SAND2021-15306 TR



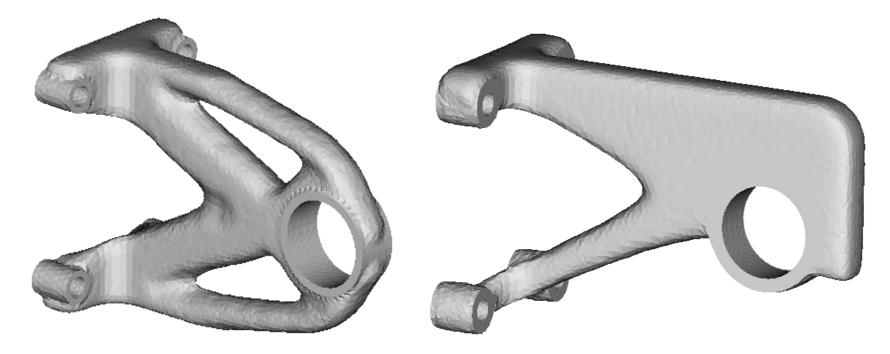
# Mass Properties Tutorial

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#### **Problem Description**

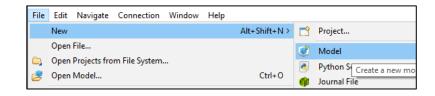


In this tutorial we will demonstrate the feature for constraining Plato designs to have user-specified mass properties. We will design a bracket for stiffness, constrain the center of gravity to be a user-specified value and see how it affects the maximum displacement of the design.



#### Create a New Model

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

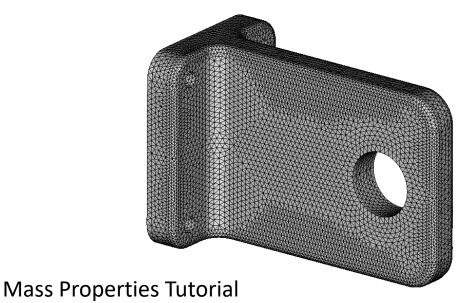


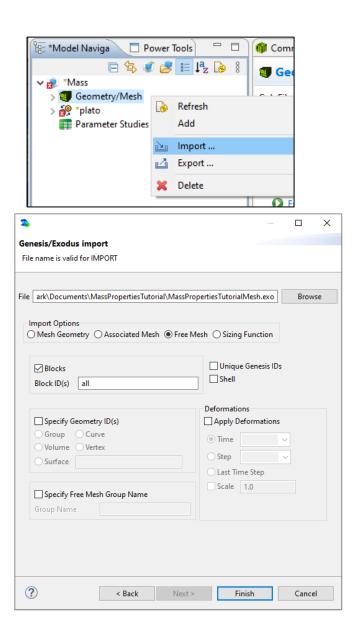
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## Import the Design Domain Mesh

- Right-click on "Geometry/Mesh" in the tree and choose "Import...".
- Choose "GENESIS" as the file type and choose "Next".
- Browse for the file called "MassPropertiesTutorialMesh.exo", choose the "Free Mesh" option, and then choose "Finish".

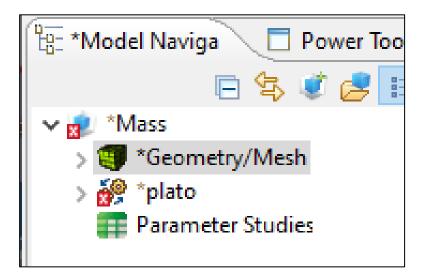


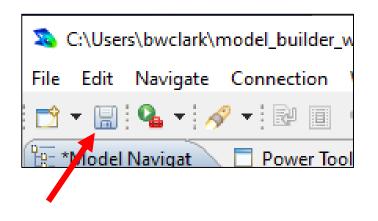


#### Save the Geometry/Mesh



 Click on the "Geometry/Mesh" node in the tree and then click the Save icon in the toolbar.



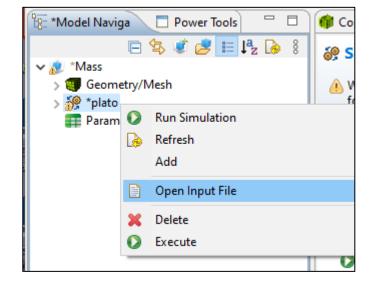


#### Load the Pre-defined Input Deck

 Right-click on the "plato" node in the tree and choose "Open Input File". This will open a text editor showing the current input file for this model. We will be replacing all of the text in the default input deck with that in the file called

"MassPropertiesTutorialInputDeck.i".

- Open "MassPropertiesTutorialInputDeck.i" in a text editor of your choice and copy and paste its contents into the input deck editor in Plato replacing the text that was there.
- Then click on the "**Save**" icon in the toolbar to save the model.









## 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

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- In the **Resources** area make sure **Mass.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

After about 50 iterations you should have a result that looks like the one below. This initial run did not have the center of gravity (CG) constrained to be a specific value. To measure the CG we will first create an STL version of the result and then list its mass properties.

- Expand the "Geometry/Mesh" node in the tree to show all of the results from this initial run.
- Right click on the last one and choose "Generate STL".
- In the CUBIT console type "list volume 1 geometry". Toward the end of the output you will see some mass properties. Note: to get to the CUBIT console click on the icon in the Console toolbar (below) until it cycles back to the CUBIT console. This initial result has a center of gravity of about 1.27, 0.0, 0.0.

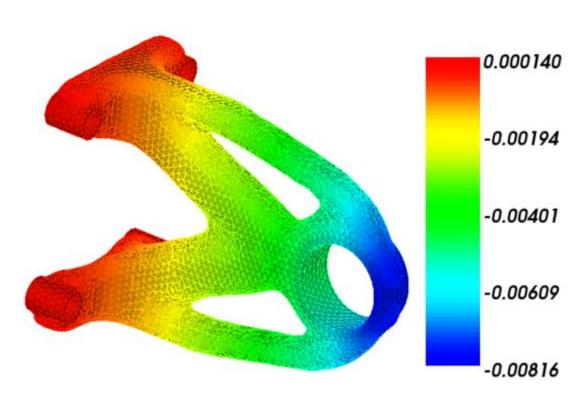
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#### Max Displacement in Y

 View the max y displacement by right clicking on the last result in the "Geometry/Mesh" folder and choosing "Fringe Plot->dispy\_plato\_analyze\_2". For this design the max displacement in y is -0.00816.

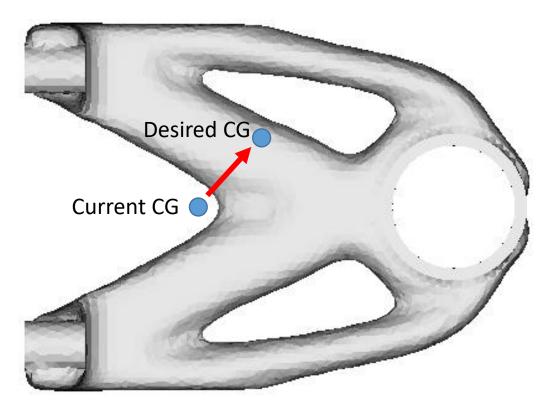
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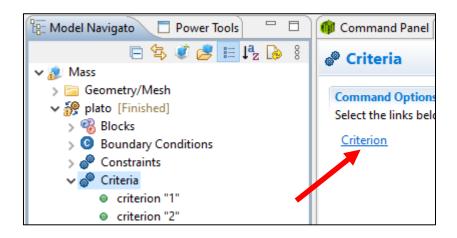
#### Re-run with a CG Constraint

Now we will pretend there is a requirement to have the CG located at 1.8, 0.5, 0.0 and will rerun Plato with this constraint. We will actually enforce the desired CG by adding an additional sub-objective to the problem. You can also add it as an actual constraint but this problem converges more quickly with it enforced as part of the objective.



#### **Create CG Criterion**

- DIATO OPTIMIZATION-BASED DESIGN
- Click on the "Criteria" node in the tree and then in the Settings panel choose "Criterion" to create a new criterion.
- Set the "id" to "3", "type" to "mass\_properties", and add criterion parameters as shown below to set the CG x and y to "1.8" and "0.5" respectively.
- Note: To add a parameter right-click anywhere in the "Line commands" pane and choose "Add...".



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#### Add a New Service

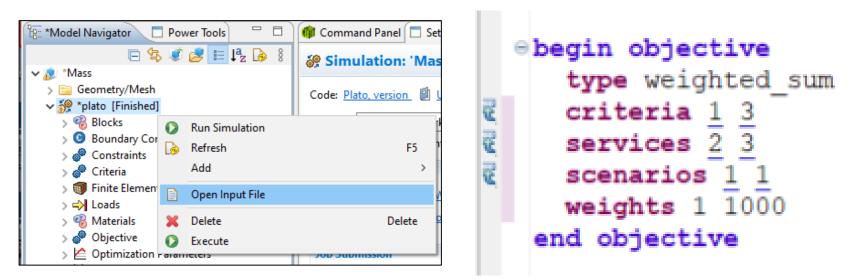
- Click on the "Services" node in the tree and then in the Settings panel choose "Service" to create a new service.
- Set the "id" to "3" and add service parameters as shown below.

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## Update the Objective

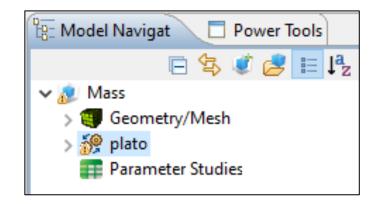
- Right-click on the "**plato**" node in the tree and choose "**Open Input File**" to open the input deck in a text editor.
- Find the "objective" definition and update it to look like that below. This will tell Plato to evaluate the objective by evaluating criterion 1 (mechanical\_compliance) and then criterion 3 (mass\_properties) and then do a weighted sum using a weight of 1 for mechanical\_compliance and 1,000 for mass\_properties. We have to weight the mass\_properties sub-objective heavily to make sure the CG constraint is enforced.





#### **Re-run the Optimization**

- Click on the plato node in the tree to bring up the job submission panel in the Settings view
- Launch the job by clicking on Submit Simulation Job toward the top of the panel

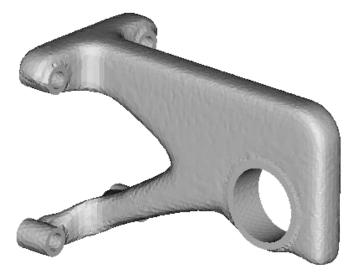




#### **CG-constrained Results**

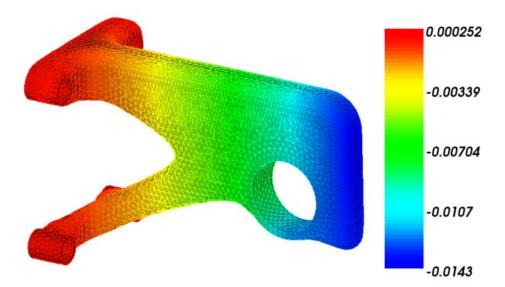
After 50 iterations you should have a result that looks like the one below. The CG was not exactly enforced. This is due to mesh discretization error as well as density values not being completely 0 or 1. However, it is pretty good. Mesh refinement and running the optimization longer can improve the enforcement of the CG.

Also note that because we forced a constraint on the design we did not reach the same performance level as far as how stiff the design is. In the new design the max y displacement is larger than the previous design.



Desired CG: 1.8, 0.5, 0 Achieved CG: 1.82, 0.54, 0

**Mass Properties Tutorial** 



Previous Max Y Disp: -0.00816 Current Max Y Disp: -0.0143