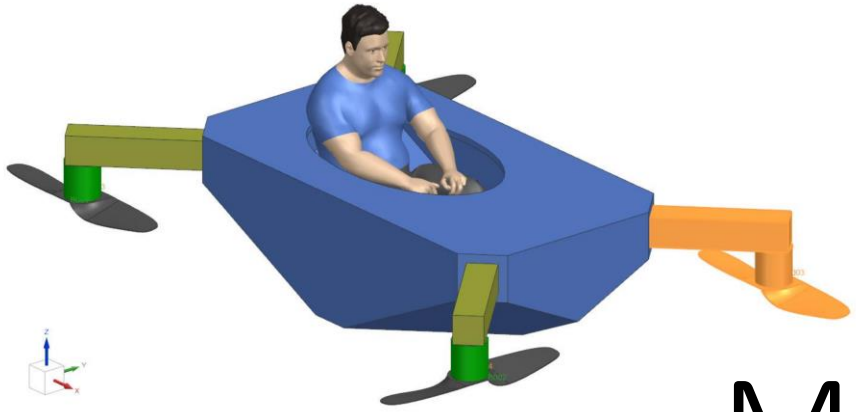
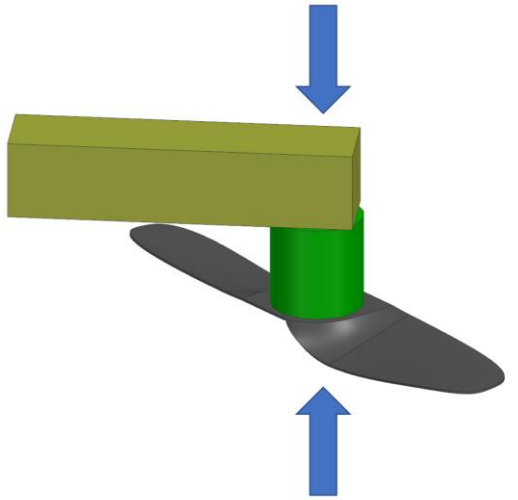




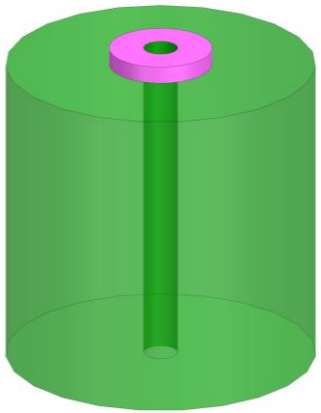
ME 204 Project 4
Design Optimization

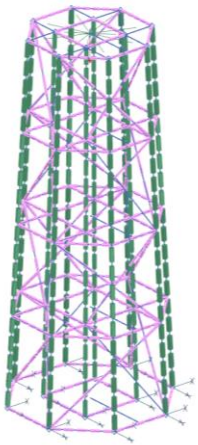
Team #1

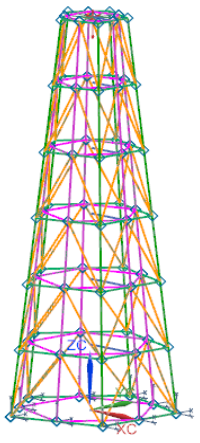
Team name: RHL

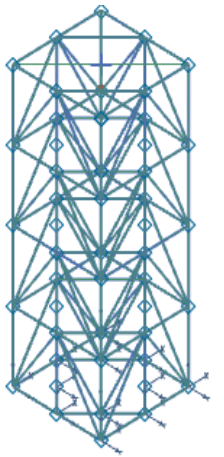
Humfrey Kimanya, Linh Vu, Rafael Luna

11/27/2022









Mechanical Engineering
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Design Problem and Objectives

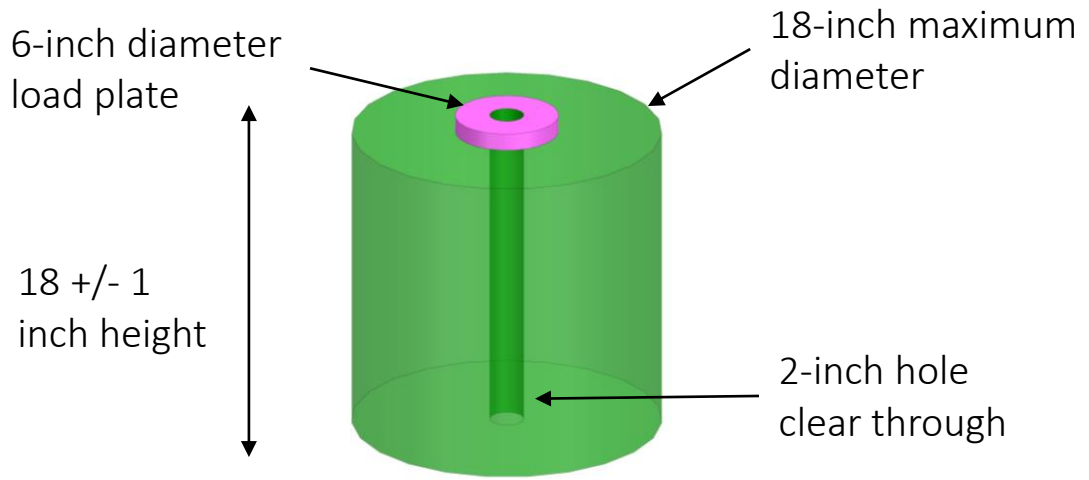
- Design a balsa structure to support a limb in a human vehicle. The design should follow the given space envelope to support a specific load. A Nastran analysis is followed to predict the weight, ultimate load, and failure mode of the structure. Lastly, the structure will be manufactured using the provided materials and tested for failure.
- The project goal is to design for the maximum strength/weight (S/W) ratio.

Requirements

- Design requirements
  - Stay within the space envelope.
  - Touch the support only where allowed.
  - Lamination/overlapping of joints is unlimited.
- Analysis requirements
  - Use the given materials and cross-sectional properties.
  - Provide analysis of S/W = minimum failure load/weight.
- Test requirements
  - Manufactured structure will be weighted and loaded to failure.
  - Actual S/W will be compared to the theoretical one.

Specifications

- Design specifications
  - Total weight of the structure ≤ 0.15 $lb_{f.}$
  - 10 lb_f ≤ applied load ≤ 250 $lb_{f.}$
  - Space envelope is given below.
- Analysis specifications
  - If predicted failure load ≥ 250 $lb_{f,}$ S/W = 250/W.
- Test specifications
  - If actual failure load ≥ 250 $lb_{f,}$ S/W = 250/W.



Design 1
Humfrey Kimanya
Project 4
PDR
11/25/2022

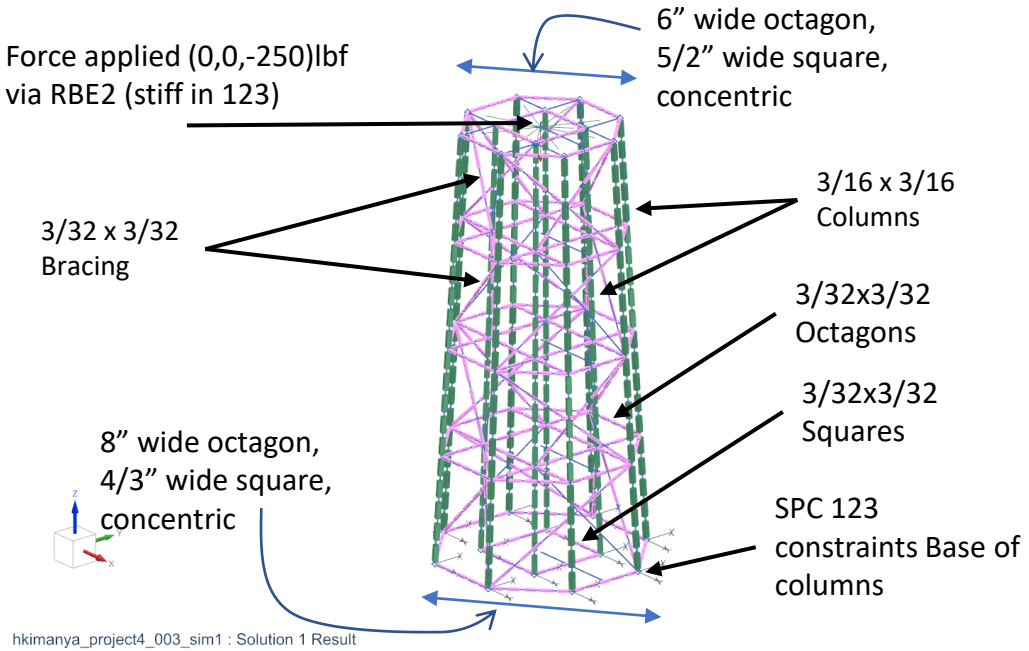
P_{APP}	1	lbf
S_{ULT}	1000	psi
G	386.6	in/s^2

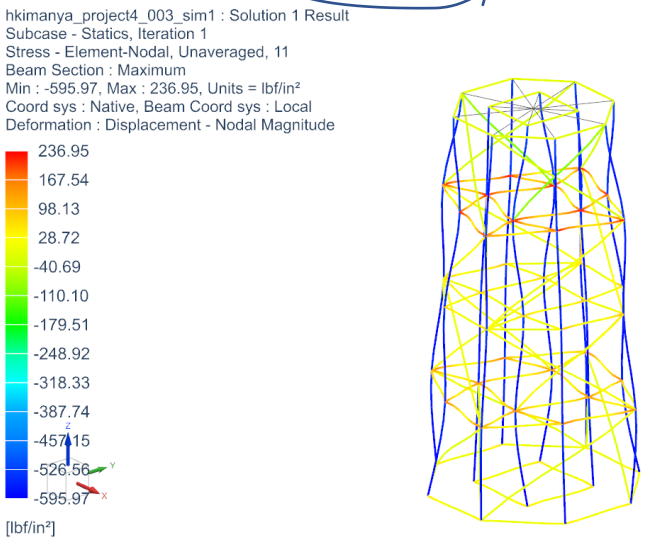
	Smax	Smin	Lambda	Mass	|Smax|	P_{ULT}	P_{CR}	P*	safety	W	S/W
	psi	psi		$lbf\text{-}s^2/in$	psi	lbf	lbf	lbf	safe/fails	lbf	
Design 1 (hkimanya)	2.37E+02	-6.75E+02	1.53E+00	1.84E-04	674.68	370.55	382.00	370.55	safe	7.13E-02	3505.89

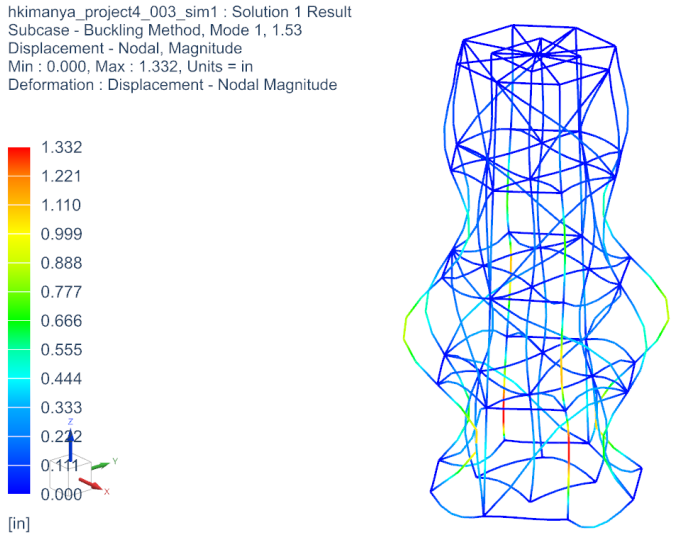
Computed Strength to Weight (S/W) is 3505.89

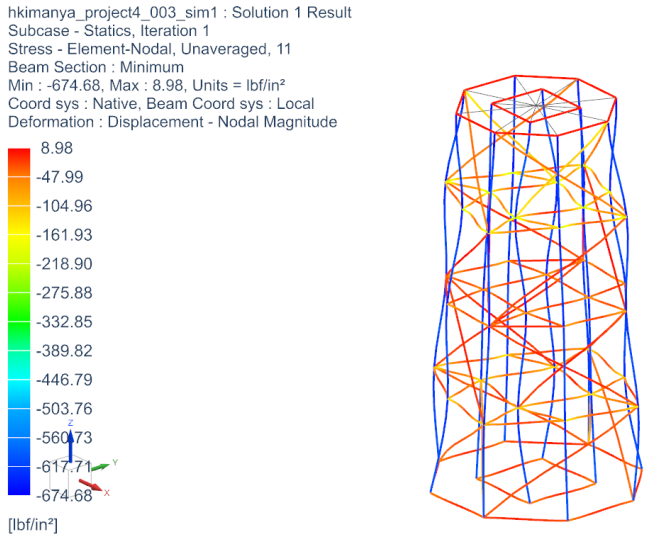
Baseline design contained 3/16x3/16 elements throughout.
Iterations made for selected mesh elements. *See annotated design image*

Material Properties of Balsa
E=0.55e6 psi
G=0.25E6 psi
r=0.0065 lb_m/in^3
S_{ULT}=1000 psi









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Design 2
Linh Vu
Project 4
PDR
11/25/2022

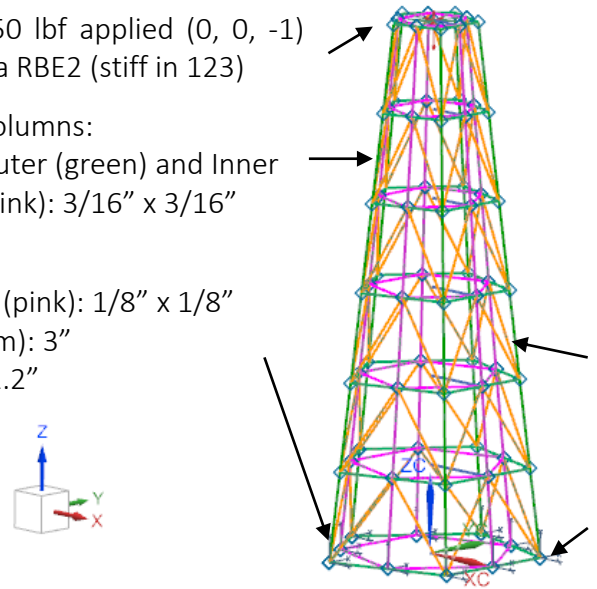
P_{APP}	1	lbf
S_{ULT}	1000	psi
G	386.6	in/s^2

	Smax	Smin	Lambda	Mass	|Smax|	P_{ULT}	P_{CR}	P*	safety	W	S/W
	psi	psi		$lbf\text{-}s^2/in$	psi	lbf	lbf	lbf	safe/fails	lbf	
Design 2 (lvu4)	4.22E+02	-8.33E+02	2.71E+00	1.89E-04	832.68	300.24	677.50	300.24	safe	7.29E-02	3428.40

250 lbf applied (0, 0, -1) via RBE2 (stiff in 123)

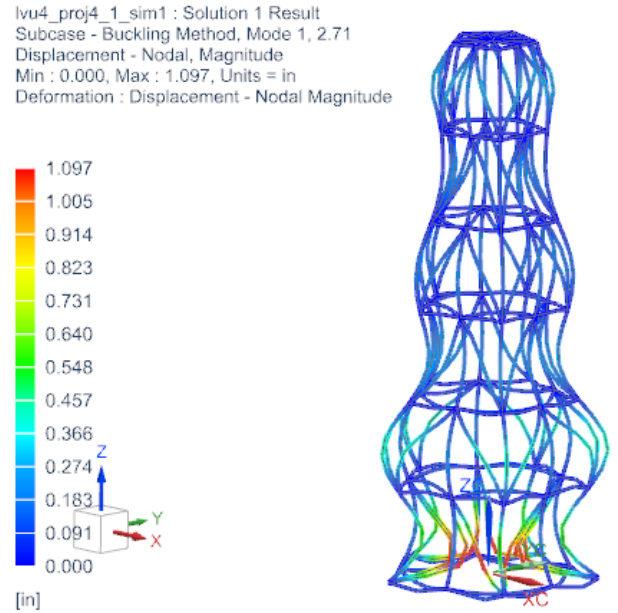
Columns:
Outer (green) and Inner (pink): 3/16” x 3/16”

Pentagon bases:
Outer (green) and Inner (pink): 1/8” x 1/8”
Maximum radius (bottom): 3”
Minimum radius (top): 1.2”



Bracings (orange): 3/32” x 3/32”

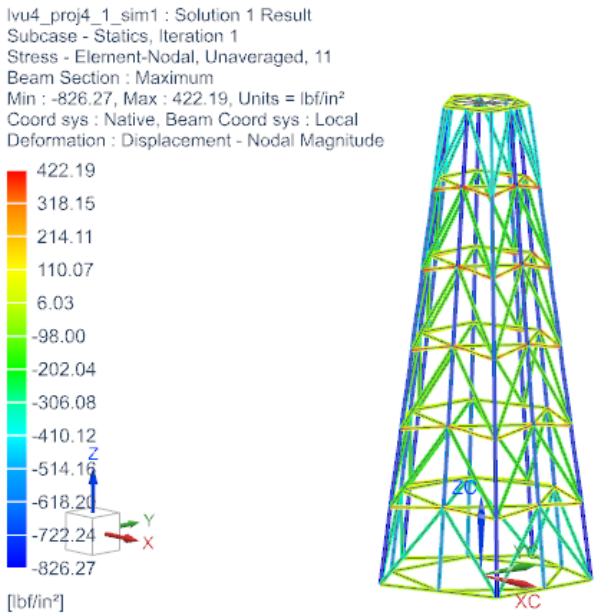
SPC 123 constrains base of columns

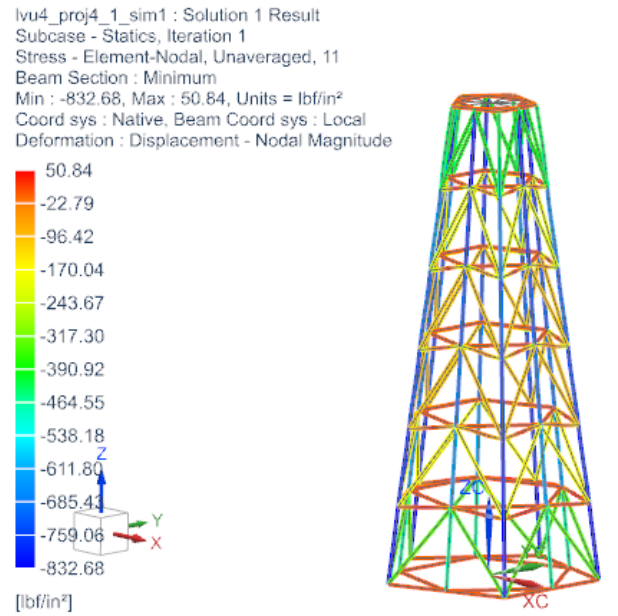


Strength to Weight Ratio: 3428.40

Analysis Type: Structural

Material Properties for Balsa:
E = 0.55E6 psi
G = 0.25E6 psi
ρ = 0.0065 lb_m/in^3
S_{ULT} = 1000 psi





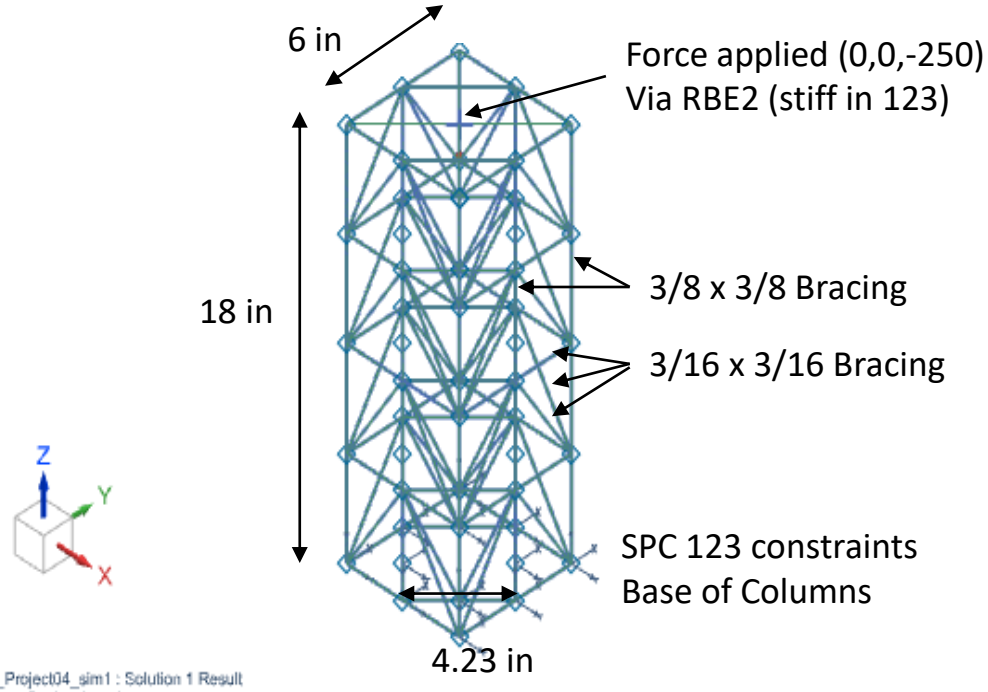
Designed 3
Rafael Luna
Project 4
PDR
11/25/2022

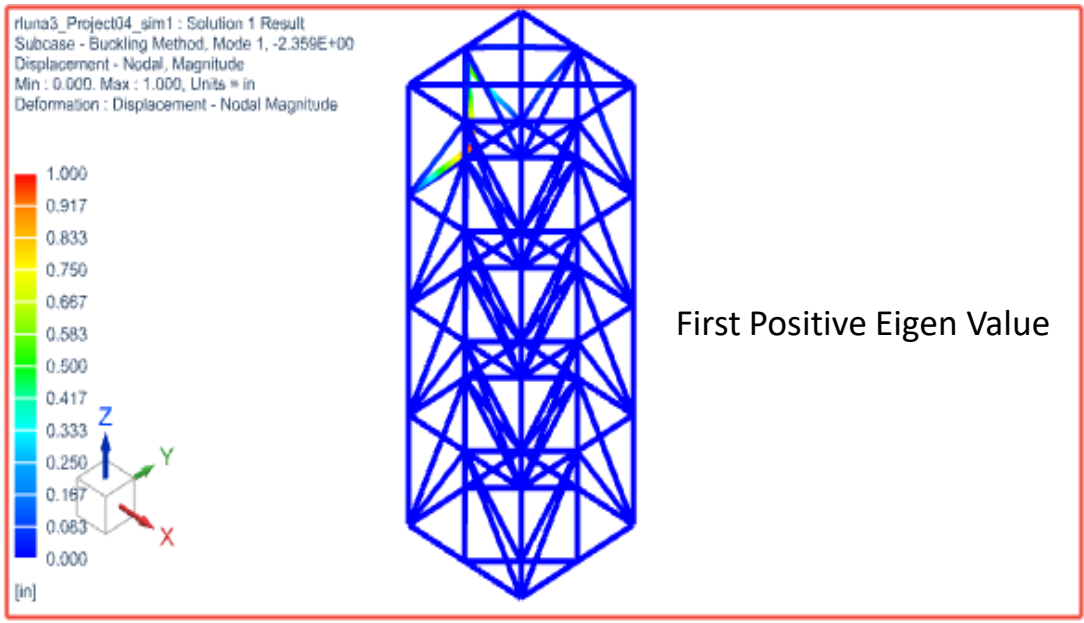
P_{APP}	1	lbf
S_{ULT}	1000	psi
G	386.6	in/s^2

	Smax	Smin	Lambda	Mass	|Smax|	P_{ULT}	P_{CR}	P*	safety	W	S/W
	psi	psi		$lbf\text{-}s^2/in$	psi	lbf	lbf	lbf	safe/fails	lbf	
Design 3 (rluna3)	4.32E+02	-4.82E+02	6.97E+00	5.10E-04	481.89	518.79	1743.44	518.79	safe	1.97E-01	1268.41

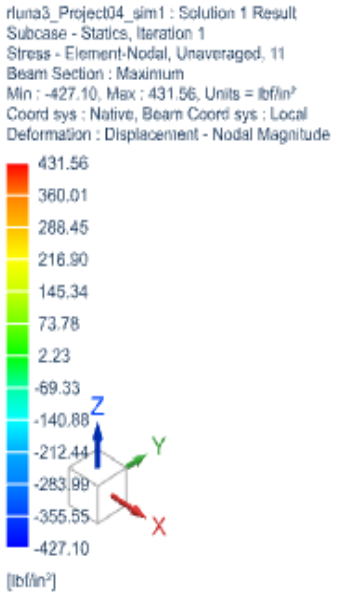
Strength to Weight:
1268.41

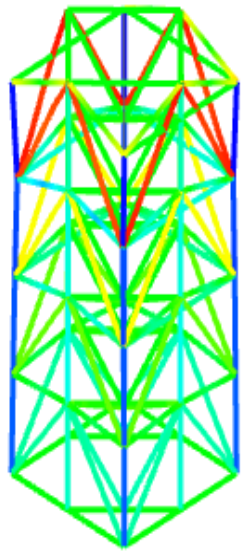
Material Properties:
E=0.55e6 psi
G=0.25E6 psi
r=0.0065 lbm /in3
sULT=1000 psi



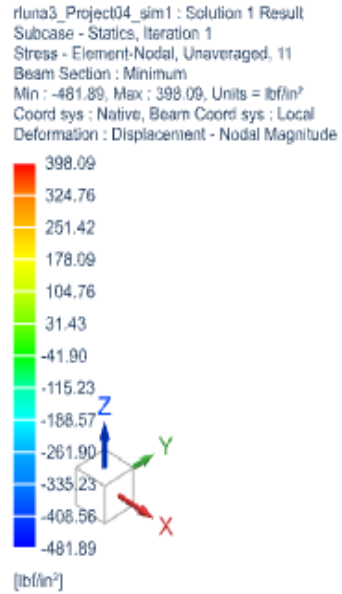


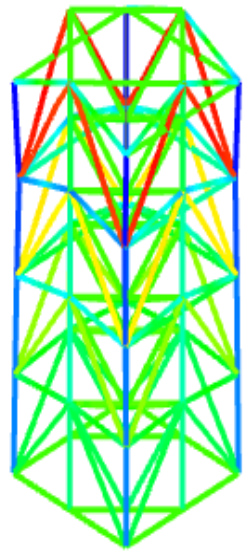
First Positive Eigen Value





Stress Maximum





Stress Minimum

Summary

Team design data

P_{APP}	250	lbf
S_{ULT}	1000	psi
G	386.6	in/s^2

	Smax	Smin	Lambda	Mass	|Smax|	P_{ULT}	P_{CR}	P*	safety	W	S/W
	psi	psi		$lbf\text{-}s^2/in$	psi	lbf	lbf	lbf	safe/fails	lbf	
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Design 3 (rluna3)	4.32E+02	-4.82E+02	6.97E+00	5.10E-04	481.89	518.79	1743.44	518.79	safe	1.97E-01	1268.41

Pugh matrix

Criterion	Design 1	Design 2	Design 3
Ease of Assembly	+	Baseline	+
Robustness		Baseline	
Optimization	+	Baseline	-
Current S/W value	+	Baseline	-
Total	+3	Baseline	-1

Team direction

Currently, Design 1 has the highest S/W value, but Design 3 is easier to assemble. Both Design 2 and 3 have high chances of being optimized. Before deciding our final design, we will optimize Design 2 and 3.