesh, and will then refine the pruned mesh 1 time before starting the next run.
- Resubmit the job by clicking on the **Submit Simulation Job** in the job submission area in the **Settings** panel

A screenshot of a software interface showing the 'Prune and Refine' settings. The panel has a blue header with a downward arrow and the text 'Prune and Refine'. Below the header, there is a checkbox labeled 'Prune Mesh' which is checked. Underneath the checkbox are three input fields, each with a label and a value, and a small downward arrow on the right side of each field. The first field is labeled 'Number Buffer Layers:' and has the value '2'. The second field is labeled 'Number Refines:' and has the value '1'. The third field is labeled 'Restart Iteration:' and has the value '65'.

▼ Prune and Refine	
<input checked="" type="checkbox"/> Prune Mesh	
Number Buffer Layers:	2 ▼
Number Refines:	1 ▼
Restart Iteration:	65 ▼

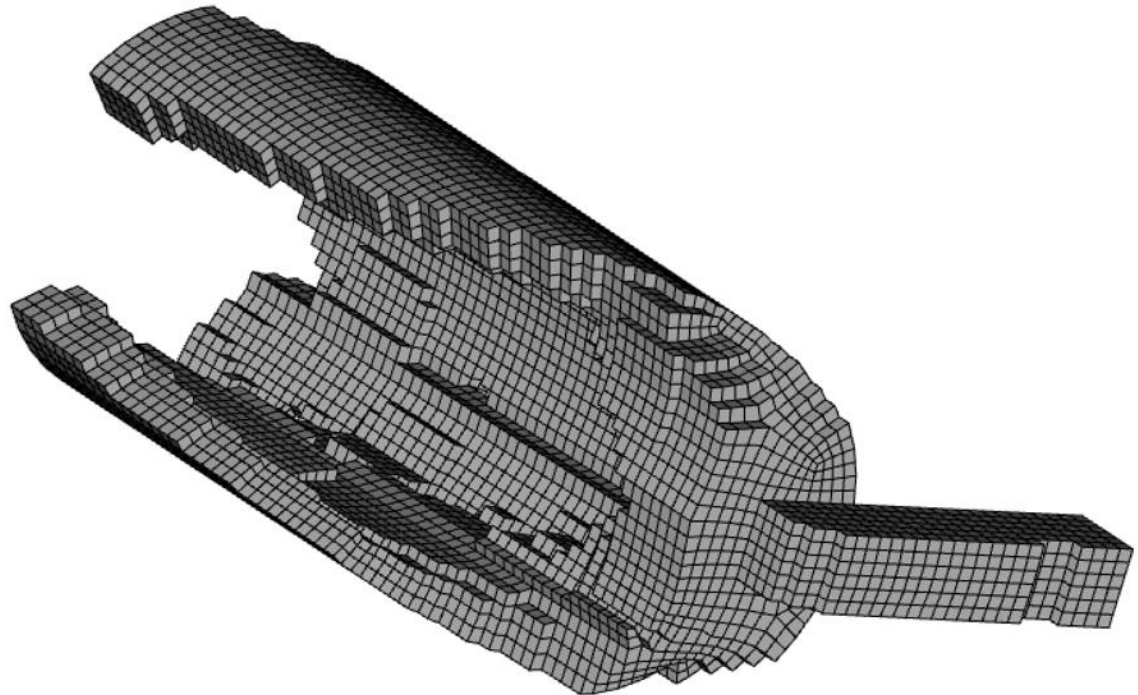
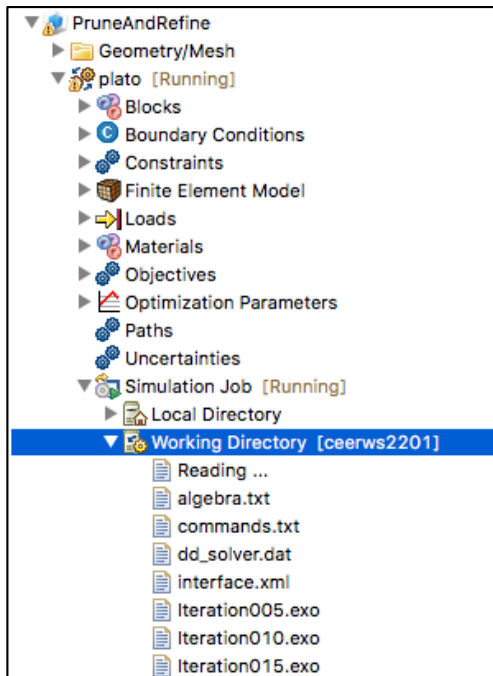
Result after 1st Prune/Refine

Your result should look something like that shown below. As you can see the features are smoother than in the first run. This is because we are using a finer mesh.



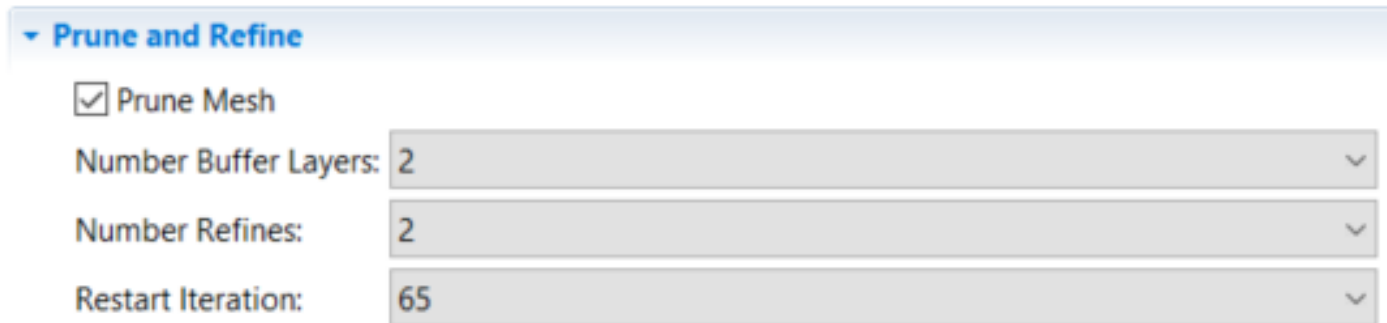
Pruned and Refined Mesh

- Let's take a look at the pruned and refined mesh used for this second run.
- Open the **Working Directory** as shown in the image below. Look for a file called **PruneAndRefine_mod.gen**. Right-click on this file and choose **Load Mesh**. The mesh will be loaded in the **Geometry/Mesh** area in the tree.
- In the **CUBIT** console type “edge vis on” and you should see something like the mesh shown below.
- If you type “list hex” at the **CUBIT** prompt you will see how many hexes are in this pruned and refined mesh. It is more than when we started but much less than if we had refined the starting mesh without first pruning.



2 Levels of Refinement

- Bring up the job submission panel by clicking on the **plato** node in the tree.
- Under the **Prune and Refine** area change **Number Refines** from **1** to **2**.
- Resubmit the job by clicking on the **Submit Simulation Job** in the job submission area in the **Settings** panel. This mesh will now grow substantially in size (roughly 8x) but the problem size is again much smaller than if we were to refine without pruning.



The screenshot shows a software interface for the 'plato' optimization-based design tool. A panel titled 'Prune and Refine' is expanded, showing several settings. The 'Prune Mesh' checkbox is checked. Below it are three dropdown menus: 'Number Buffer Layers' set to 2, 'Number Refines' set to 2, and 'Restart Iteration' set to 65.

▼ Prune and Refine	
<input checked="" type="checkbox"/> Prune Mesh	
Number Buffer Layers:	2
Number Refines:	2
Restart Iteration:	65

Result after 2nd Prune/Refine

Your result should look something like that shown below. You should only have to let it run about 5-10 iterations. Now the features are really starting to look nice. If you like you can again load the **PruneAndRefine_mod.gen** file (delete the existing one first) to examine the mesh that was used on this second restart.

