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Design for Industry 4.0

Generative Design

Presented

by

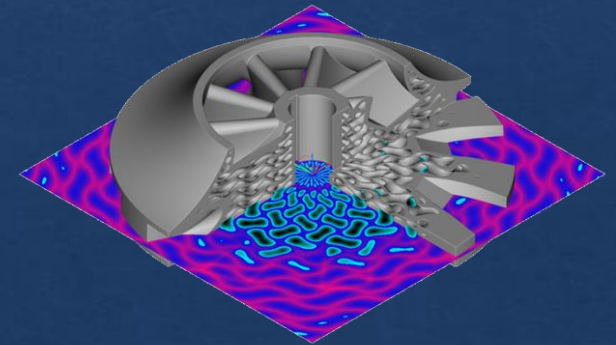
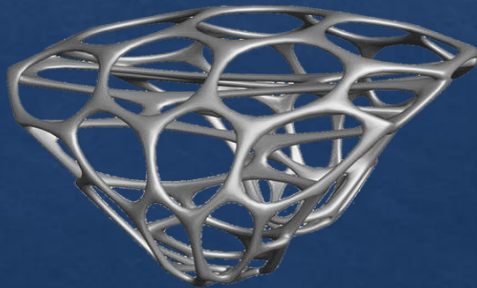
Richard Burnell

- ◆ Introduction
- ◆ Design Process
- ◆ Results
- ◆ Summary
- ◆ Questions

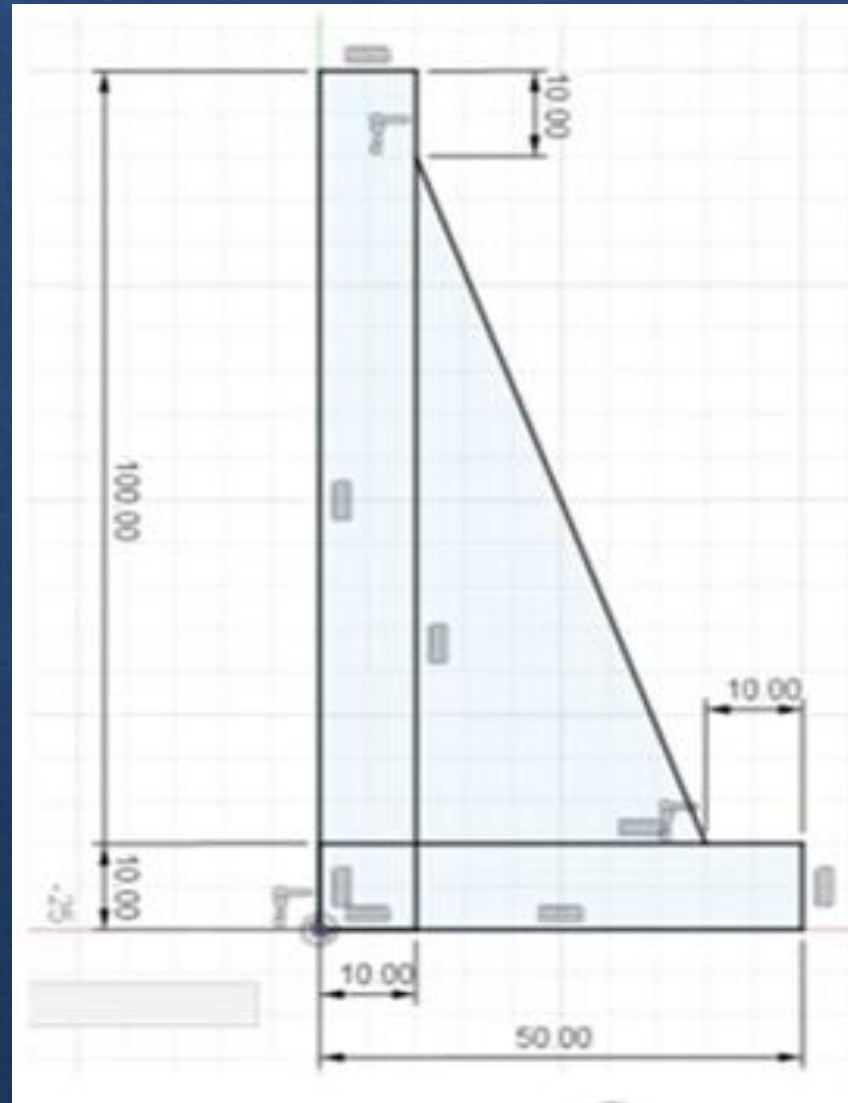
Generative Design in a Nutshell

“Generative design replicates the natural world's evolutionary approach with cloud computing to provide thousands of solutions to one engineering problem.”

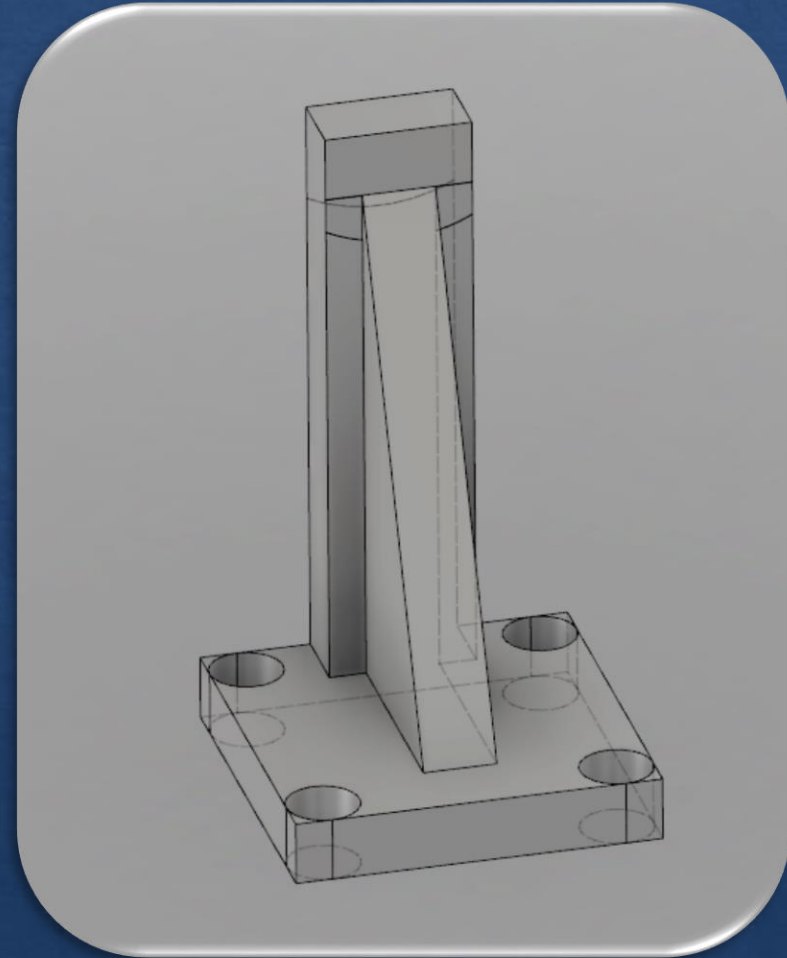
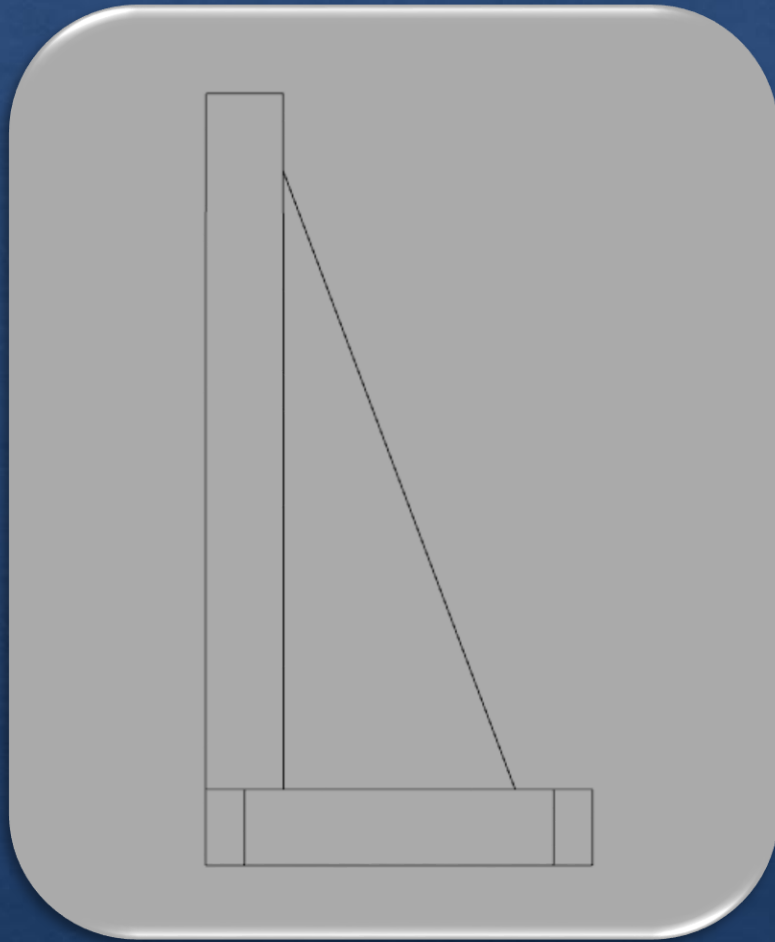
Ravi Akella - Director of generative design software at Autodesk (2018)



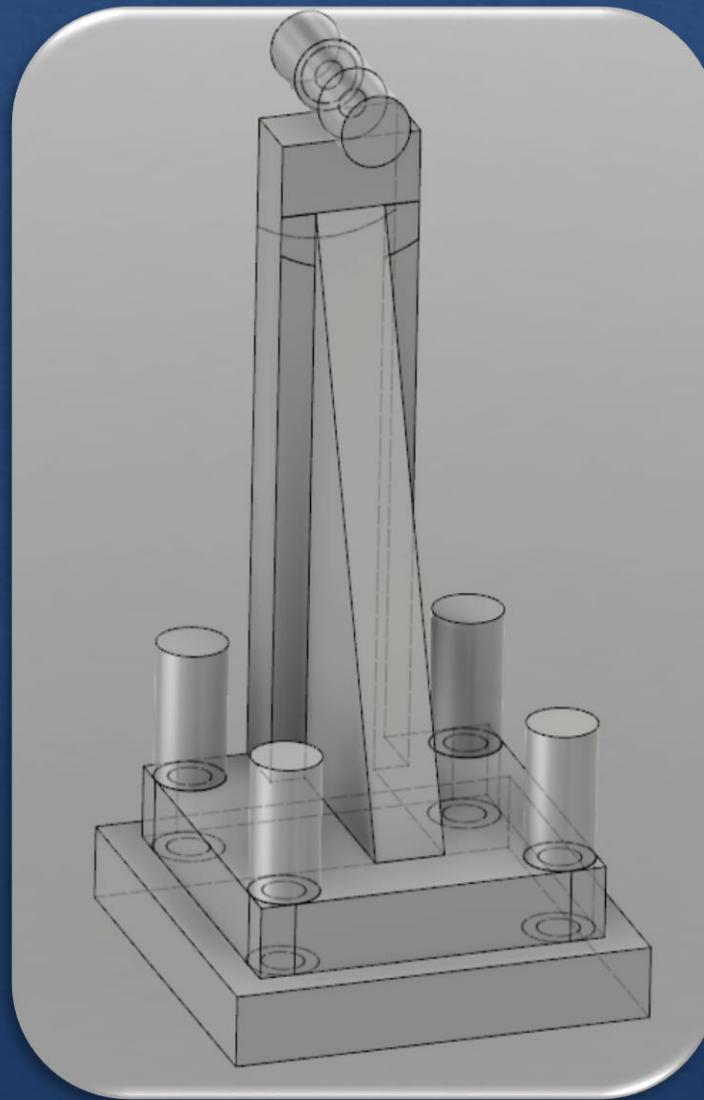
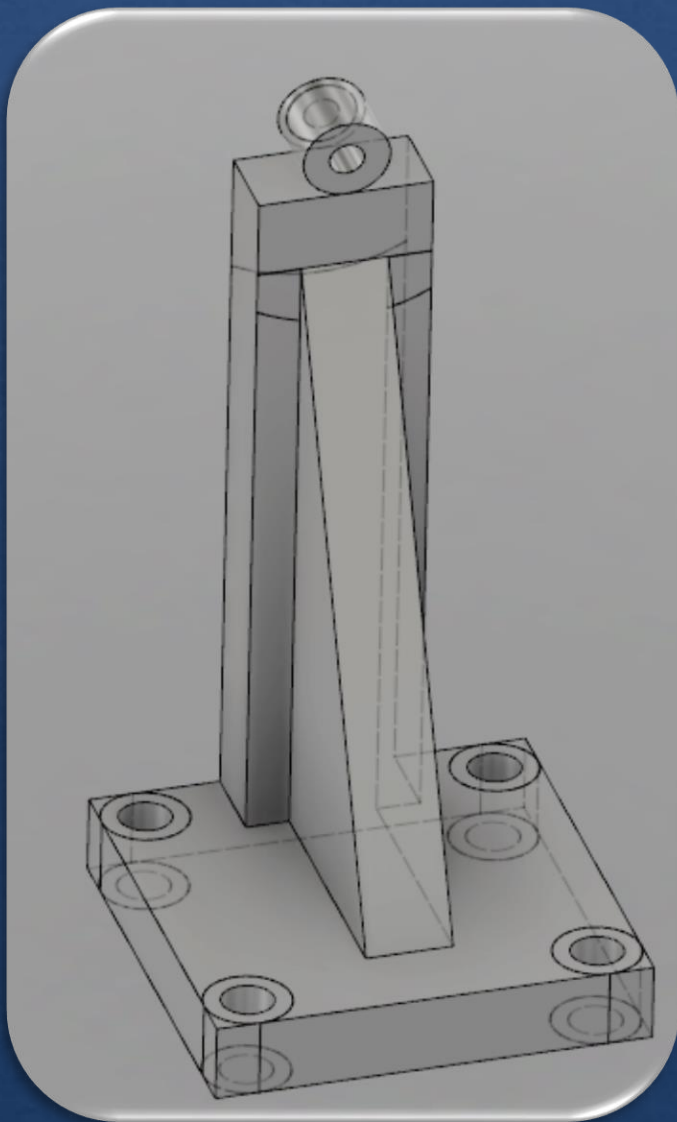
Design Process: Drawing (Starting Geometry)



Starting Shape

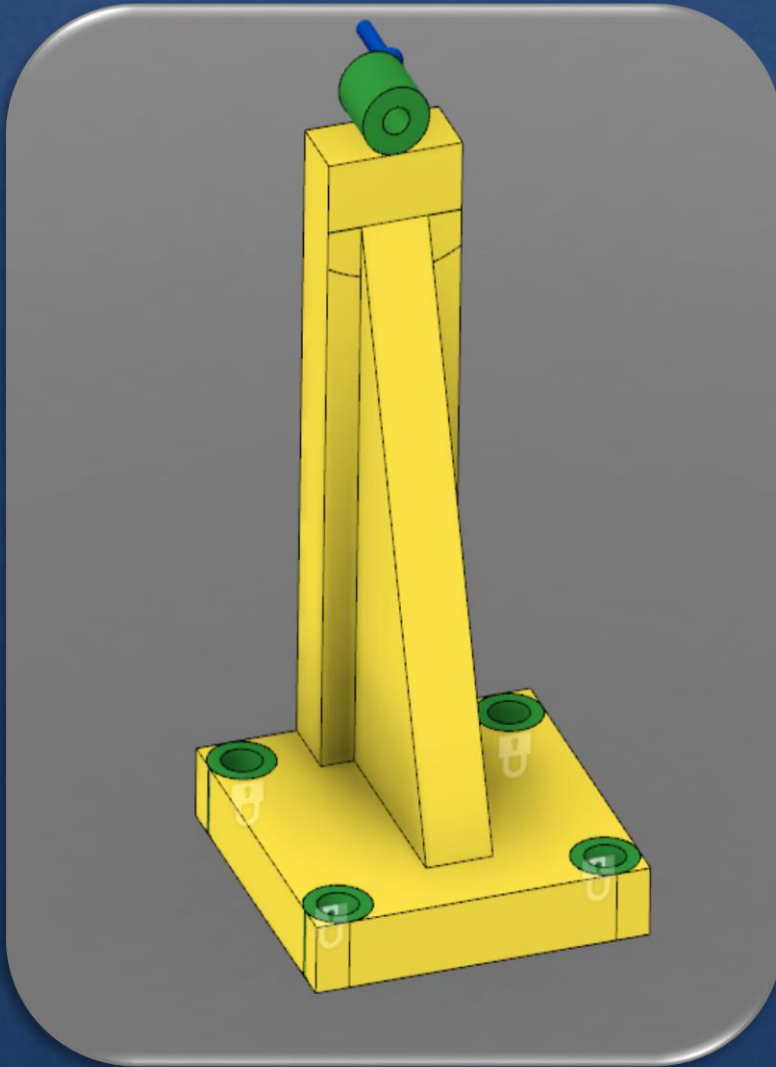


Preserved and Obstacle Geometry

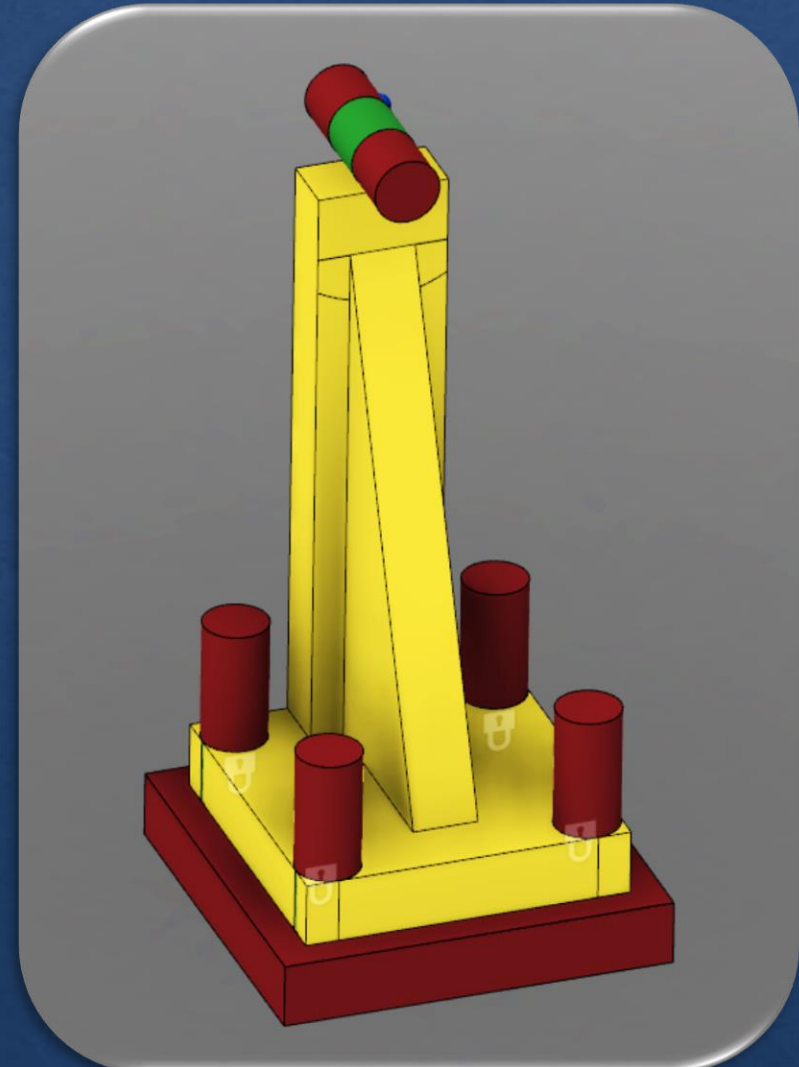


Generative Design – Assigning Geometries

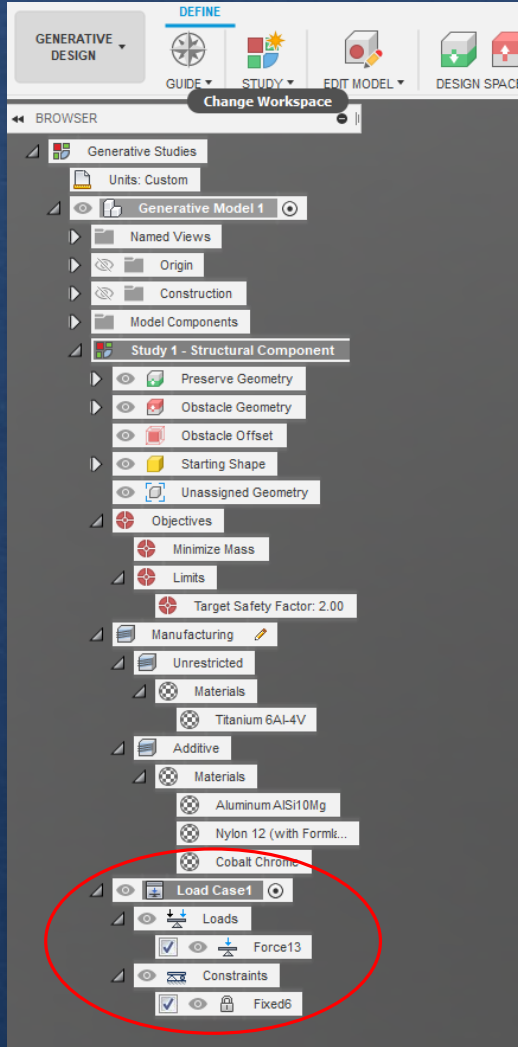
Assigning **starting** and **preserved** geometry:



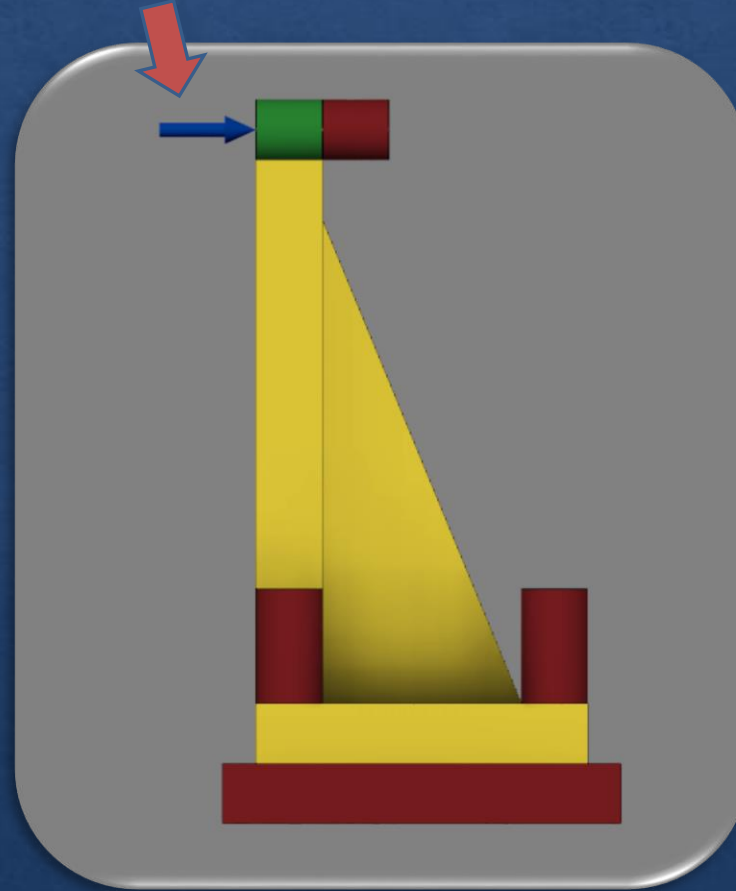
Assigning **obstacle** geometry:



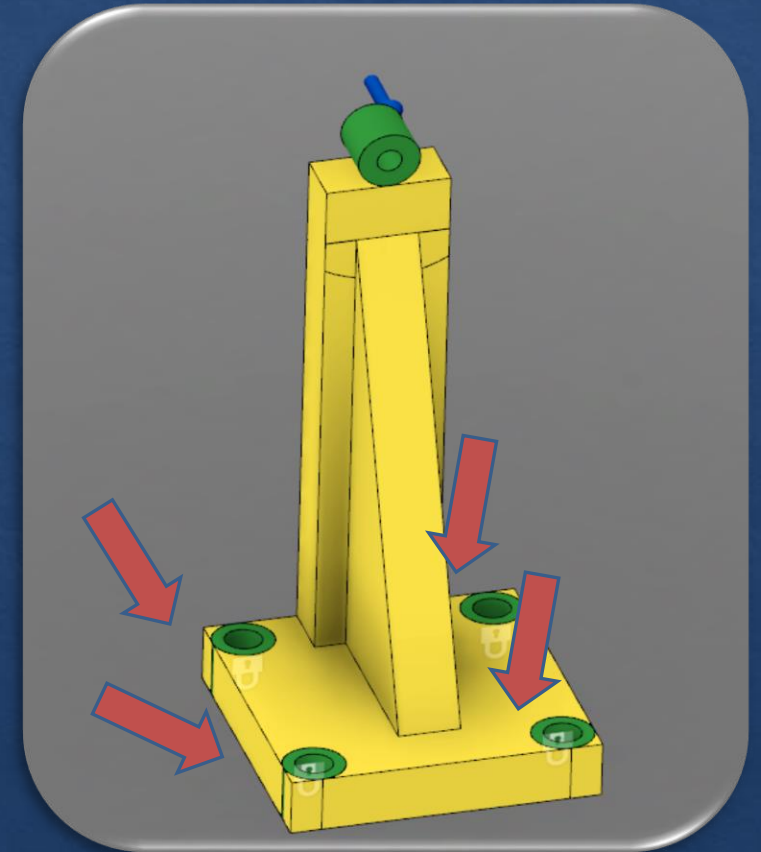
Generative Design – Loads and Constraints



Load Applied = 1000N (101.97Kg)
Load Applied to upper preserved geometry

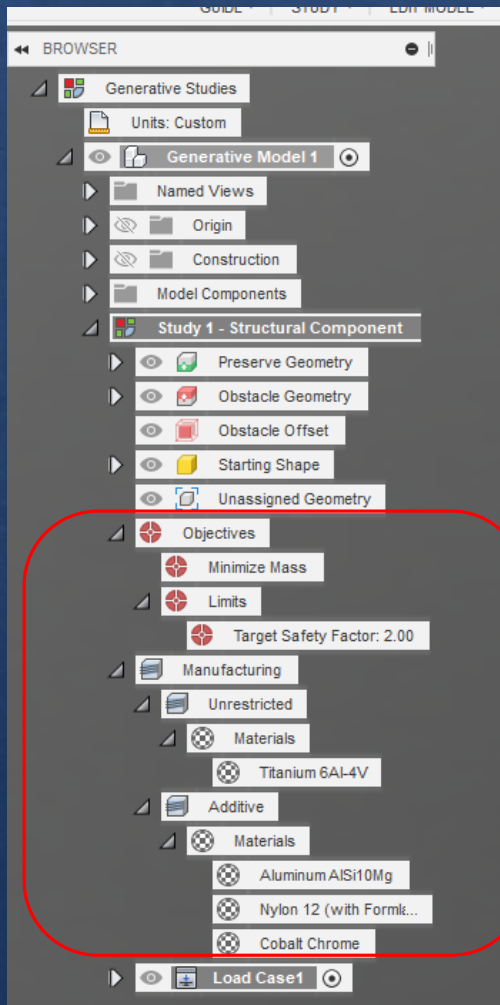


Constraints applied to 4 base holes
(fixing holes)



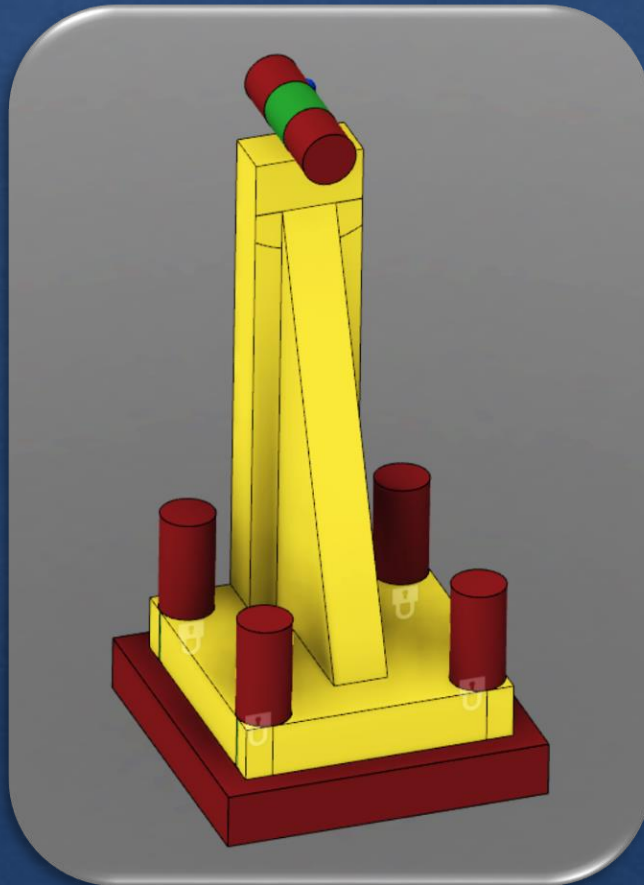
Generative Design

Manufacturing Methods / Objective / Safety Factor / Materials



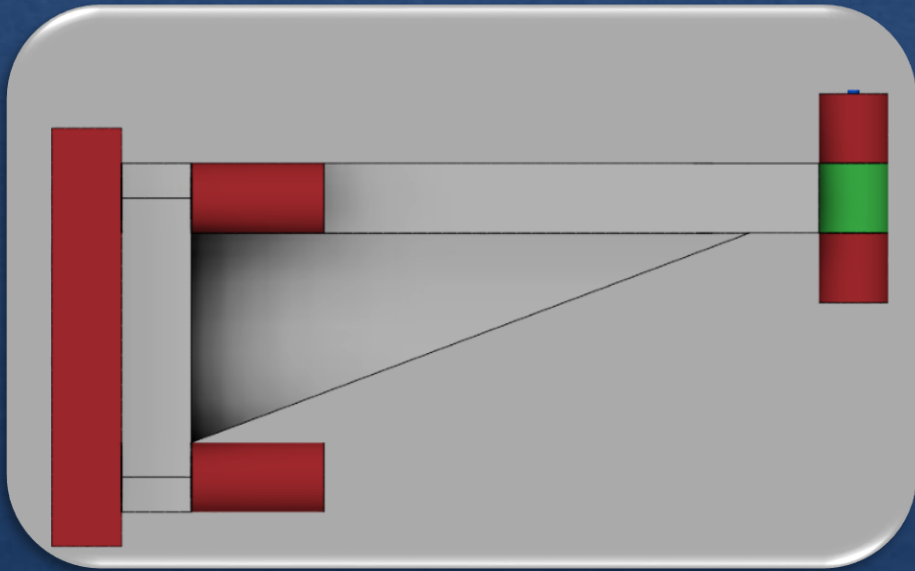
- **Manufacturing Methods Chosen:** Unrestricted and Additive Manufacturing
- **Objective of Study:** Minimise Mass
- **Target Safety Factor:** 2.00
- **Materials:** Titanium (unrestricted)
Aluminium / Nylon 12 / Cobalt Chrome (Additive)

Generative Design – Study 1

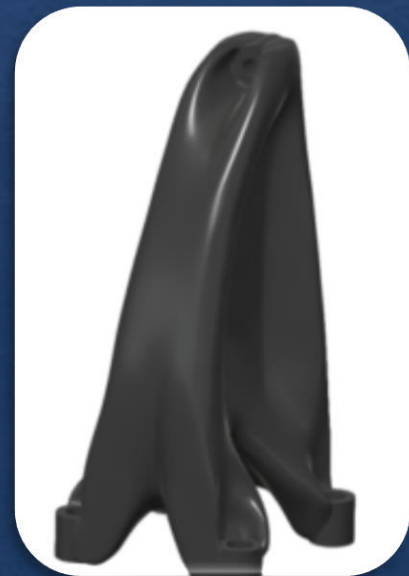
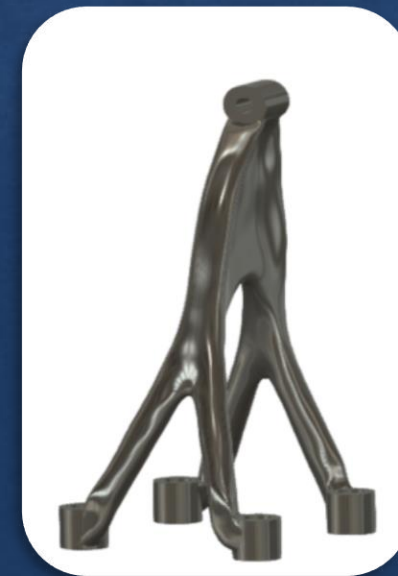
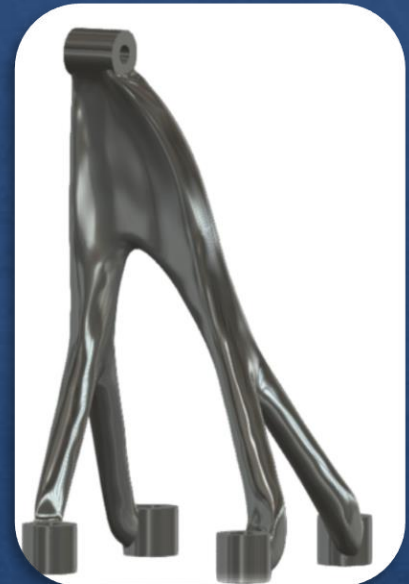
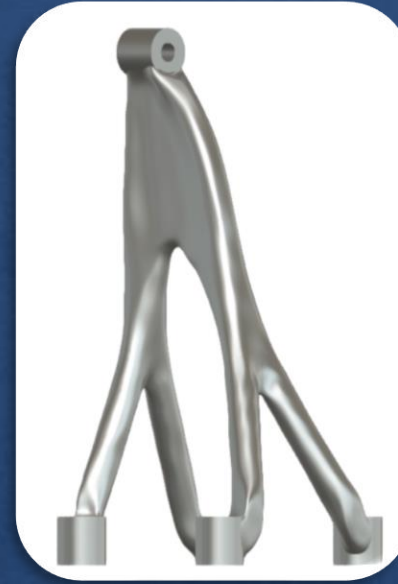


Generative Design – Study 2

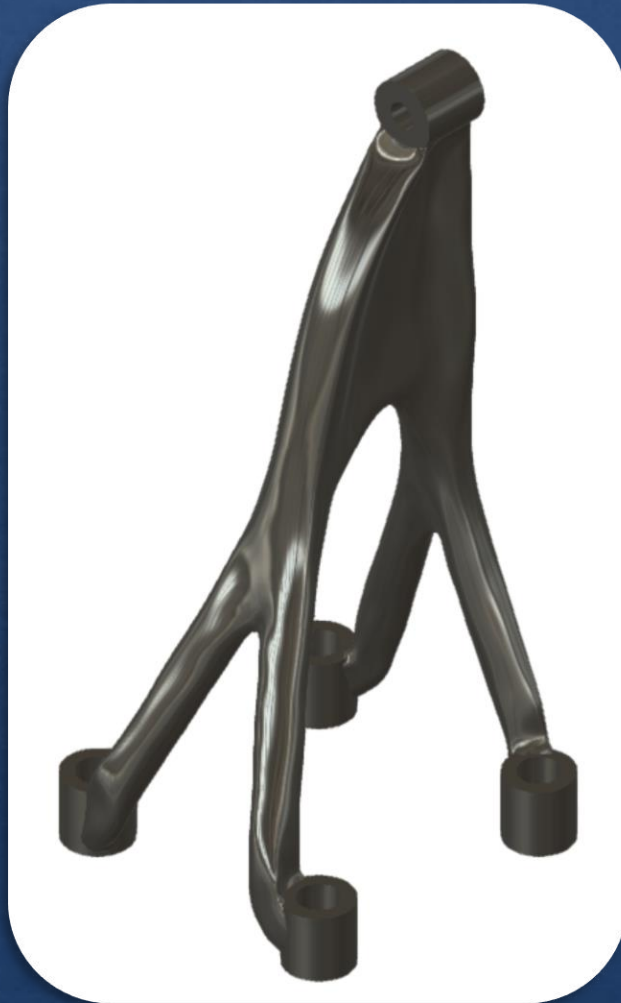
Starting Geometry removed due to error in the construction and generative design was re-launched.



RESULTS



Unrestricted - Titanium



Study 1 - Structur... - Outcome 1 Iteration 36 (final)

Properties

Status	Converged
Generative model	Generative Model 1
Material	Titanium 6Al-4V
Orientation	-
Manufacturing method	Unrestricted
Visual similarity	Ungrouped
Production volume (pcs.)	-
Piece part cost	
Range (USD)	-
Median (USD)	-
Fully burdened cost	
Range (USD)	-
Median (USD)	-
Volume (mm ³)	14,216.274
Mass (kg)	0.063
Max von Mises stress (MPa)	73.625
Factor of safety limit	2
Min factor of safety	11.987
Max displacement global (mm)	0.16

Additive – Aluminium AlSi10Mg



Study 1 - Structur... - Outcome 3 Iteration 36 (final)

Properties

Status	Converged
Generative model	Generative Model 1
Material	Aluminum AlSi10Mg
Orientation	Z+
Manufacturing method	Additive
Visual similarity	Ungrouped
Production volume (pcs.)	-
Piece part cost	
Range (USD)	-
Median (USD)	-
Fully burdened cost	
Range (USD)	-
Median (USD)	-
Volume (mm ³)	14,315.879
Mass (kg)	0.038
Max von Mises stress (MPa)	74.629
Factor of safety limit	2
Min factor of safety	3.216
Max displacement global (mm)	0.265

Additive – Cobalt Chrome



Study 1 - Structur... - Outcome 2 Iteration 36 (final)

Properties

Status	Converged
Generative model	Generative Model 1
Material	Cobalt Chrome
Orientation	Z+
Manufacturing method	Additive
Visual similarity	Ungrouped
Production volume (pcs.)	-
Piece part cost	-
Range (USD)	-
Median (USD)	-
Fully burdened cost	-
Range (USD)	-
Median (USD)	-
Volume (mm ³)	14,312.795
Mass (kg)	0.119
Max von Mises stress (MPa)	74.665
Factor of safety limit	2
Min factor of safety	7.848
Max displacement global (mm)	0.094

Additive – Nylon 12



Study 1 - Structur... - Outcome 5 Iteration 36 (final)

Properties

Status	Converged
Generative model	Generative Model 1
Mat...	Nylon 12 (with Formlabs Fuse 1 3D Pri...
Orientation	Z+
Manufacturing method	Additive
Visual similarity	Ungrouped
Production volume (pcs.)	-
Piece part cost	
Range (USD)	-
Median (USD)	-
Fully burdened cost	
Range (USD)	-
Median (USD)	-
Volume (mm ³)	74,995.163
Mass (kg)	0.076
Max von Mises stress (MPa)	23
Factor of safety limit	2
Min factor of safety	2
Max displacement global (mm)	1.836

SUMMARY

Questions

References

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