SAND2021-15306 TR



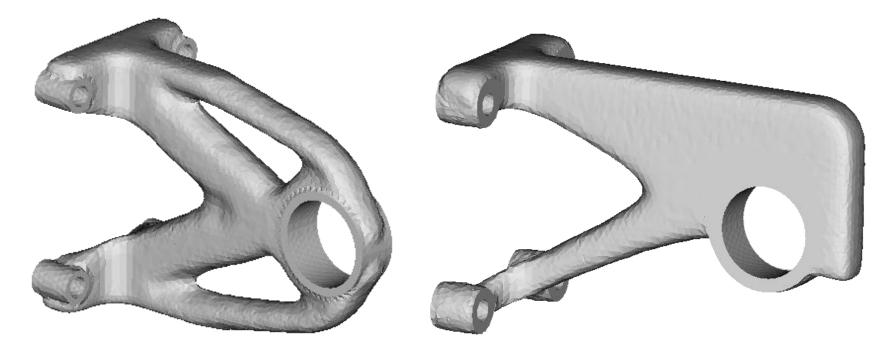
Mass Properties Tutorial

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia LLC, a wholly owned subsidiary of Honeywell International Inc. for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

Problem Description

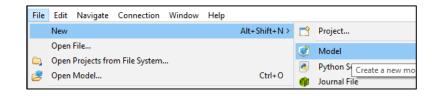


In this tutorial we will demonstrate the feature for constraining Plato designs to have user-specified mass properties. We will design a bracket for stiffness, constrain the center of gravity to be a user-specified value and see how it affects the maximum displacement of the design.



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

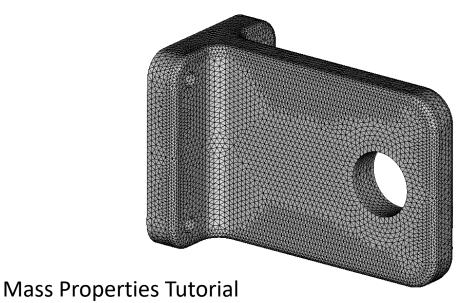


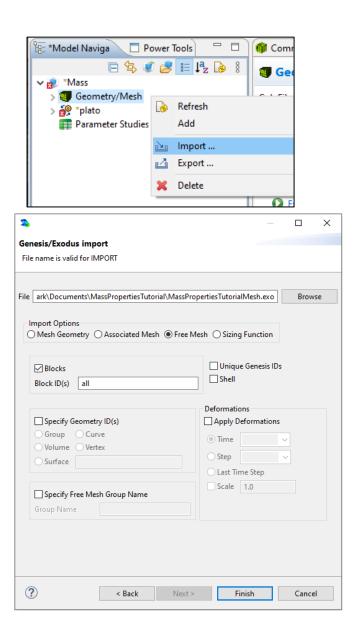
20	-	x c
Template Mo	del	
Model Name:	Mass	
Location:	C:\Users\bwclark\Documents\PlatoRuns	Browse
type filter to	ext	
V 📂 Plato	•	^
🗸 🏳 B		
	Blank Input File Match Modes (SierraSD)	
	Maximize Heat Conduction (PlatoAnalyze)	
	Maximize Stiffness (PlatoAnalyze)	~
Desident	nplate content:	
Preview ten	ipiace contenta	
begin servic	e 1	^
begin servic code plate	e 1 omain	^
begin servic code plate	e 1	î
begin servic code plate number_p	e 1 omain	^
begin servic code plate number_p	e 1 omain	 ~



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".

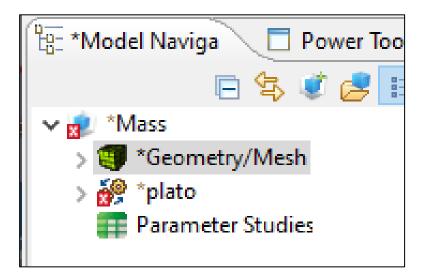


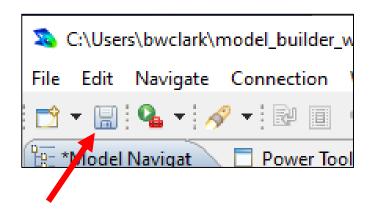


Save the Geometry/Mesh



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



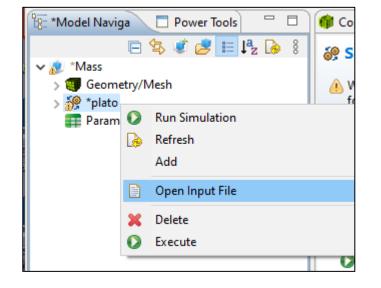


Load the Pre-defined Input Deck

 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

🕆 Model Navigat 📃 Powe	er Tools		
E 🕏 🦸	🞐 🔝 J ^a z		
🗸 🔊 Mass			
> 🗐 Geometry/Mesh			
> 🔗 plato			
Parameter Studies			
▼ Resources			
Input files: 🔽 Mass	.gen		
	launch		
Mass	addren		
	launen		
➡ Prune and Refine			
✓ Prune and Refine	2		

- 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.

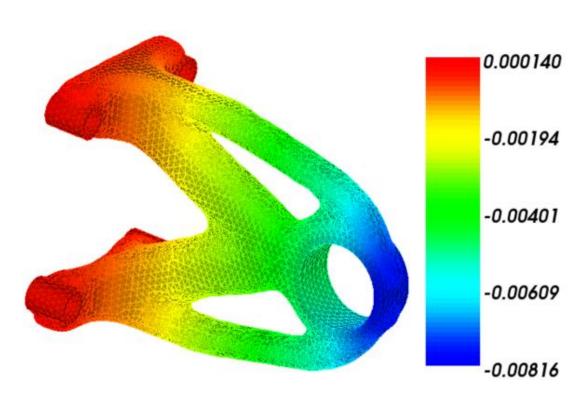
📴 Model Navigat 🗖 P	ower Tools 📃 🗖 🗖	
 Mass Mass Geometry/Mesh Iteration05 Iteration20 Iteration30 Iteration35 Iteration40 	i 🤔 🧮 🎝 🕞	Machines Console Console Machine name: ascicgpu17 Obtaining machine nameMachine name: ascicgpu17 Obtaining machineDone! Obtaining machine's file systemDone! Resolving local directoryDone!
> @ Iteration50 > @ Mass > @ plato [Finishe @ Parameter Stu	Add Import	PREPARING REMOTE DIRECTORY Job cancellation request received. Terminating job submission
	Delete Fringe Plot Smooth Results Generate STL	CUBIT Console × Machines CUBIT Console Merge Setting = Auto Volume of Volume: 3.637863
Mass Properties Tutorial	Execute	Centroid: 1.268965 -0.000370 -0.000446 Volume Geometry: Engine=facet Journaled Command: list volume 1 geometry CUBIT>



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.

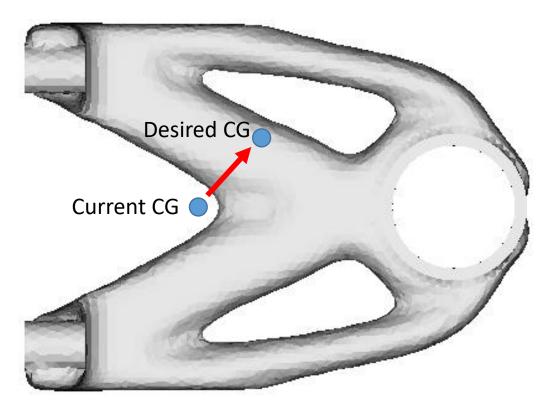
B: Model Navigator	Power Tools	🖻 🕏 🦸 🛃 📙	z 🜛 🖇 🗖 🗖 🎯 Comr
 ✓ Mass ✓ Geometry/Mesh > (1 teration05 > (2 teration20 > (3 teration30 > (3 teration35 > (4 teration36 > (5 teration36 > (6 teration36 > (7 teration36 > (8 teration36 > (9 teration50 > (9 teration50) > (9 teration50)	Refresh Add	F5 >	Ged Cub File Journal F Mesh File Next S
2 2	Import Export		
×	Delete	Delete	
	Fringe Plot	>	dispx_plato_analyze_2
1	Smooth Results		dispy_plato_analyze_2
1	Generate STL		dispz_plato_analyze_2
0	Execute		vonmises_plato_analyze_2





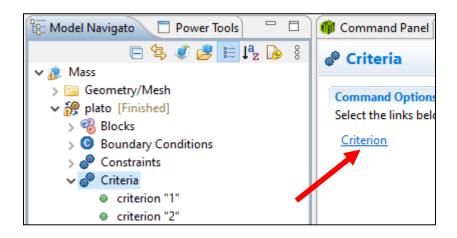
Re-run with a CG Constraint

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...".



()	Command Panel 🗖 Settings	
criterion		
+ Summary		
Name: 3		
	 type mass_properties cgx 1.8 weight 1 	
	● cgy 0.5 weight 1	



Add a New Service

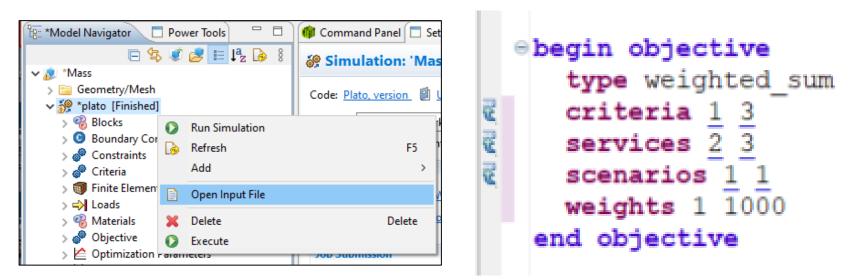
- Click on the "Services" node in the tree and then in the Settings panel choose "Service" to create a new service.
- Set the "id" to "3" and add service parameters as shown below.

🖫 Model Navigator 🛛 🗖 Power Tools 🛛 🖓 🗖	🎯 Command Panel 🗖 Set	🞯 Command Panel 🗖 Settings
🖻 🔄 🖉 📑 📭 🖇		
Image: A set of the set of th	Services	a® service
> Geometry/Mesh		
✓ in plato [Finished]	Command Options	A service '3' not referenced
> 😵 Blocks	Select the links below to c	in service of norrelefenced
> O Boundary Conditions	Service	+ Summary
> 🧬 Constraints	7	
> 📌 Criteria		
> 🗊 Finite Element Model		N 2
> 🔿 Loads		Name: 3
> 🍪 Materials		
> 🧬 Objective		
> 🖄 Optimization Parameters		Line commands
> 🖄 Outputs		
Paths		code plato_analyze
> 🧬 Scenarios		number_processors 1
✓		• Humber_processors 1
service "1"		
service "2"		



Update the Objective

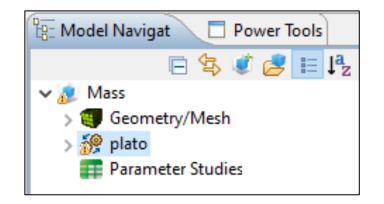
- Right-click on the "**plato**" node in the tree and choose "**Open Input File**" to open the input deck in a text editor.
- Find the "objective" definition and update it to look like that below. This will tell Plato to evaluate the objective by evaluating criterion 1 (mechanical_compliance) and then 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

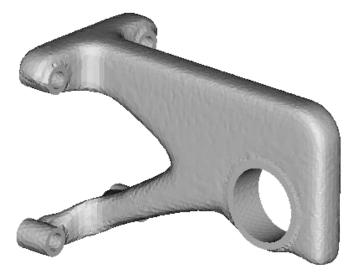




CG-constrained Results

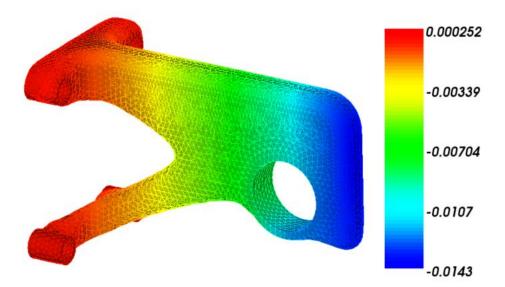
After 50 iterations you should have a result that looks like the one below. The CG was not exactly enforced. This is due to mesh discretization error as well as density values not being completely 0 or 1. However, it is pretty good. Mesh refinement and running the optimization longer can improve the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