



Mechanical Design & Fabrication

WEEK 5

Timeline

- 16 September 2021, 7-9pm
- SOAR Projects Showcase

- 27 September 2021, 7-9pm
- Intro To Mechanical Design
- Fusion360 Part I, Basics

- 4 October 2021, 7-9pm
- Fusion360 Part 2, Assemblies

- 30 September 2021, 7-9pm
- Introduction to Arduino

- 7 October 2021, 7-9pm
- Programming & PWM

WEEK 1



WEEK 3



WEEK 4

Timeline

- 11 October 2021, 7-9pm
- Fusion360 Part 3, Simulation
- CAD Speed Challenge

- 14 October 2021, 7-9pm
- Ultrasound & Motor Drivers

- Study Break

TO BE CONFIRMED

- 27 (1030-1800)-28 October (1000-1800) 2021
- SOAR Challenge!

WEEK 5



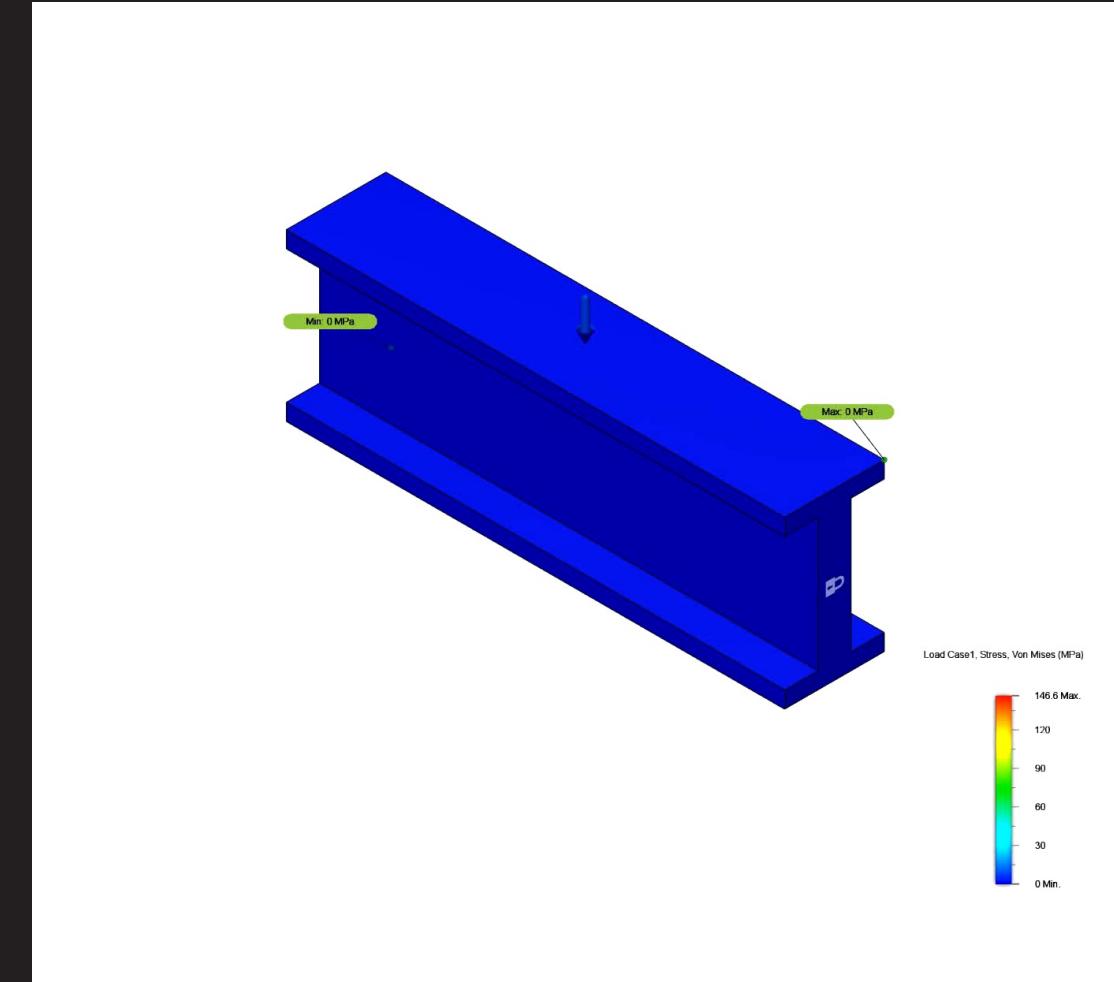
WEEK 6



WEEK 7

Today's Goal

Fusion360 Simulation



DOWNLOAD Files

https://github.com/sutd-robotics/soar_challenge_2021

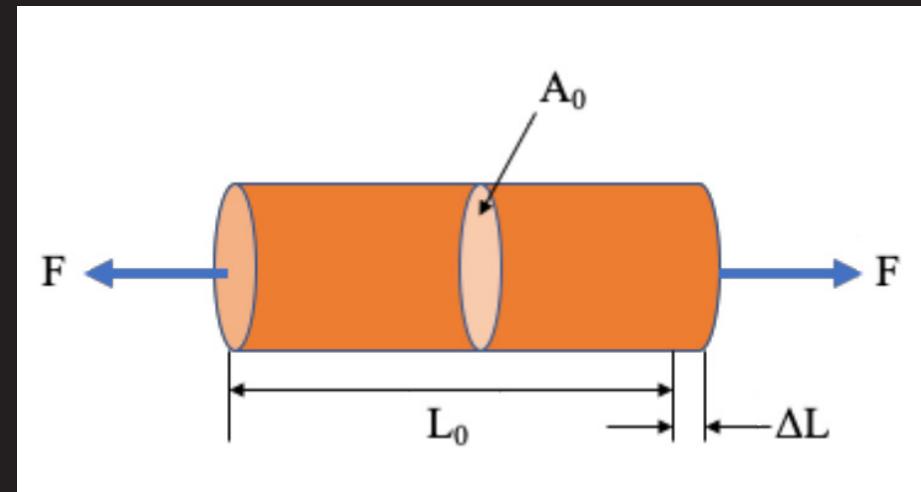
Stress!

$$\sigma = \frac{F}{A_0}$$

σ = stress ($\frac{N}{m^2}$, Pa)

F = force (N)

A_0 = cross - sectional area (m^2)



What's FEA?

Finite element analysis: Simulation of physical phenomena using a numerical technique called the Finite Element Method (FEM)

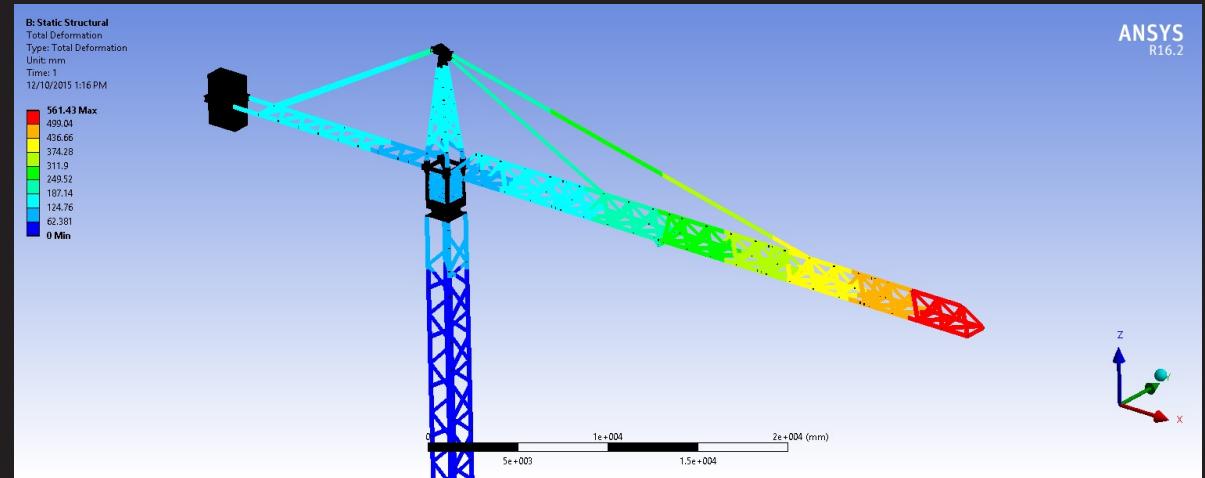
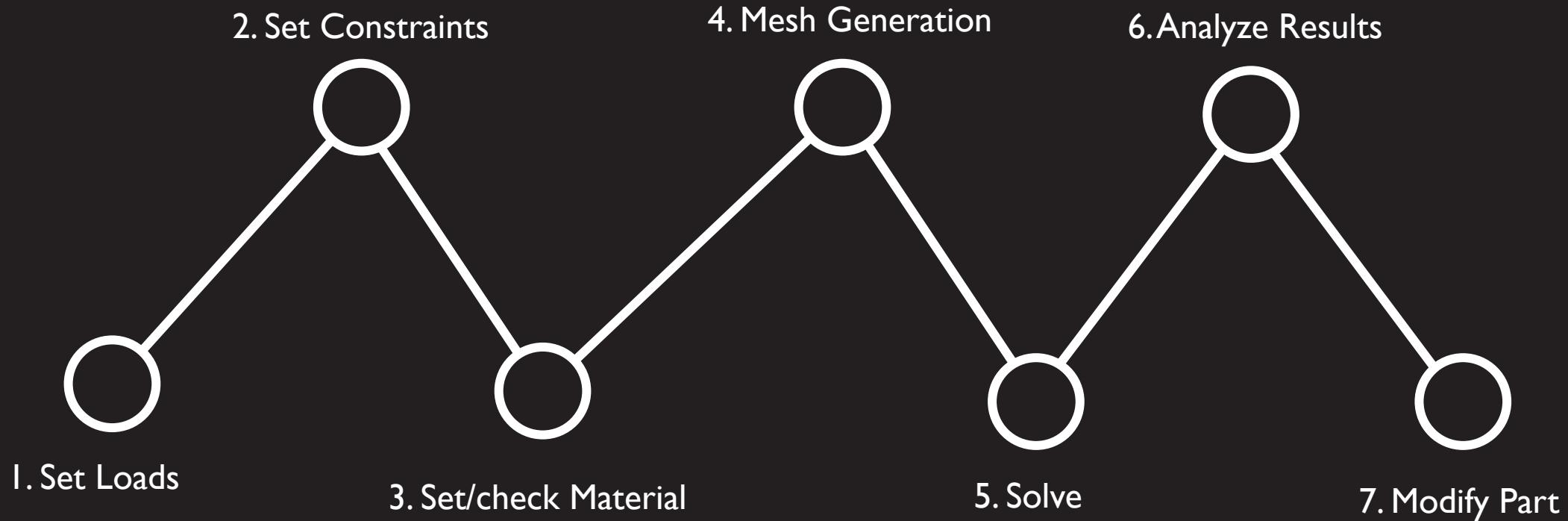
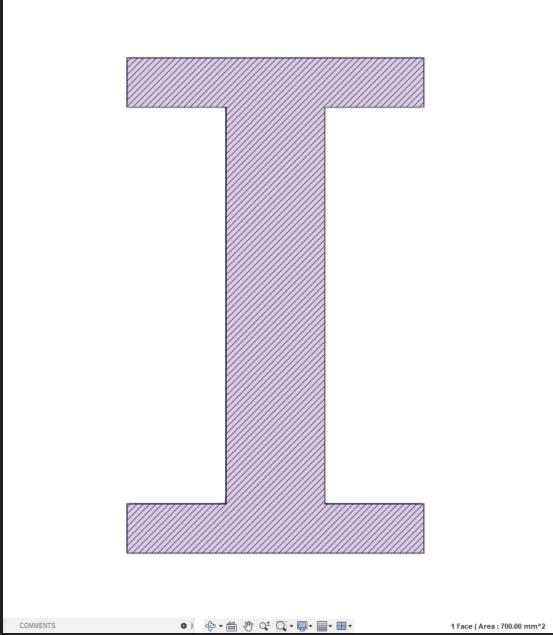


Image: <https://finiteelementanalysis.com.au>

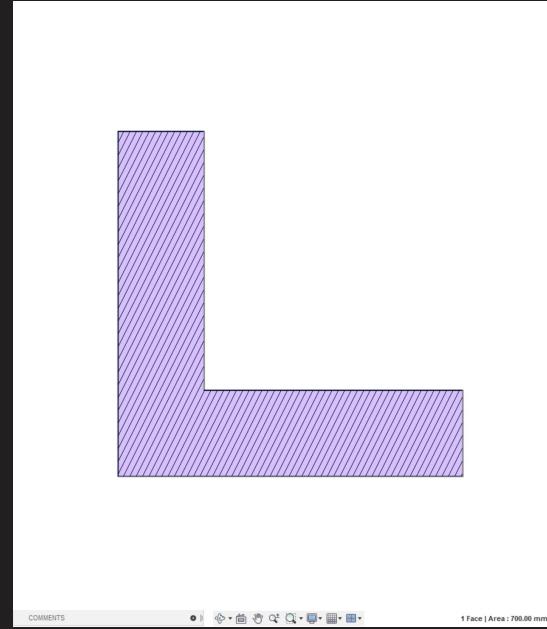
Let's get
started!

Simulation Workflow





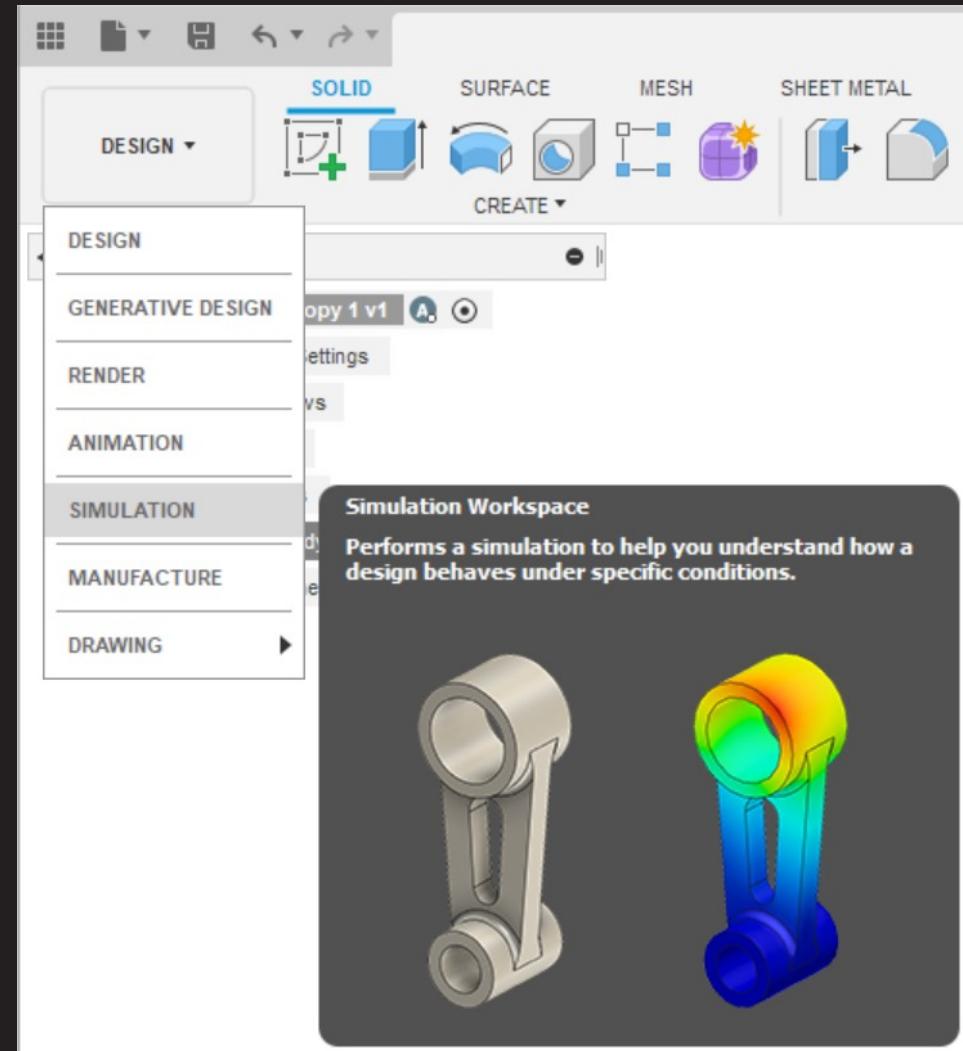
I-Beam
 700mm^2



L-Beam
 700mm^2

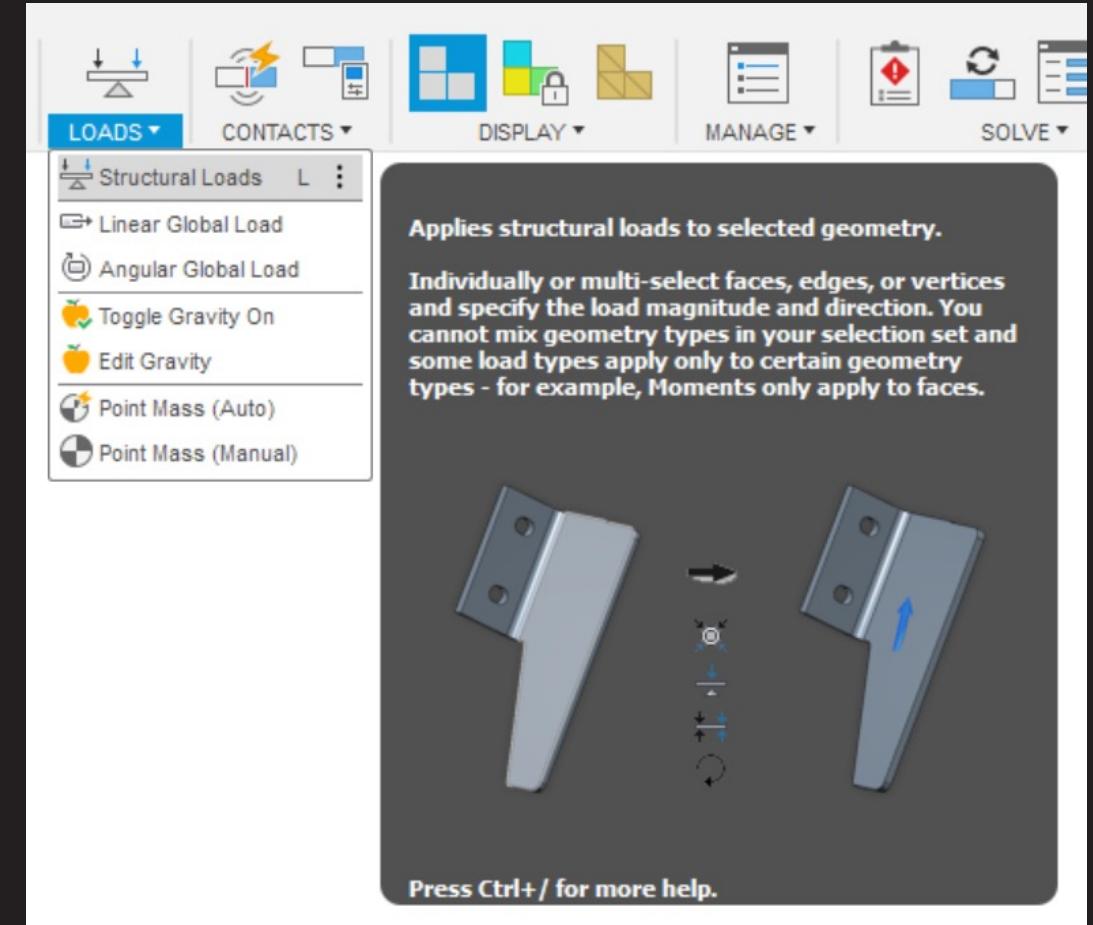
Simulation Workspace

Click the drop-down workspace menu.



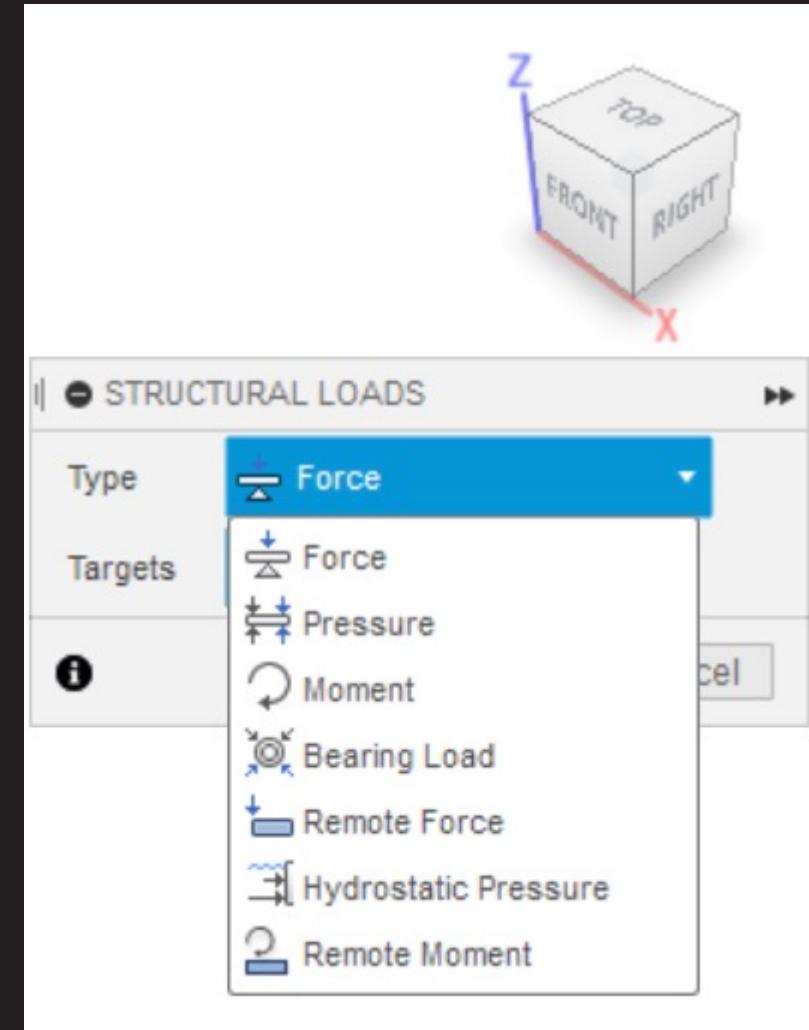
Set Loads

Keyboard shortcut: 'L'



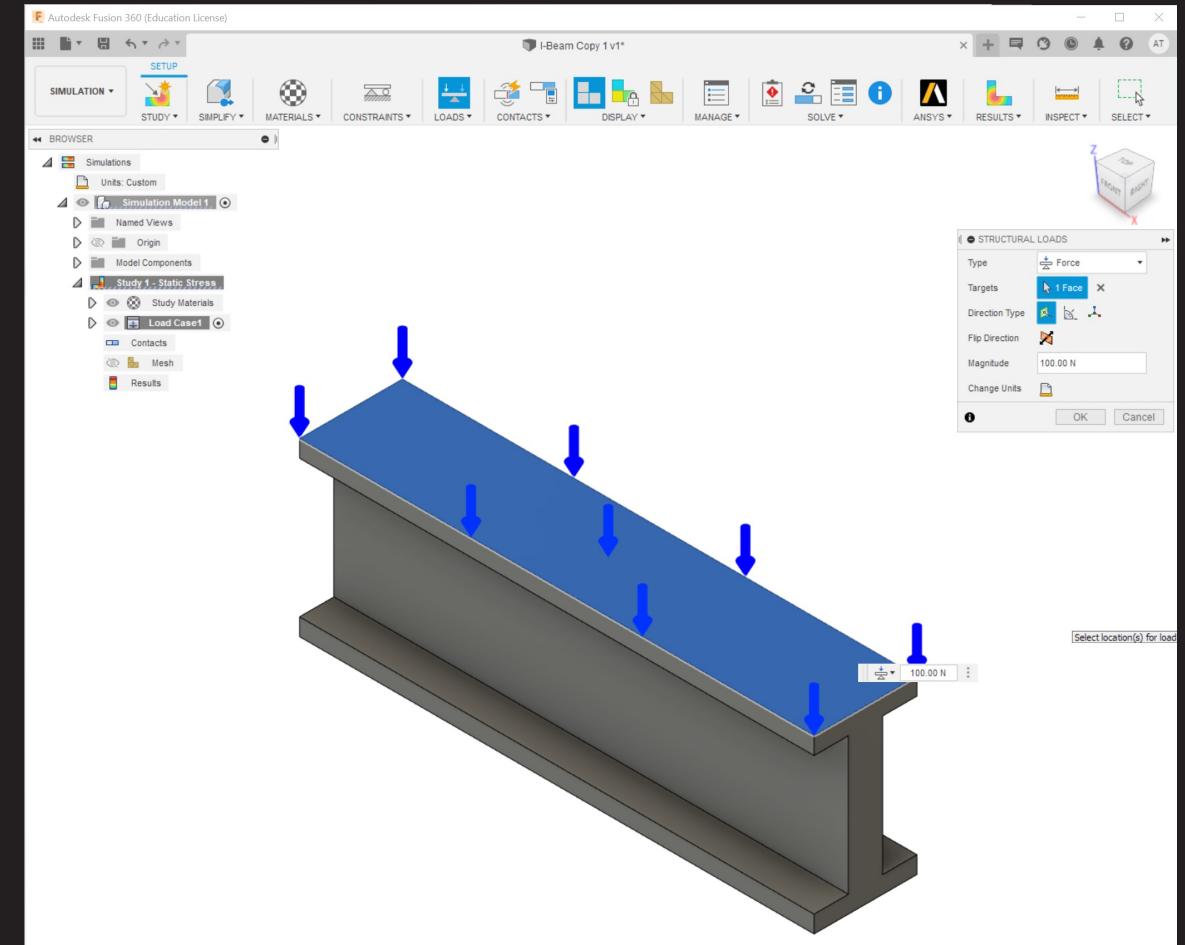
Select Load Type

Types of loads: Force, Pressure, Moment, Bearing Load, Remote Force, Hydrostatic Pressure, Remote Moment



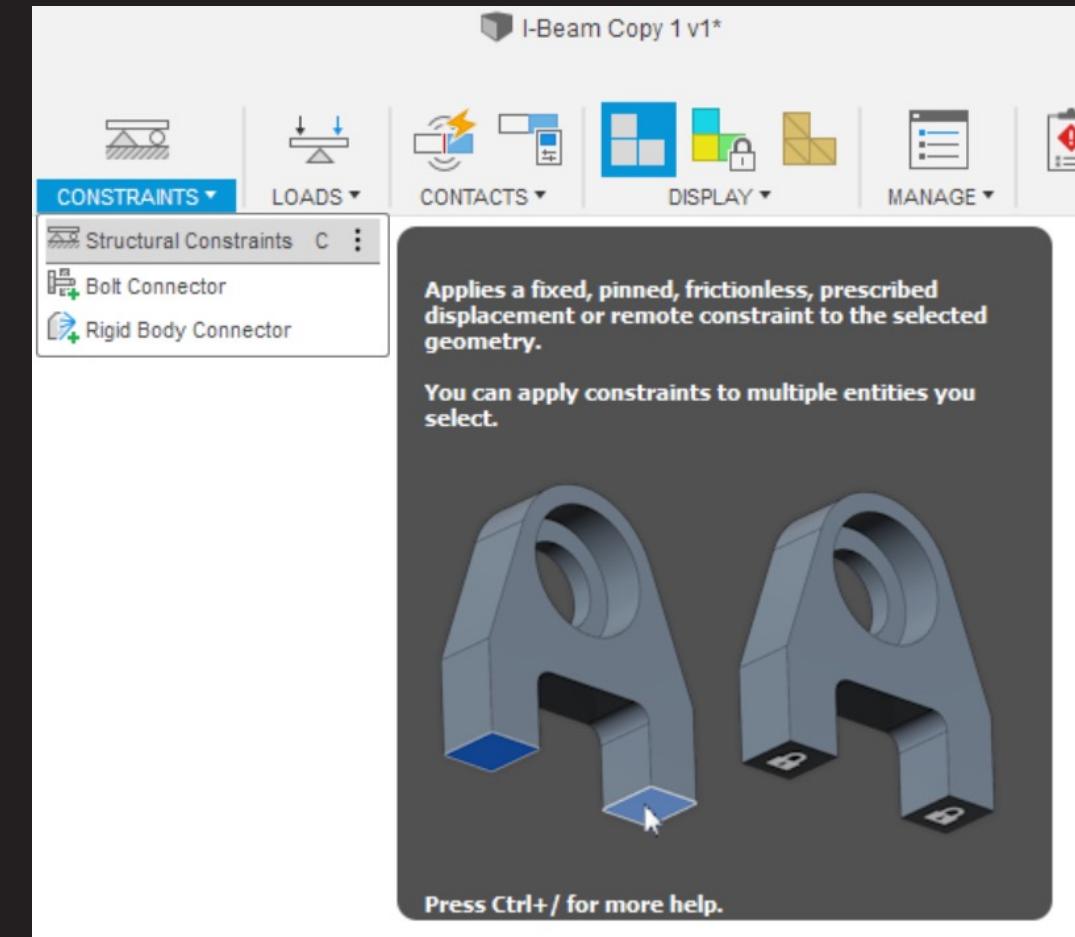
Select Load Surface

Click on the top of the I-Beam.



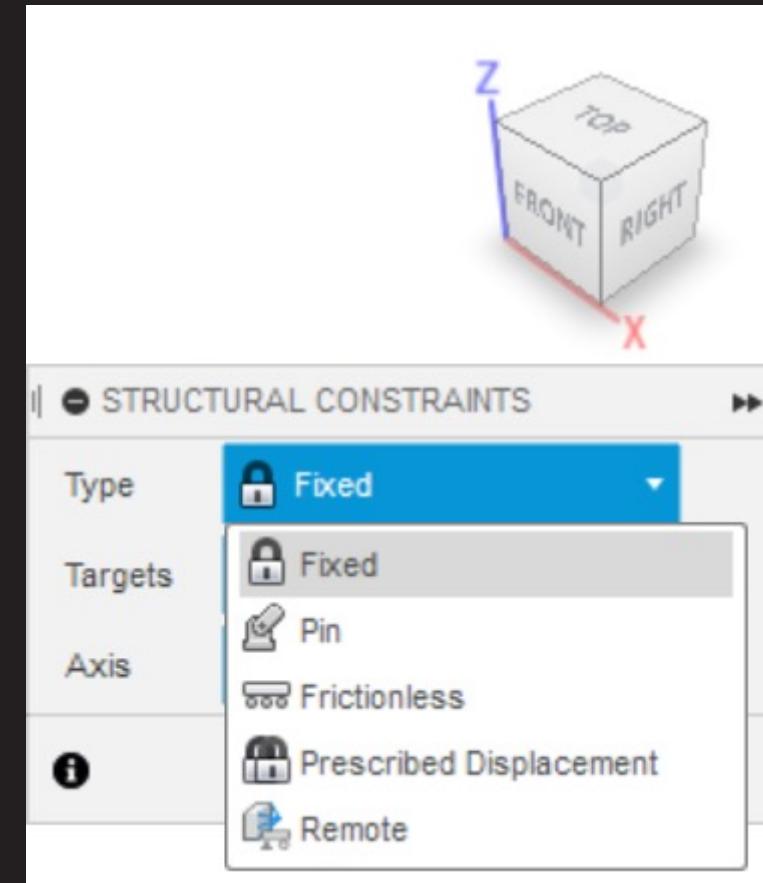
Set Constraints

Keyboard shortcut: 'C'



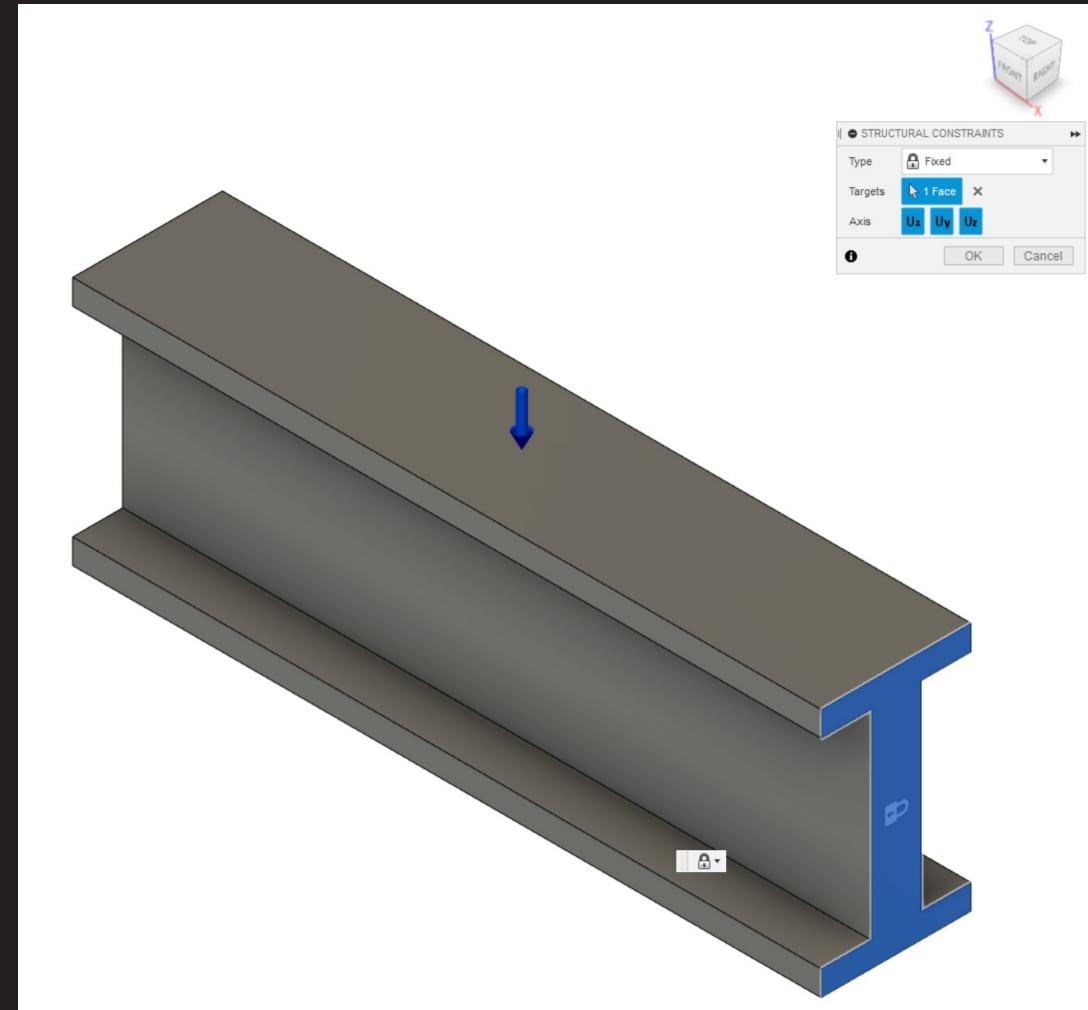
Select Constraint Type

Constraints available: Fixed, Pin, Frictionless, Prescribed Displacement, Remote



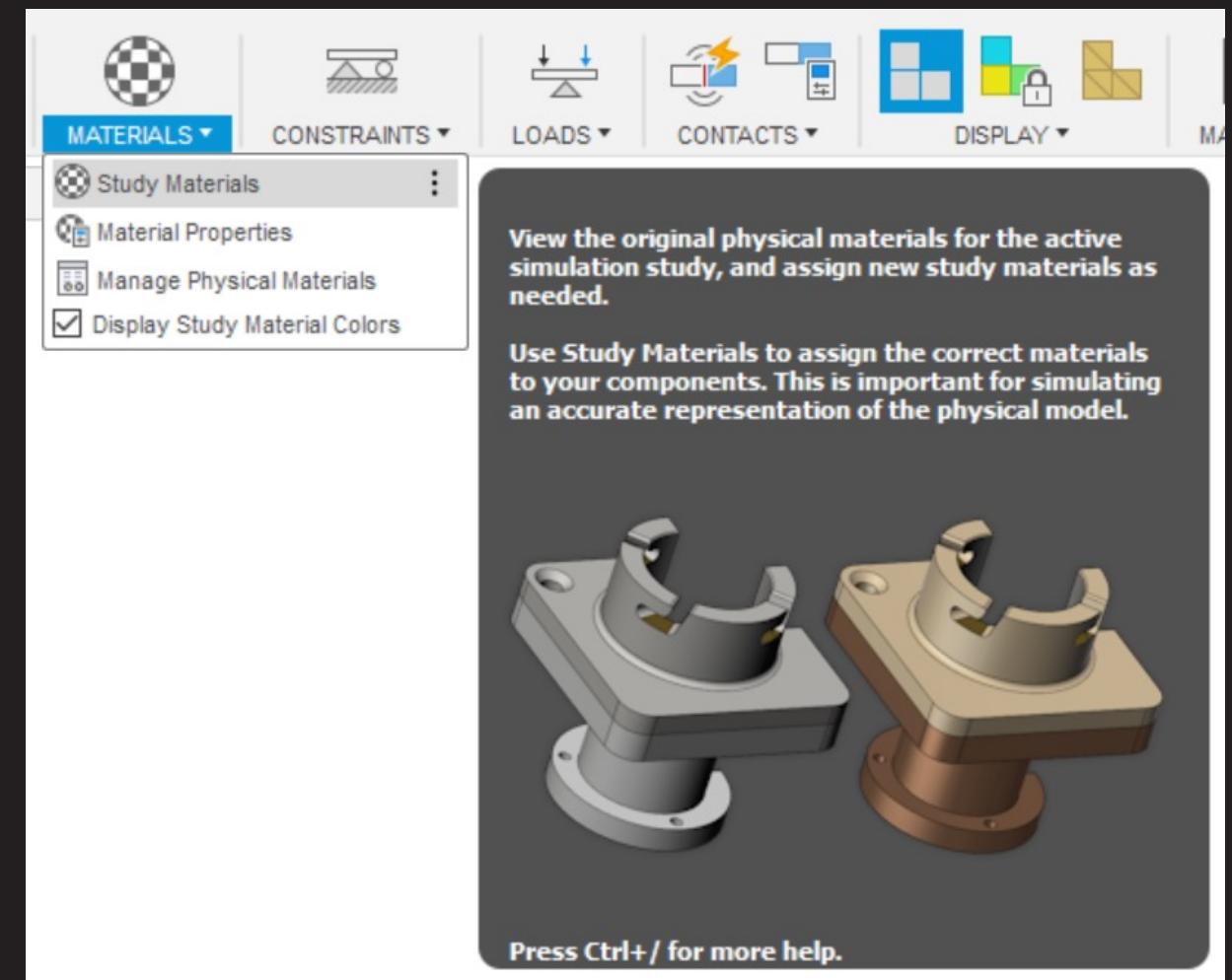
Select Constraint Surface

Click on the cross-section of the I-Beam.



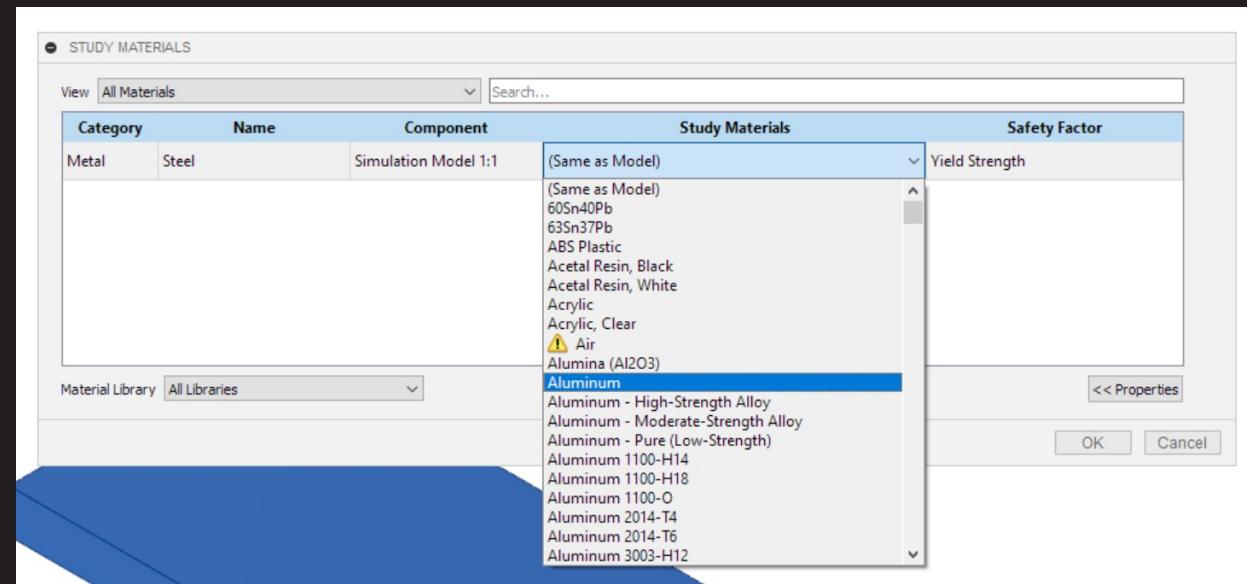
Set Material

Click on 'Study Materials'

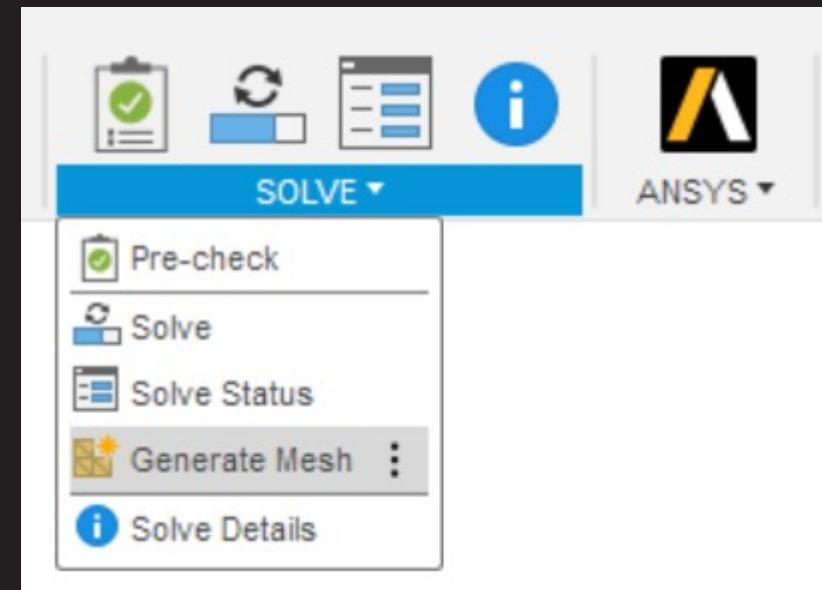


Change Material

Select the material of the component. Steel is used for this example.

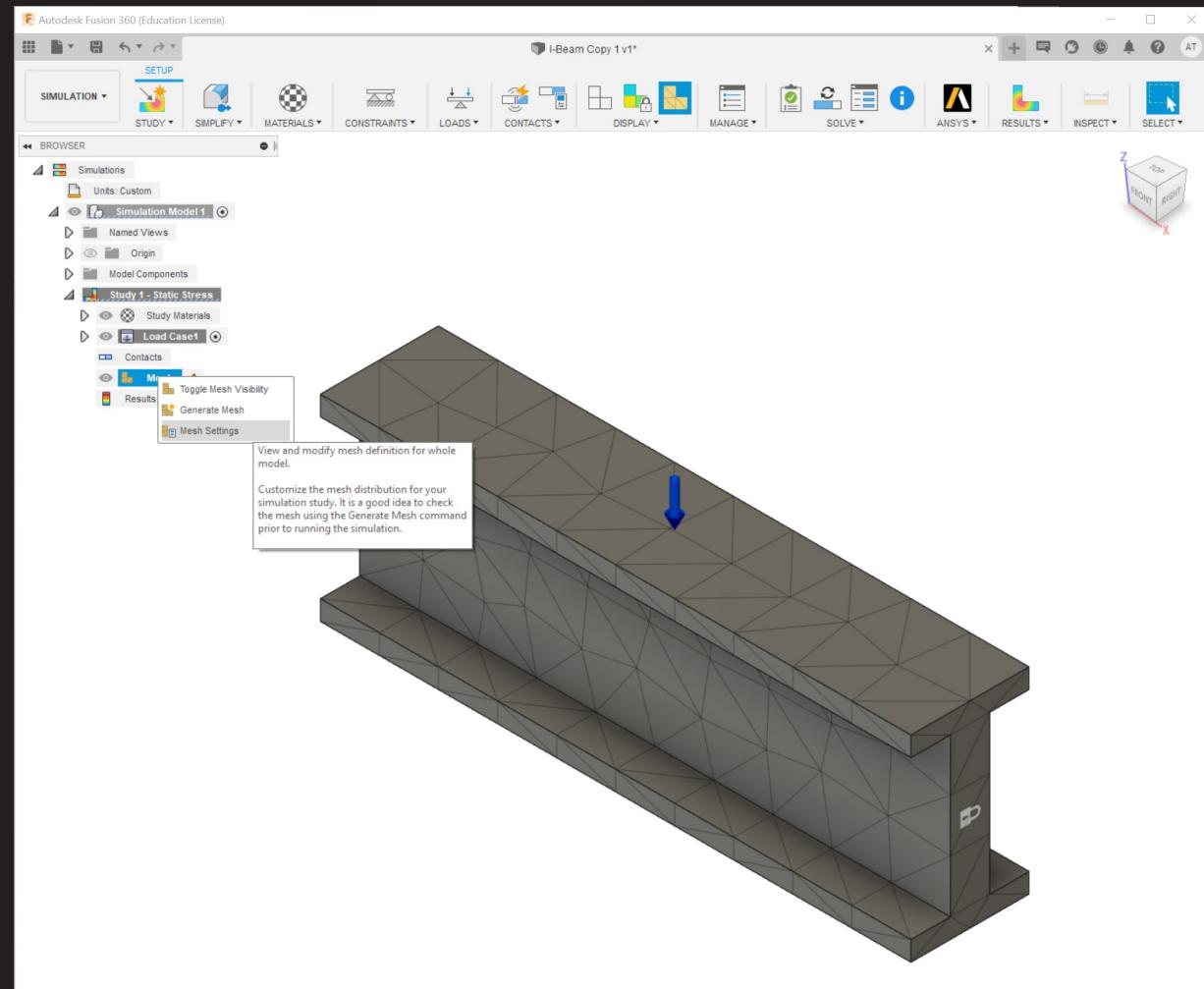


Generate Mesh



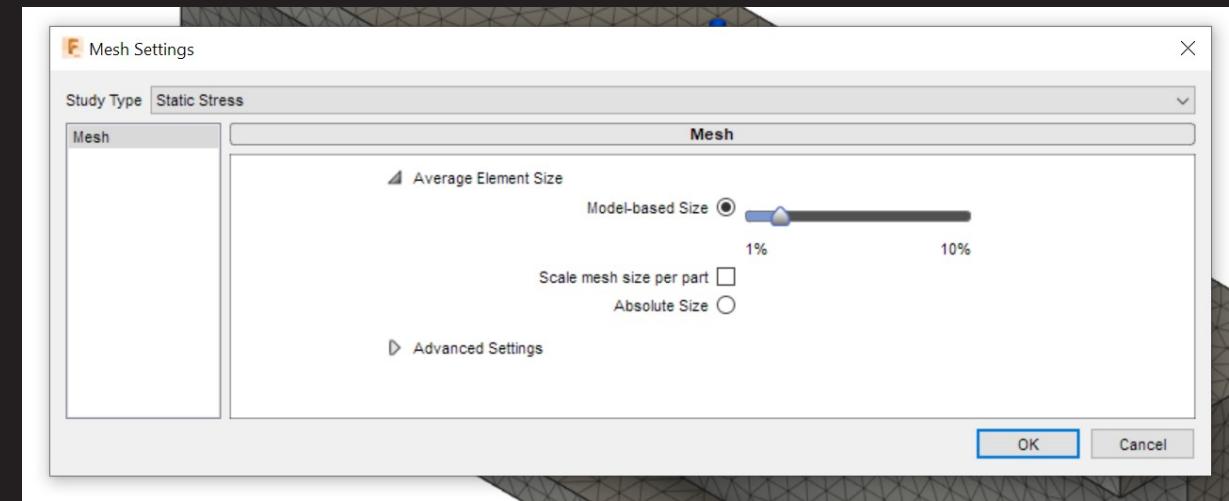
Change Mesh Settings

Right click on 'mesh' in the browser drop-down menu.



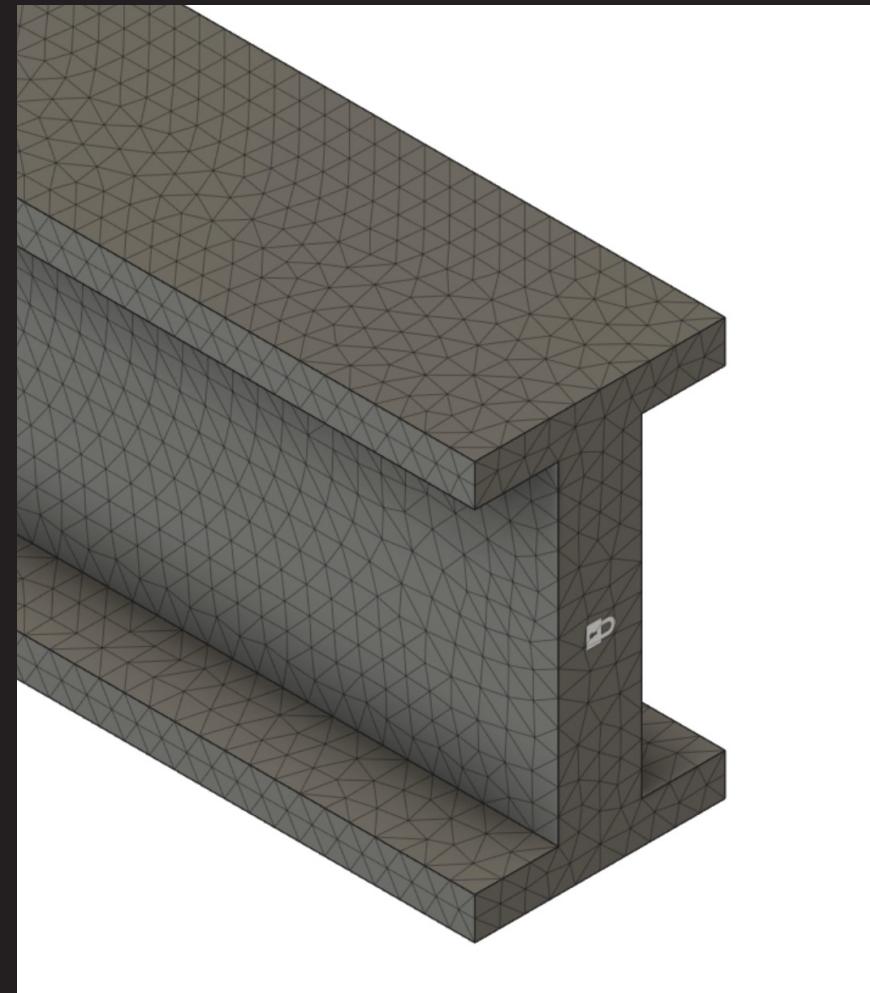
Vary Mesh Refinement

Rule of Thumb: Minimally 2 elements on each side



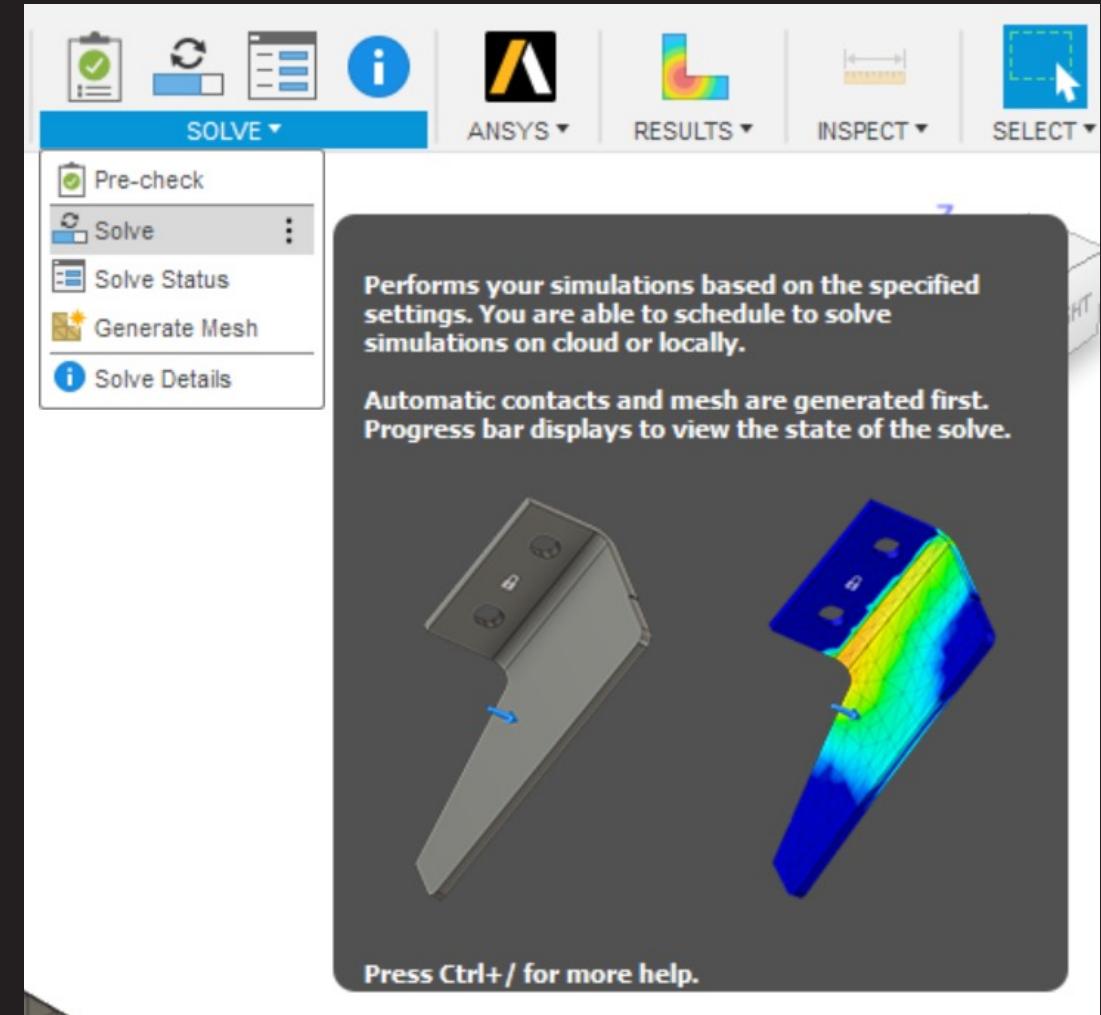
Vary Mesh Refinement

Rule of Thumb: Minimally 2 elements on each side



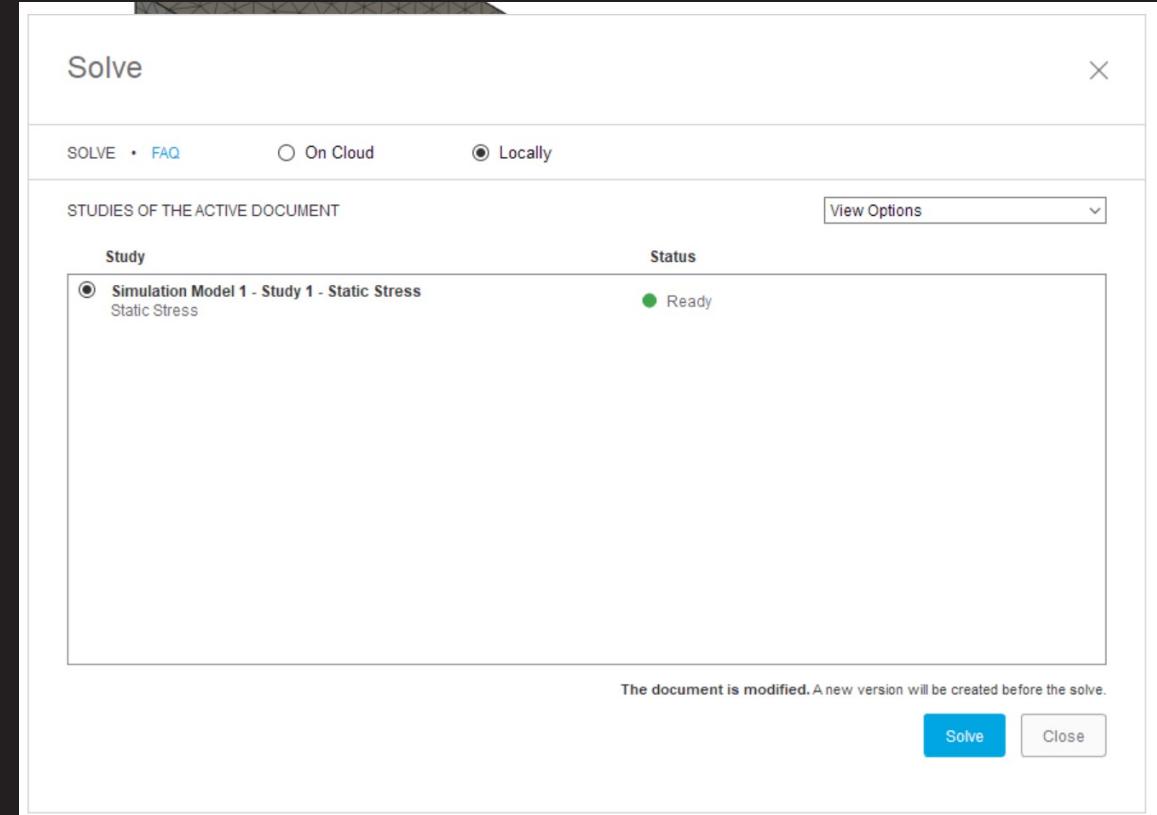
Solve

When the pre-check icon shows a ‘green tick’,
the study is ready for processing.



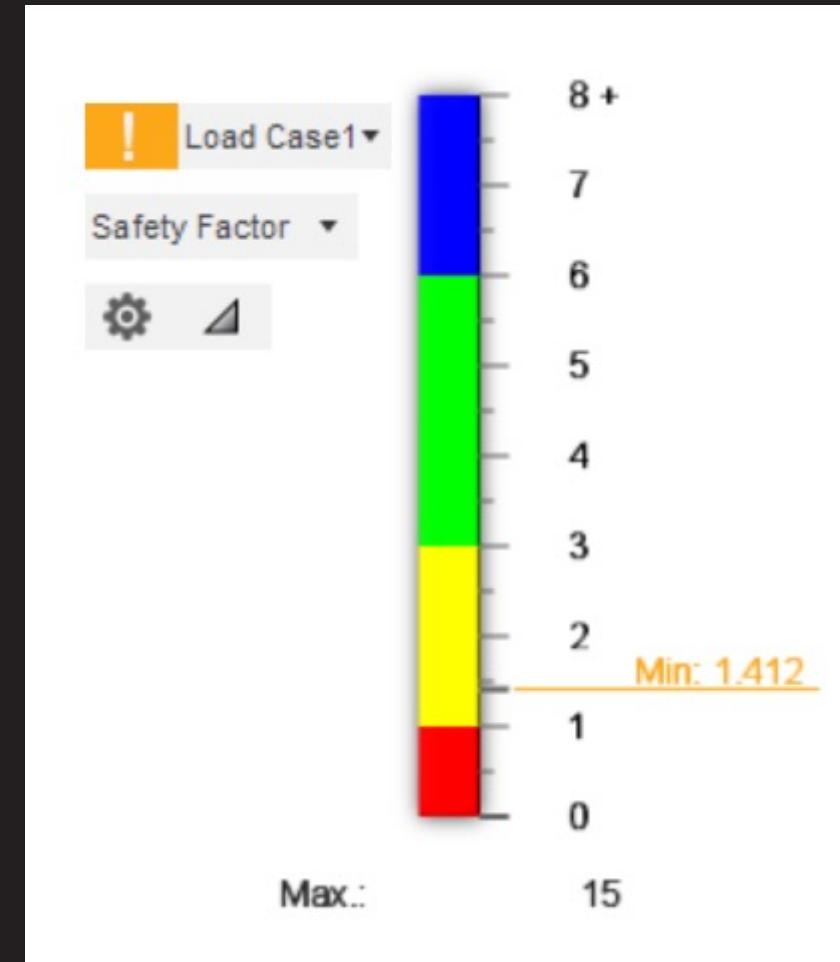
Choose Processor

Either Cloud (uses paid credits) or locally. Uses Nastran solver.



Safety Factor

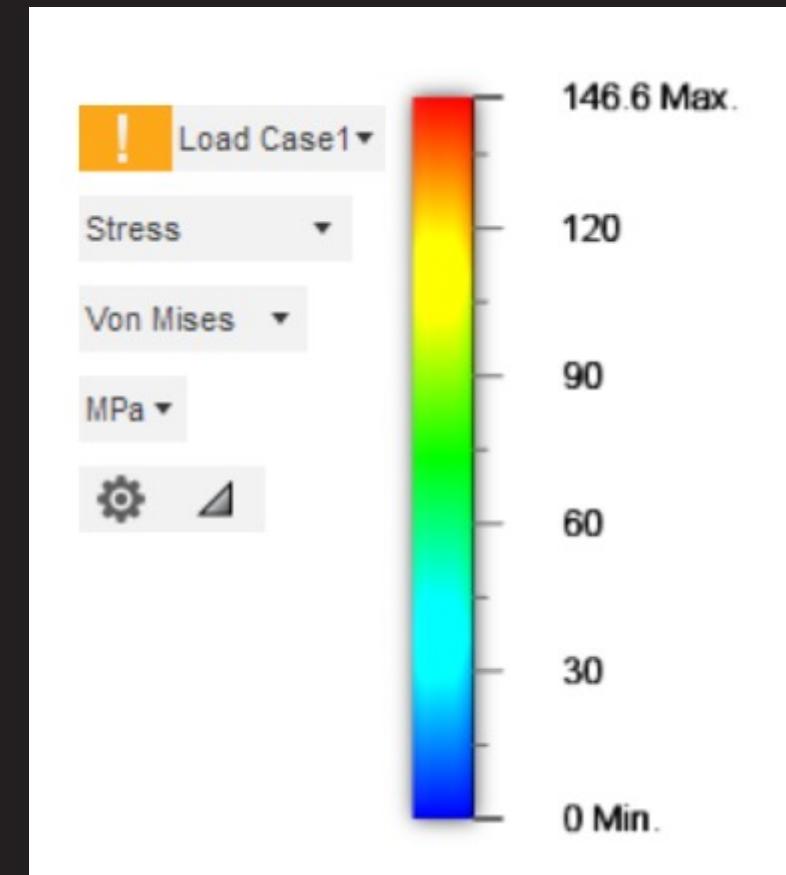
Rule of Thumb: Safety factor of 3



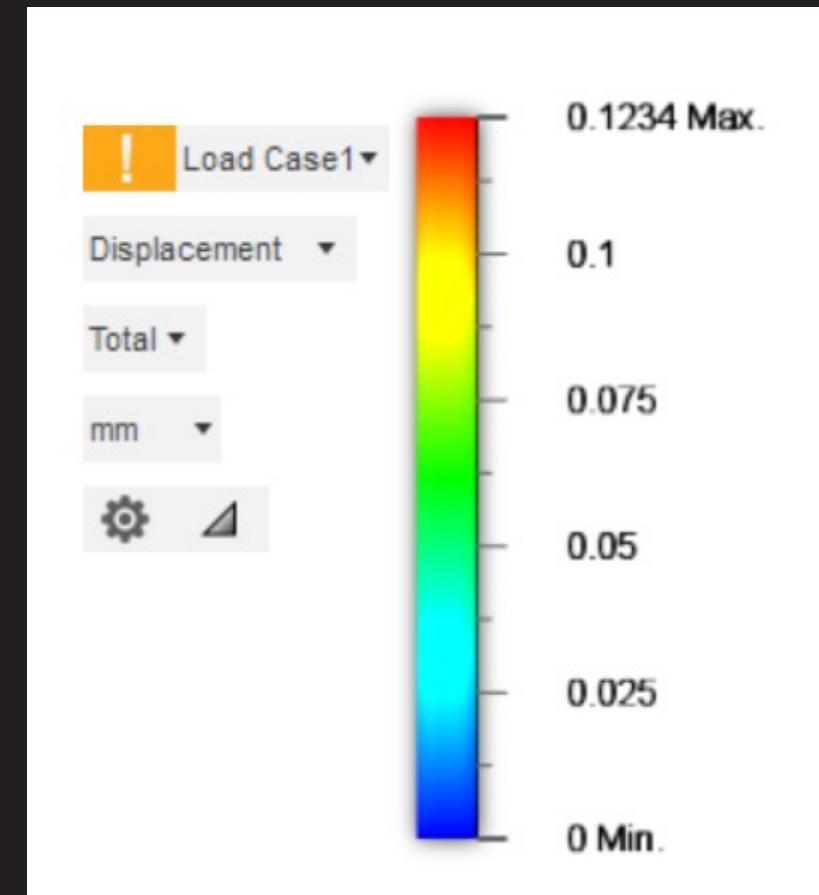
Equipment	Factor of Safety - FOS -
Aircraft components	1.5 - 2.5
Boilers	3.5 - 6
Bolts	8.5
Cast-iron wheels	20
Engine components	6 - 8
Heavy duty shafting	10 - 12
Lifting equipment - hooks ..	8 - 9
Pressure vessels	3.5 - 6
Turbine components - static	6 - 8
Turbine components - rotating	2 - 3
Spring, large heavy-duty	4.5
Structural steelwork in buildings	4 - 6
Structural steelwork in bridges	5 - 7
Wire ropes	8 - 9

Source: <https://researchgate.net>

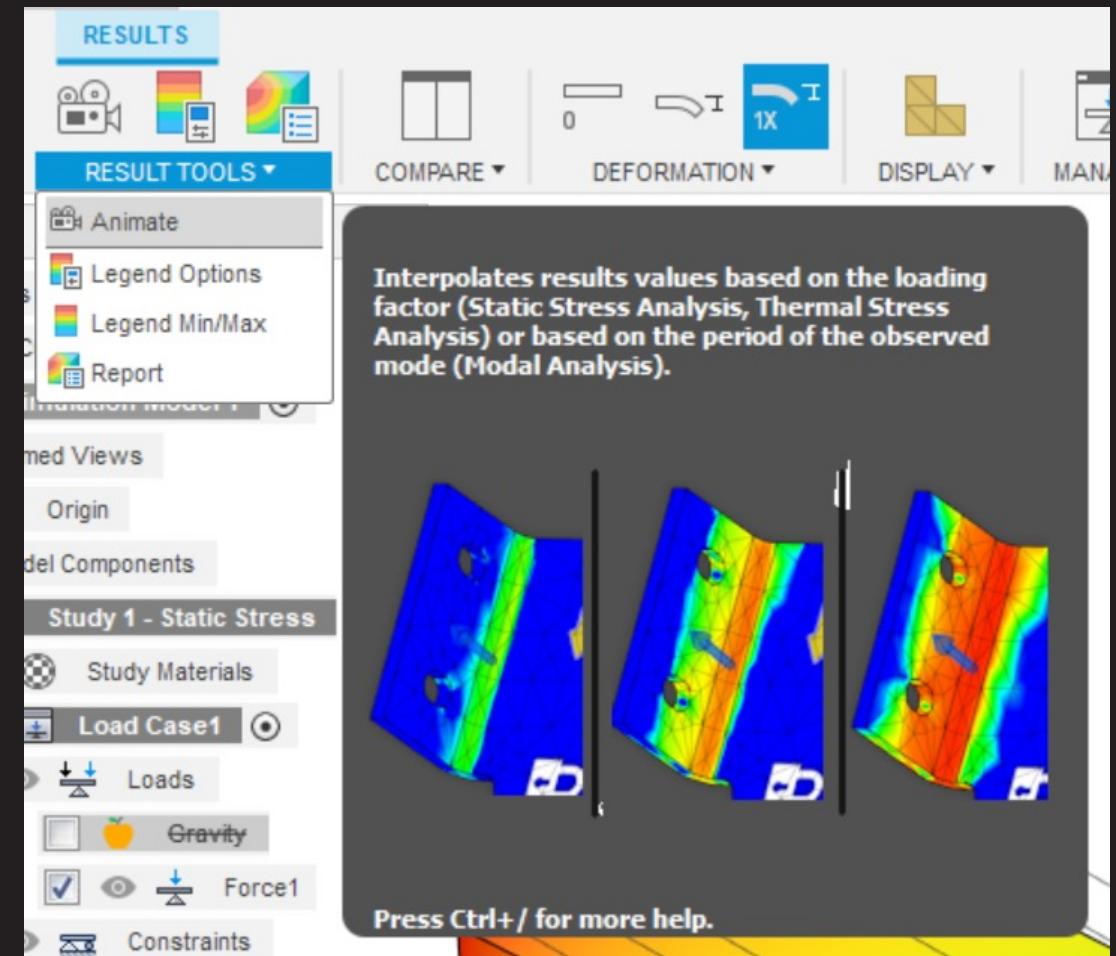
Von Mises Stress



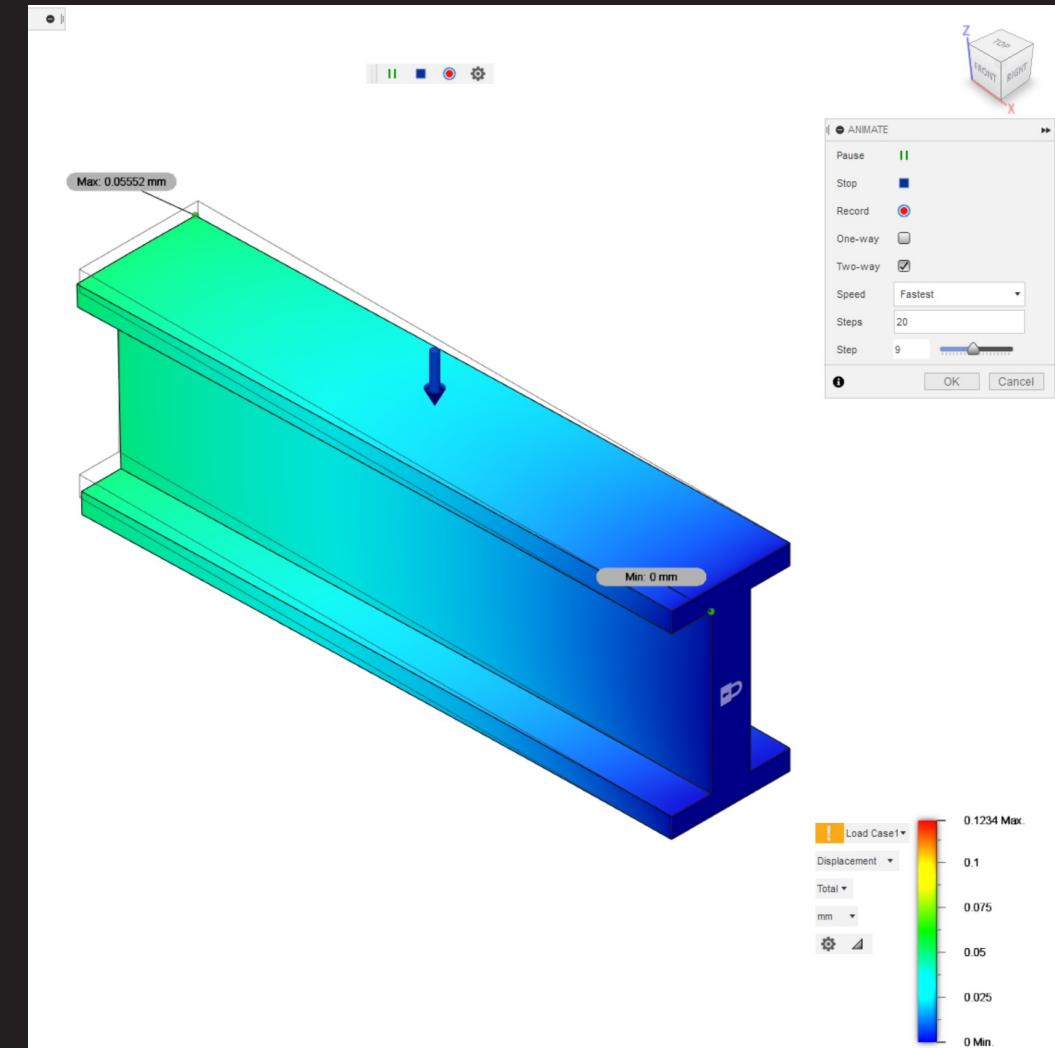
Displacement

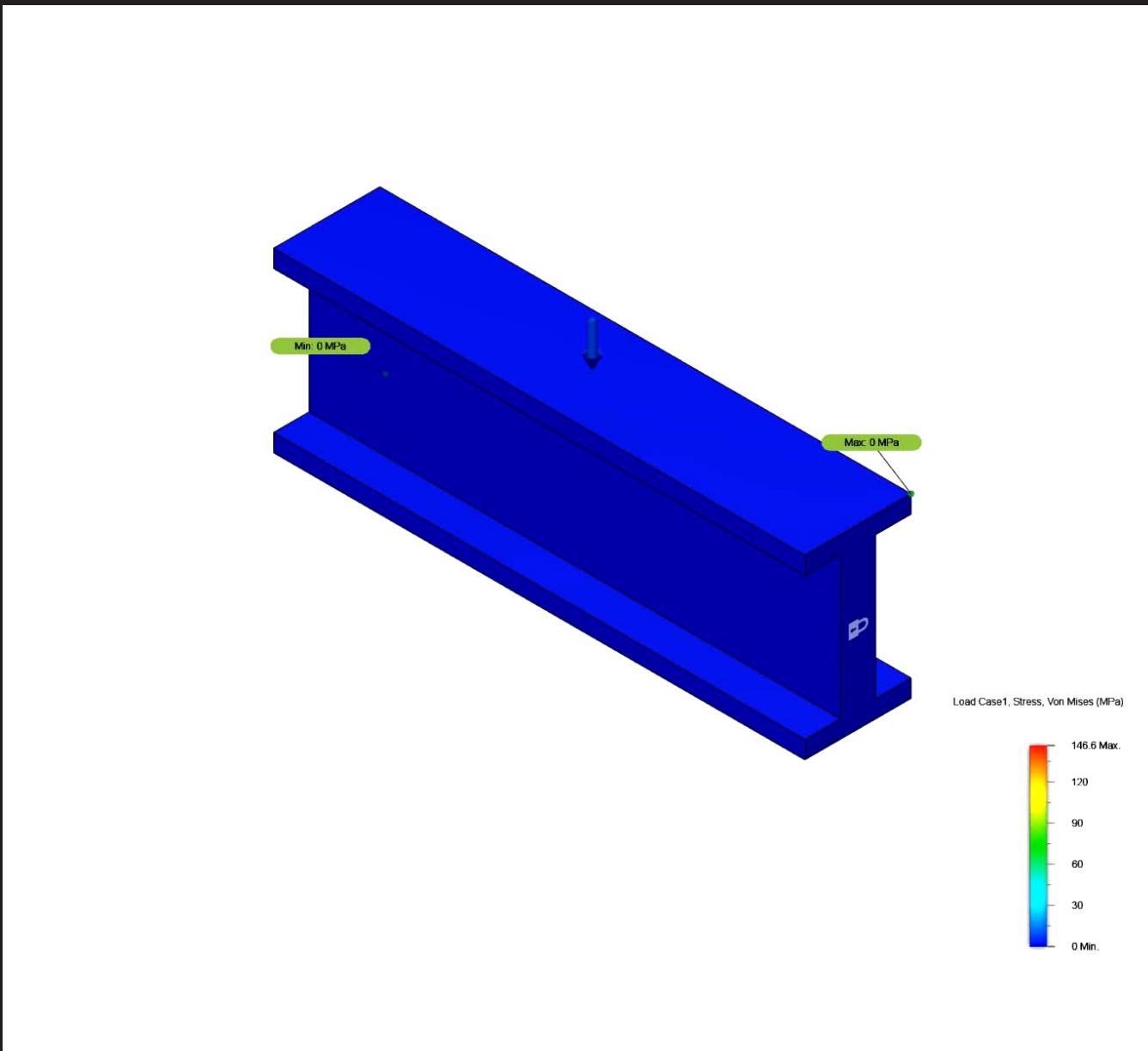


Animate Simulation



Animate Simulation



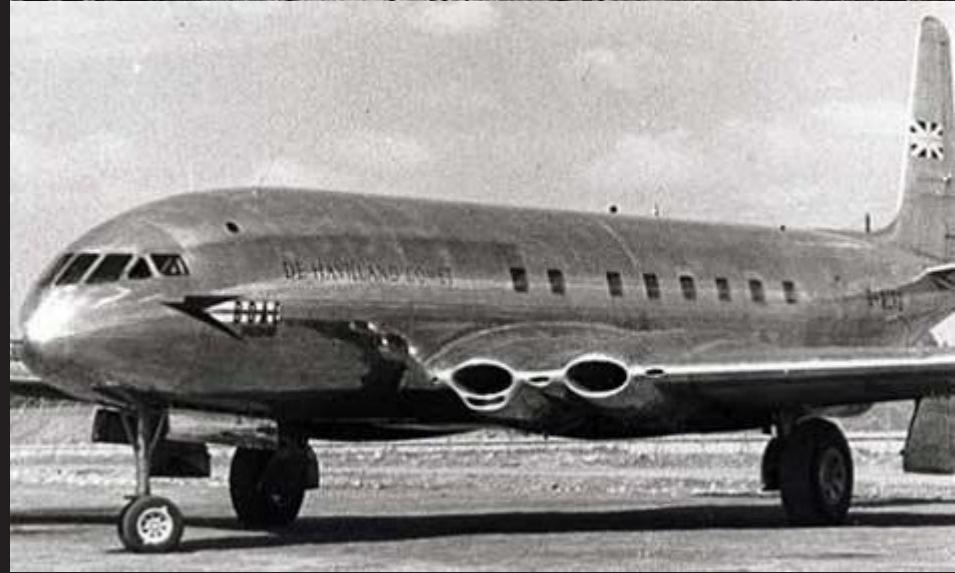
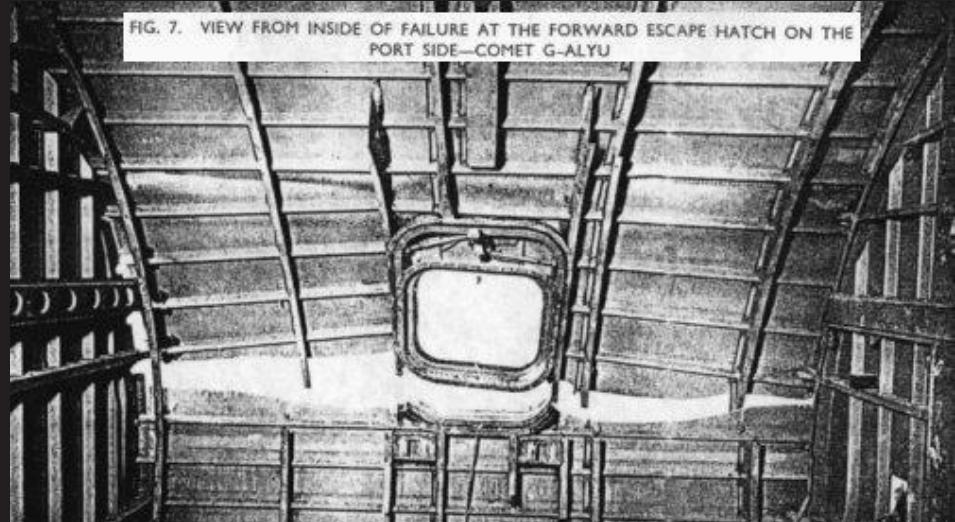


What's Next?

- Add material at stress concentrations
- Remove material at over-engineered areas

Stress Concentrations

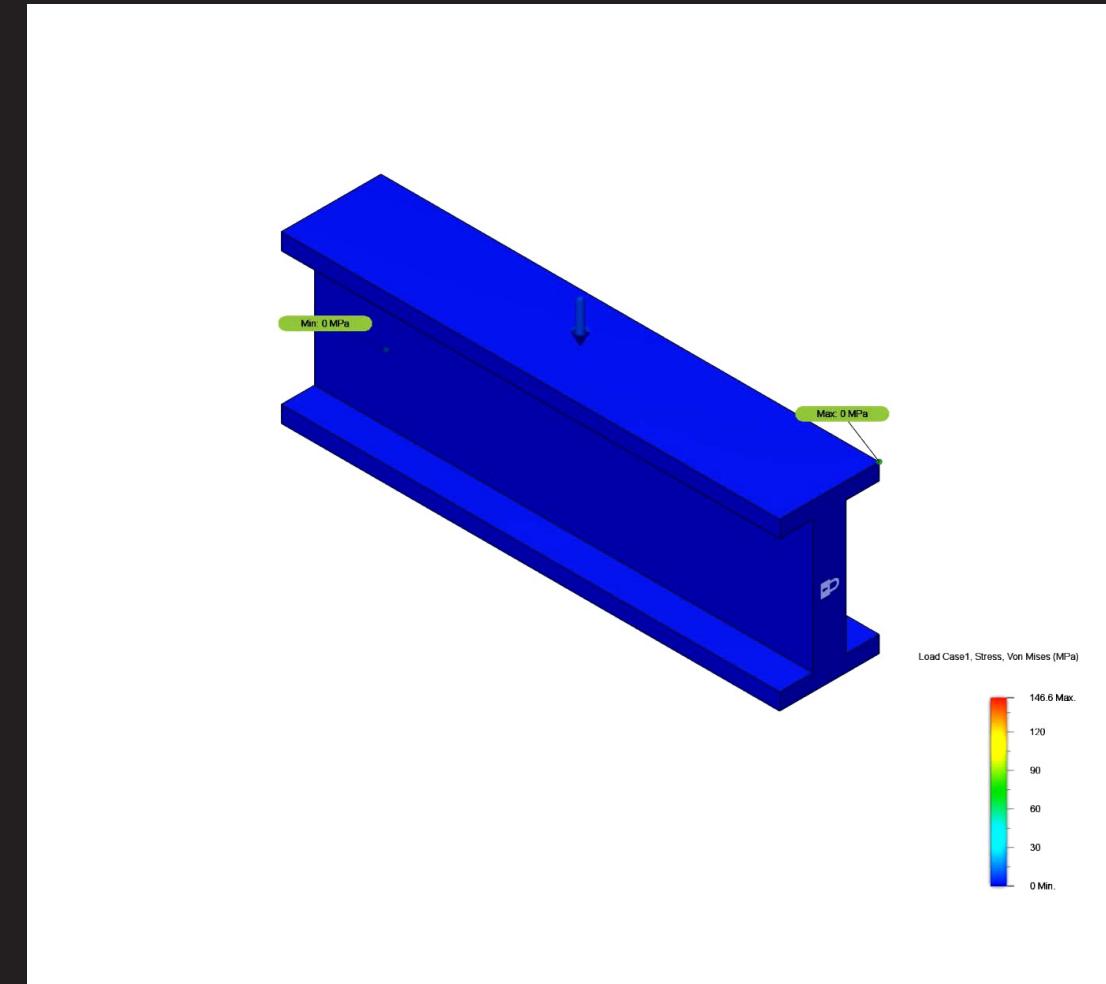
- The 1st commercial jet liner, De Havilland Comet
- Multiple jets tore apart mid-flight
- Due to metal fatigue



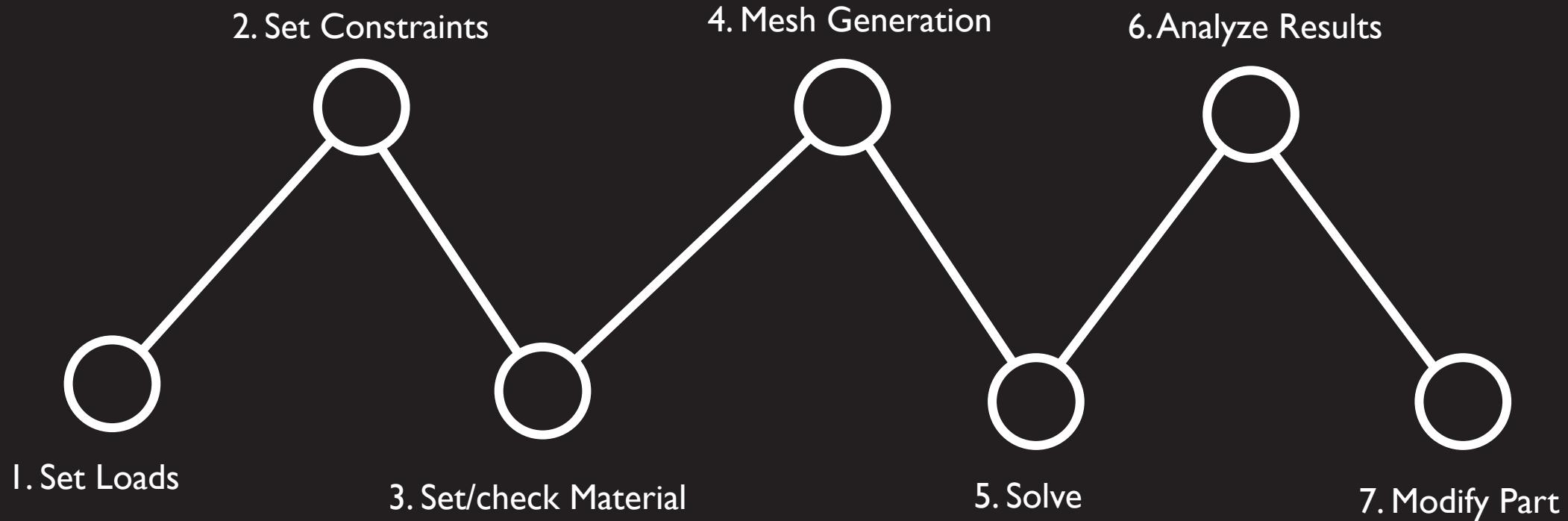
Source: <http://personal.psu.edu>

Simulation for 3D Printing

1. Anisotropy
 - Print orientation
2. Hollow structures



Simulation Workflow

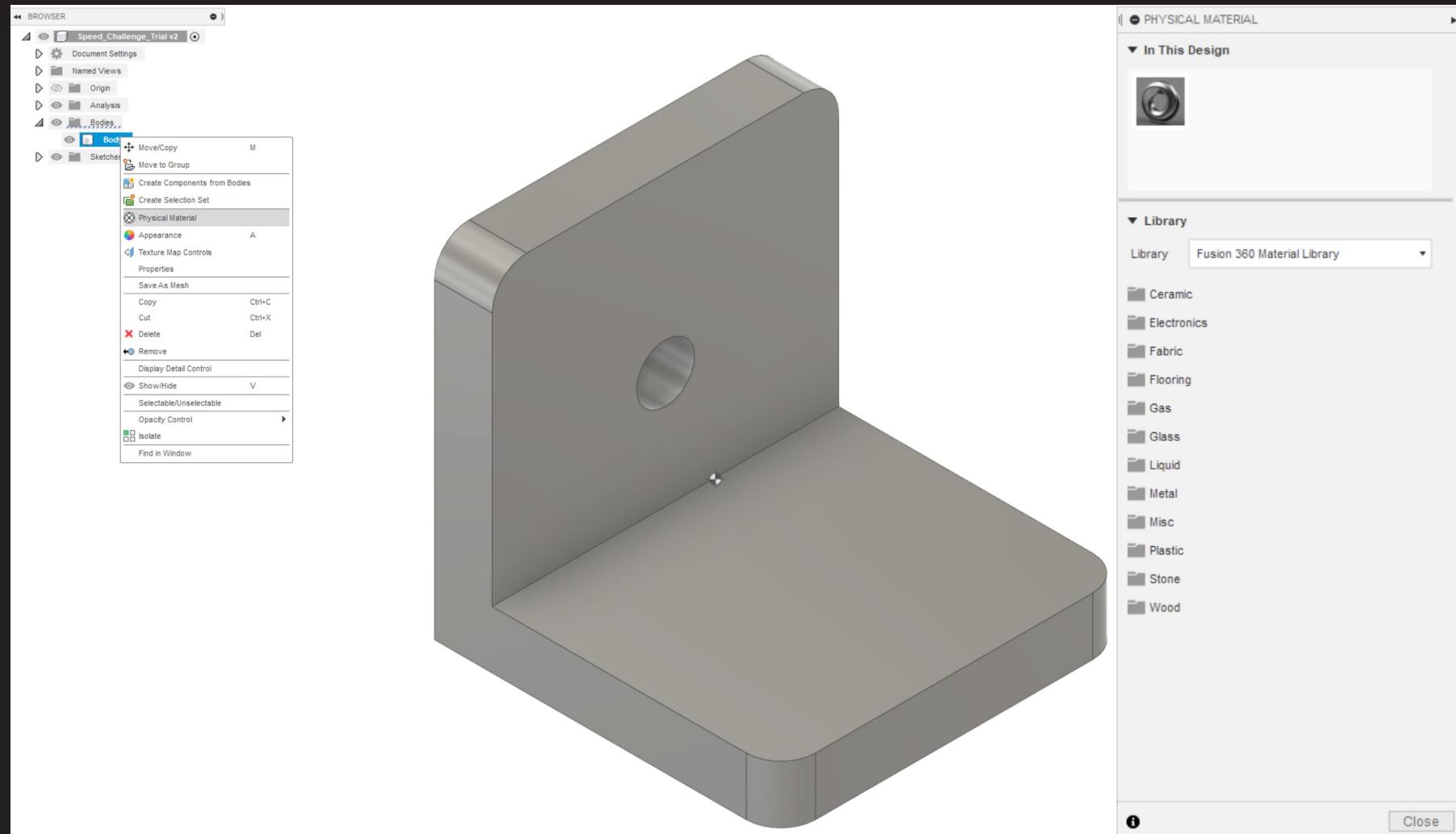


Speed Challenge!

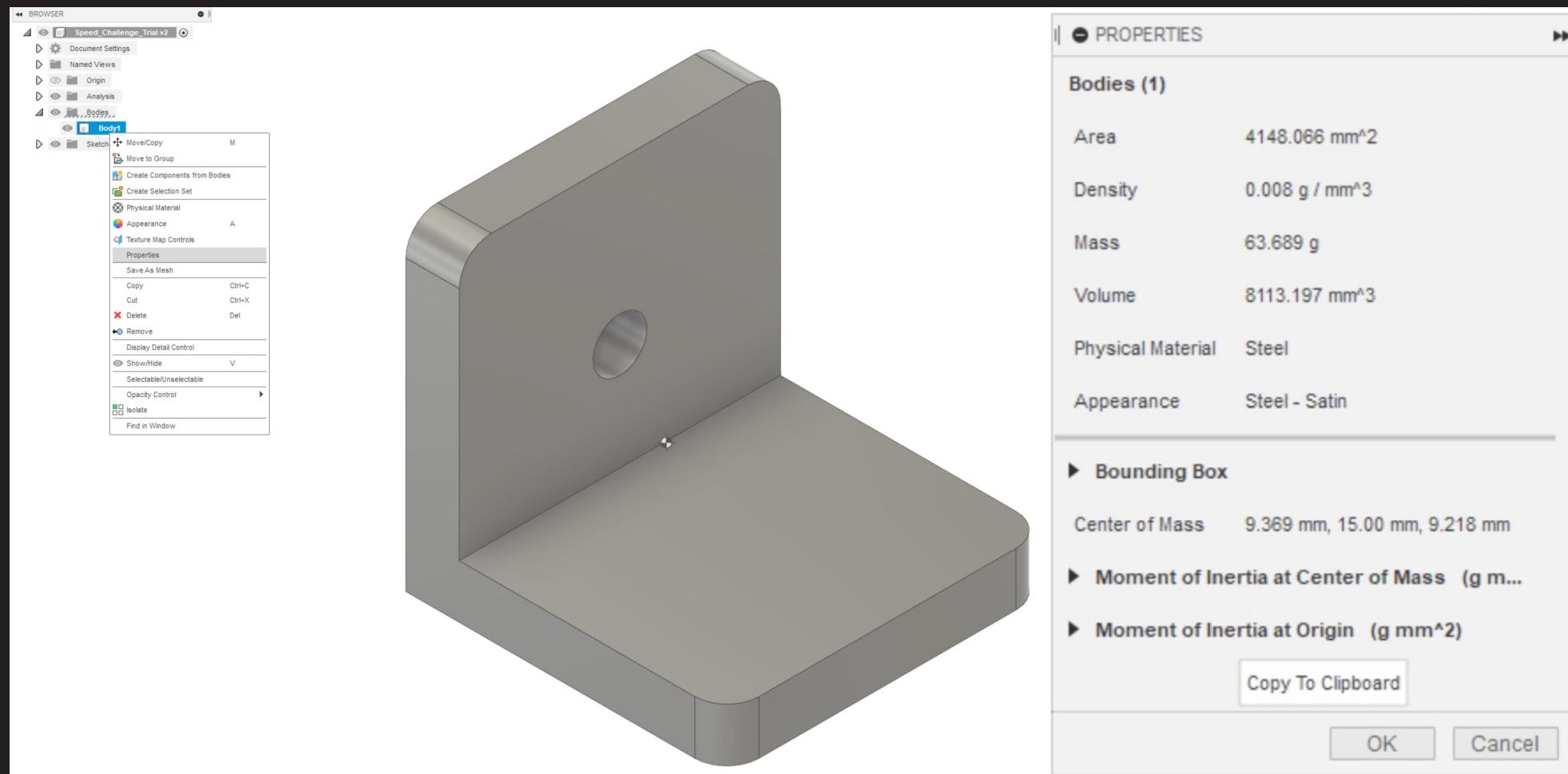
Format

1. 5x 2D drawings will be displayed here on the slides one after another
2. Using Fusion360, model the 2D drawing in 3D as quickly as you can but not compromising on accuracy
3. Set your model's material to steel
4. Under properties, find the mass (in grams) of the part & submit a screenshot of your whole fusion window (including your username, and mass property) on the Discord 'mech-qna' channel
5. The top 3 fastest correct answers (to 1 d.p.) win points
6. The total score of the 5 rounds will be tabulated (different difficulties have different points allocated)
7. Top 3 overall will get a prize! (the rest get a taste of speed CAD-ing)

Setting a Material



Checking Mass



EASY

1st 3 points
2nd 2 points
3rd 1 point

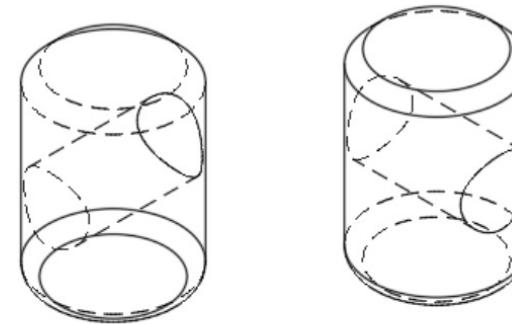
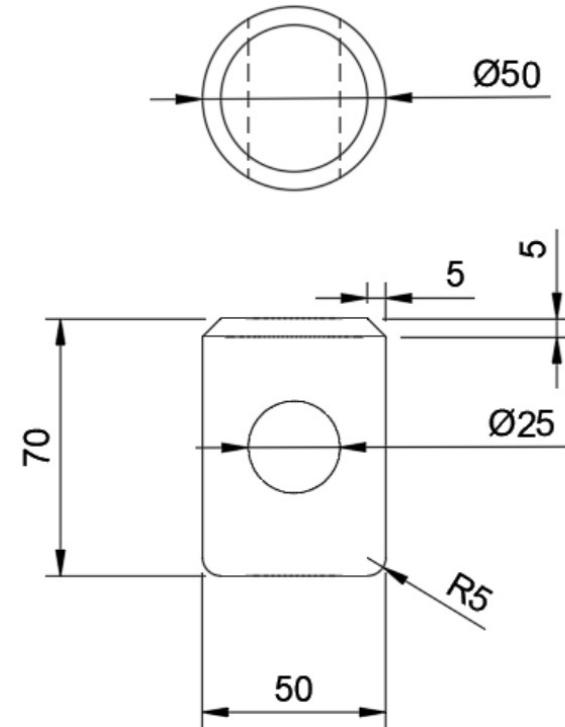
INTERMEDIATE

1st 4 points
2nd 3 points
3rd 2 points

CHALLENGING

1st 5 points
2nd 4 points
3rd 3 points

Practise



Dept.	Technical reference	Created by Abram Tan 10/10/2021	Approved by
	Document type		Document status
	Title SPEEDCHALLENGE PRACTICE		DWG No.
	Rev.	Date of issue	Sheet 1/1

ALMOST THERE... :P

SESSION 1

- Robot Design
- Sensors
- Motor Transmissions and Reductions

- Sketching
- Extrude, sweep, revolve, loft
- Bodies and Components

SESSION 2

- Fabrication techniques
 - Additive
 - Subtractive
- Canvas tracing
- Assemblies
- Drawings

SESSION 3

- Simulation
 - Static stress
- Practice & speed challenge

NEXT STEPS

I. Practice!

1. School projects
2. SOAR projects
3. Create your own 3D printed stuff!

2. YouTube Channels

1. <https://www.youtube.com/user/cadcamstuff/>
2. <https://www.youtube.com/c/jamesbruton>
3. <https://www.youtube.com/c/PracticalEngineeringChannel>
4. <https://www.youtube.com/c/RealEngineering>
5. <https://www.youtube.com/c/Electroboom>
6. https://www.youtube.com/channel/UC873OURVczg_utAk8dXx_Uw

NEXT STEPS

3. Get certified
 - I. CSWA, CSWP, CSWE
4. Learn other software tools
 1. SolidWorks
 2. CREO
 3. ANSYS

See you at
SOAR Challenge
2021!