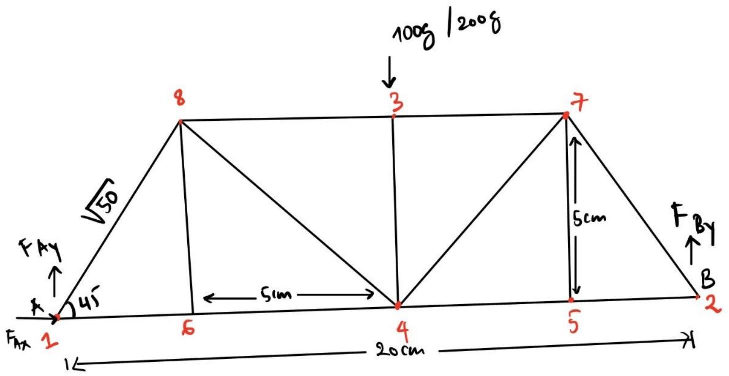
Andrew Rauscher and Jean Pascal Cyusa Shyaka

Truss

Part 1: Designing the truss and finding Support Reactions

a.) Choice: Hip truss

b.) R =3; N = 13; M = 8; 2M = R + N; 16 = 13 + 3; It is statistically determinate



Support Reactions (100 g loading)

$\overset{+}{\rightarrow}\ \Sigma F_x = 0 \qquad F_{Ax} = 0$

$+\uparrow\ \Sigma F_y = 0 \qquad F_{Ay} + F_{By} - 0.981 = 0$

$+\circlearrowleft\ \Sigma M_A = (10\text{cm})(0.981\text{ N}) - (20\text{cm}) F_{By} = 0$

$F_{By} = 0.4905\text{ N}$

Support Reactions (200g loading)

$\overset{+}{\rightarrow}\ \Sigma F_x = 0 \qquad F_{Ax} = 0$

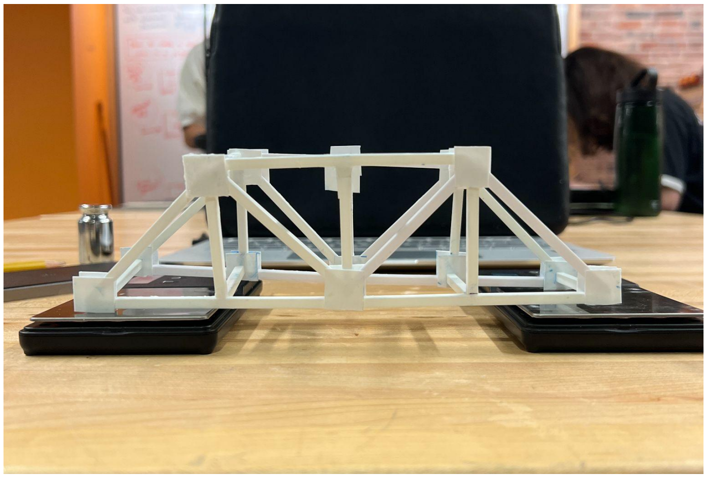
$+\uparrow\ \Sigma F_y = 0 \qquad F_{Ay} + F_{By} - 1.962 = 0$

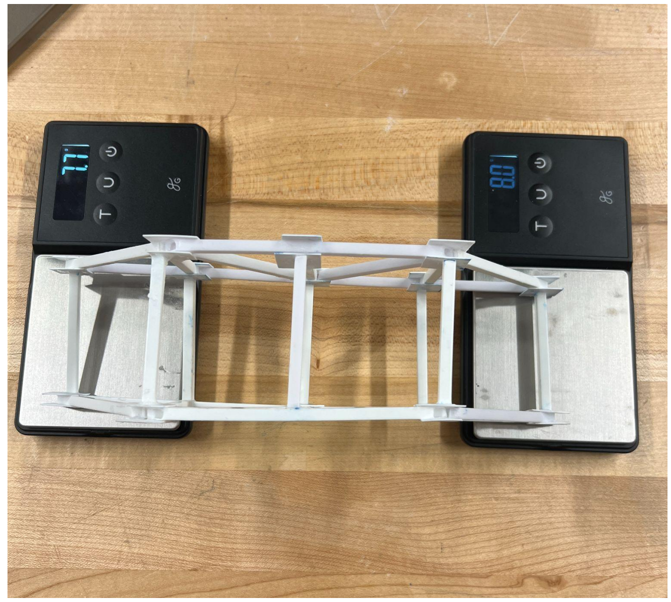
$+\circlearrowleft\ \Sigma M_A = (10\text{cm})(1.962\text{ N}) - (20\text{cm}) F_{By} = 0$

$F_{By} = 0.981\text{ N}$

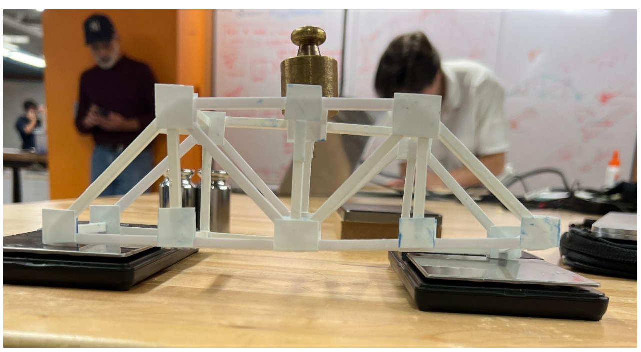
Part 2: Build the Truss and Find Support Reactions

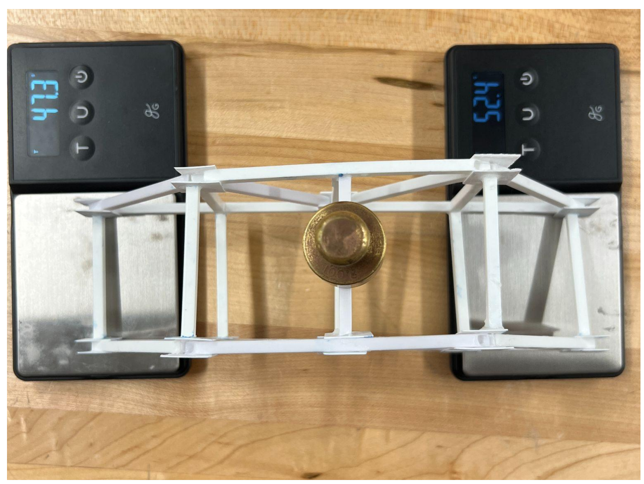
Unloaded:





100g loading:





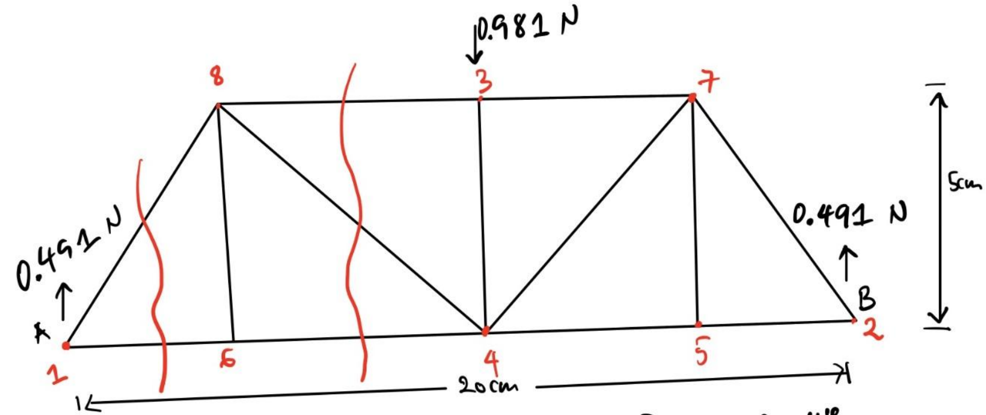
Left Scale: 47.3g
(47.3g * 9.81m/s^2) = 464.013N
Error: (490.5N - 464.013N)/490.5N = 0.054 or 5.4% error
Right Scale: 52.4g
(52.4g * 9.81m/s^2) = 514.044N
Error: (490.5N - 514.044N)/490.5N = -0.048 or -4.8% error

<u>200g loading:</u>

Left Scale: 94.0g
(94.0N * 9.81m/s^2) = 922.14N
Error: (981N - 922.14N)/981N = 0.06 or 6% error
Right Scale: 106.3g
(106.3N * 9.81m/s^2) = 1042.803N
Error: (981N - 1042.803N)/981N = -0.063 or -6.3% error

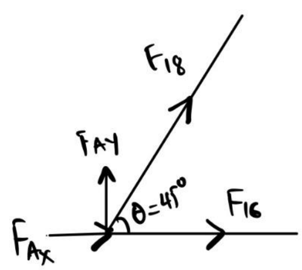
Part 3: Calculate the Members' Internal Loads (theoretical Calculations)

*** For the 100g**



To find force members F_{16}, F_{18} we use

Method of sections.



$\xrightarrow{+} \sum F_x = 0 \quad F_{16} + F_{AX} + F_{18}\cos 45^\circ = 0$

$F_{16} = -F_{18}\cos 45^\circ$

$+\uparrow \sum F_y = 0 \quad F_{Ay} + F_{18}\sin 45 = 0$

$F_{18} = -693.7N \Rightarrow \boxed{F_{18} = 0.694 \text{ N (C)}}$

$F_{Ay} = 0.491$ N

$F_{AX} = 0$ N

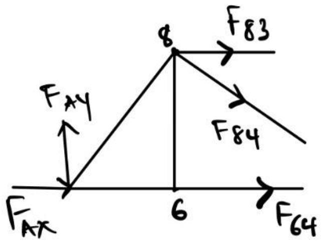
So $\boxed{F_{16} = 0.491 \text{ N (T)}}$

Because the truss is symmetrical

$F_{18} = F_{27}$ and $F_{16} = F_{25}$

$\boxed{F_{27} = 0.694 \text{ N (C)}}$ and $\boxed{F_{25} = 0.491 \text{ N (C)}}$

Section 2



$\xrightarrow{+} \Sigma F_x = F_{83} + F_{64} + F_{84} \cos 45 = 0$

$+\uparrow \Sigma F_y = F_{AY} - F_{84} \sin 45 = 0$

$\boxed{F_{84} = 0.694 \text{ N} \quad (T)}$

$\circlearrowright + \Sigma M_8 = (0.05 \text{m}) F_{64} - (0.05) F_{AY} = 0$

$\boxed{F_{64} = 0.491 \text{ N} \quad (T)}$

$F_{83} = -F_{64} - F_{84} \cos 45$

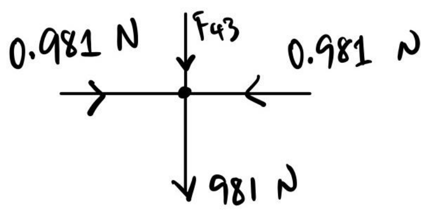
$\boxed{F_{83} = -0.981 \text{ N} \quad (C)}$

The truss is symmetrical, so

$F_{83} = F_{73}$, $F_{84} = F_{74}$, $F_{64} = F_{54}$

* F_{68} and F_{57} are zero force members.

For joint 3.



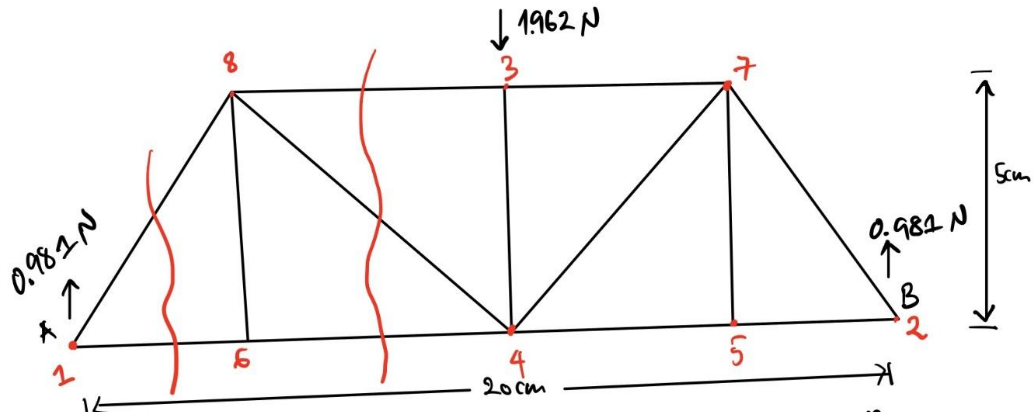
$\overset{+}{\rightarrow} \Sigma F_x = 0$

$+\uparrow \Sigma F_y = -F_{43} - 0.981 = 0$

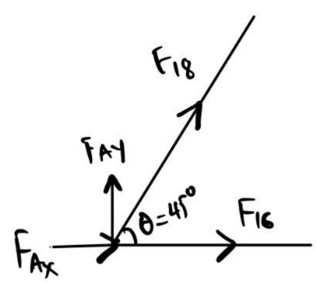
$F_{43} = -0.981\ N$

$\boxed{F_{43} = 0.981\ N\ (T)}$

*** For the 200g**



To find force members F_{16}, F_{18} we use Method of sections.



$\xrightarrow{+} \Sigma F_x = 0 \quad F_{16} + F_{AX} + F_{18}\cos 45^\circ = 0$

$F_{16} = -F_{18}\cos 45^\circ$

$+\uparrow \Sigma F_y = 0 \quad F_{Ay} + F_{18}\sin 45 = 0$

$\boxed{F_{18} = -1.386 \text{ N}}$

$F_{Ay} = 0.981\text{ N}$

$F_{AX} = 0\text{ N}$

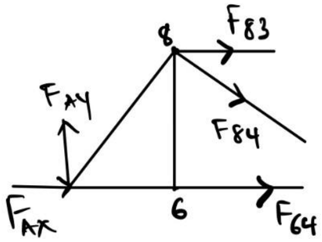
So $\boxed{F_{16} = 0.981\text{ N (T)}}$

Because the truss is symmetrical

$F_{18} = F_{27}$ and $F_{16} = F_{25}$

$\boxed{F_{27} = -1.386 \text{ N (C)}}$ and $\boxed{F_{25} = 0.981\text{ N (T)}}$

Section 2



$\overset{+}{\rightarrow} \Sigma F_x = F_{83} + F_{64} + F_{84} \cos 45 = 0$

$+\uparrow \Sigma F_y = F_{AY} - F_{84} \sin 45 = 0$

$\boxed{F_{84} = 1.386 \quad N\ (T)}$

$\circlearrowright + \Sigma M_8 = (0.05m) F_{64} - (0.05) F_{AY} = 0$

$F_{64} = 0.981 N\ (T)$

$F_{83} = -F_{64} - F_{84} \cos 45$

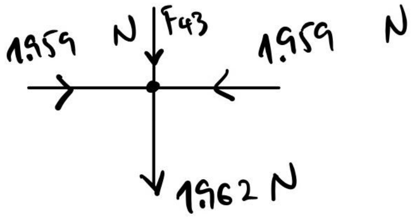
$\boxed{F_{83} = -1.959 \quad N\ (C)}$

The truss is symmetrical, so

$F_{83} = F_{73}$, $F_{84} = F_{74}$, $F_{64} = F_{54}$

* F_{68} and F_{57} are zero force members.

For joint 3.



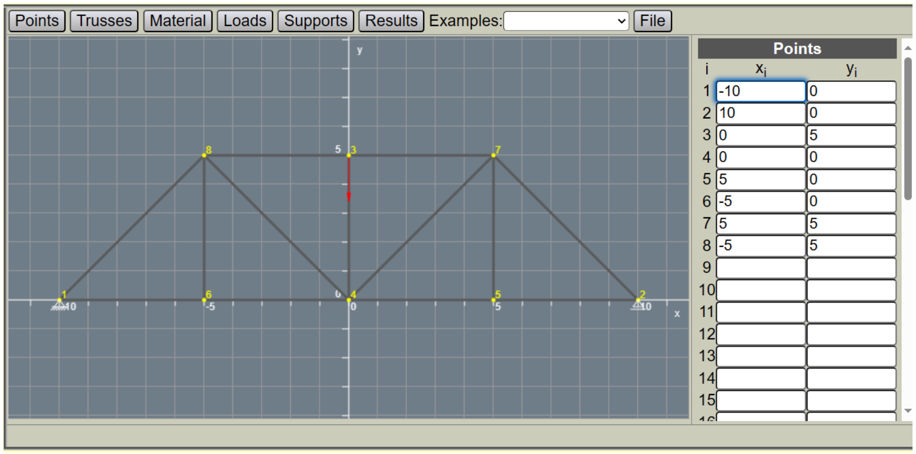
$\overset{+}{\rightarrow} \Sigma F_x = 1959.9 - 1959.9 = 0$

$+\uparrow \Sigma F_y = -F_{43} - 1962 = 0$

$F_{43} = -1.962$ (T)

$\boxed{F_{43} = 1.962 \quad (T)}$

Part 4: Check Your Answers with an Online Calculator



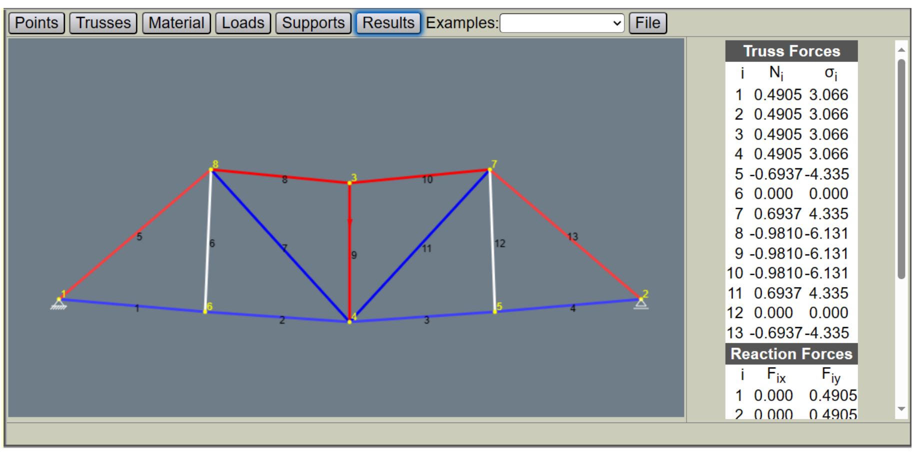


Figure above: Model of truss from online calculator (loading 1)

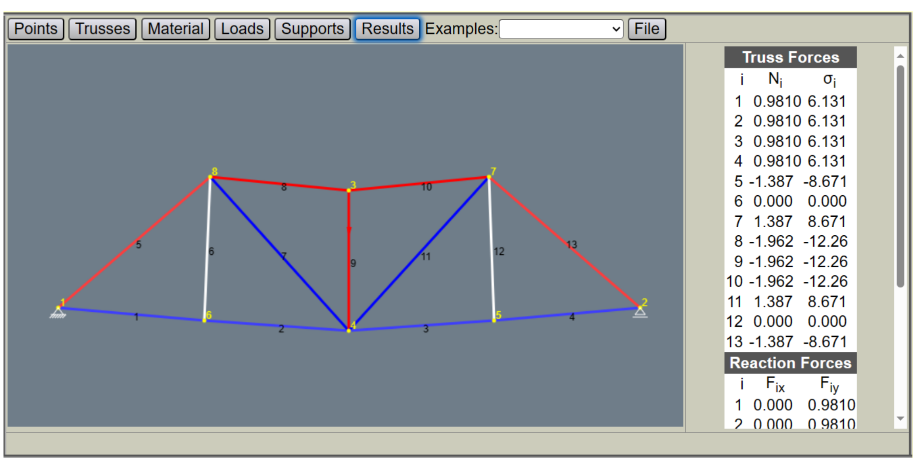
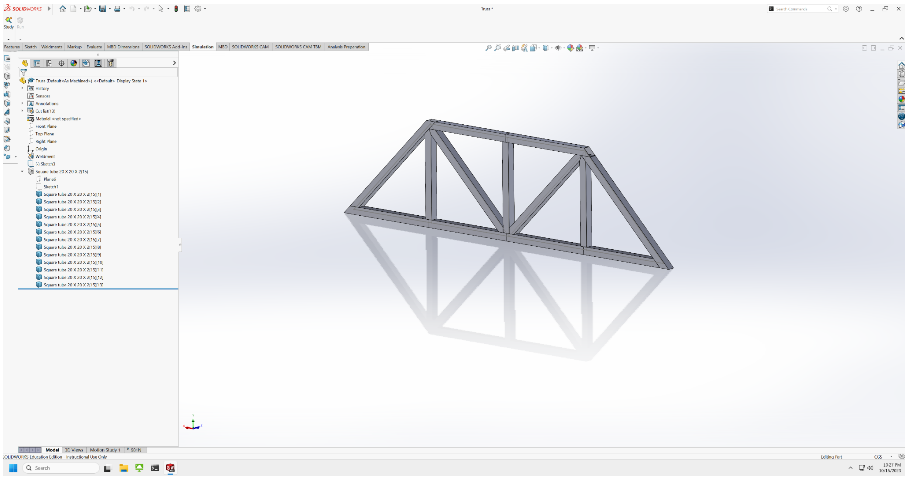
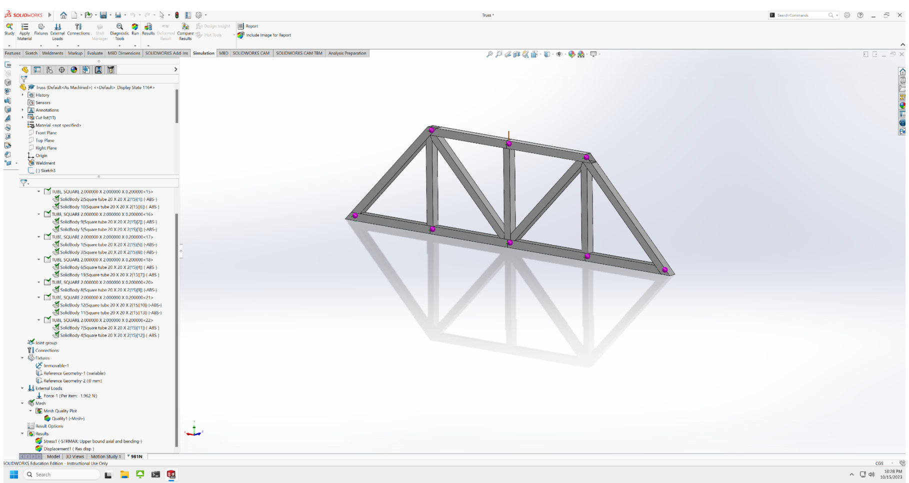


Figure above: Model of truss from online calculator (loading 2)

Part 5: Finite Element Analysis (FEA)

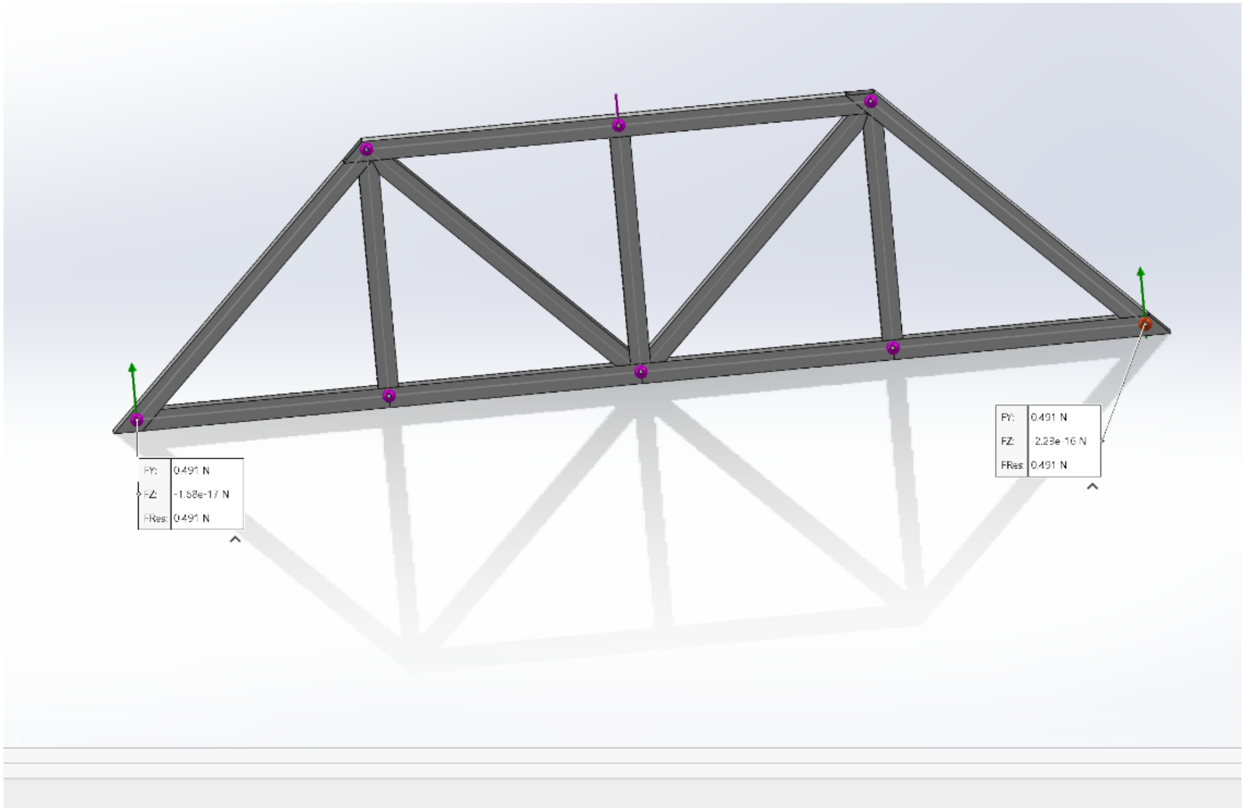


3D model of truss in Solidworks

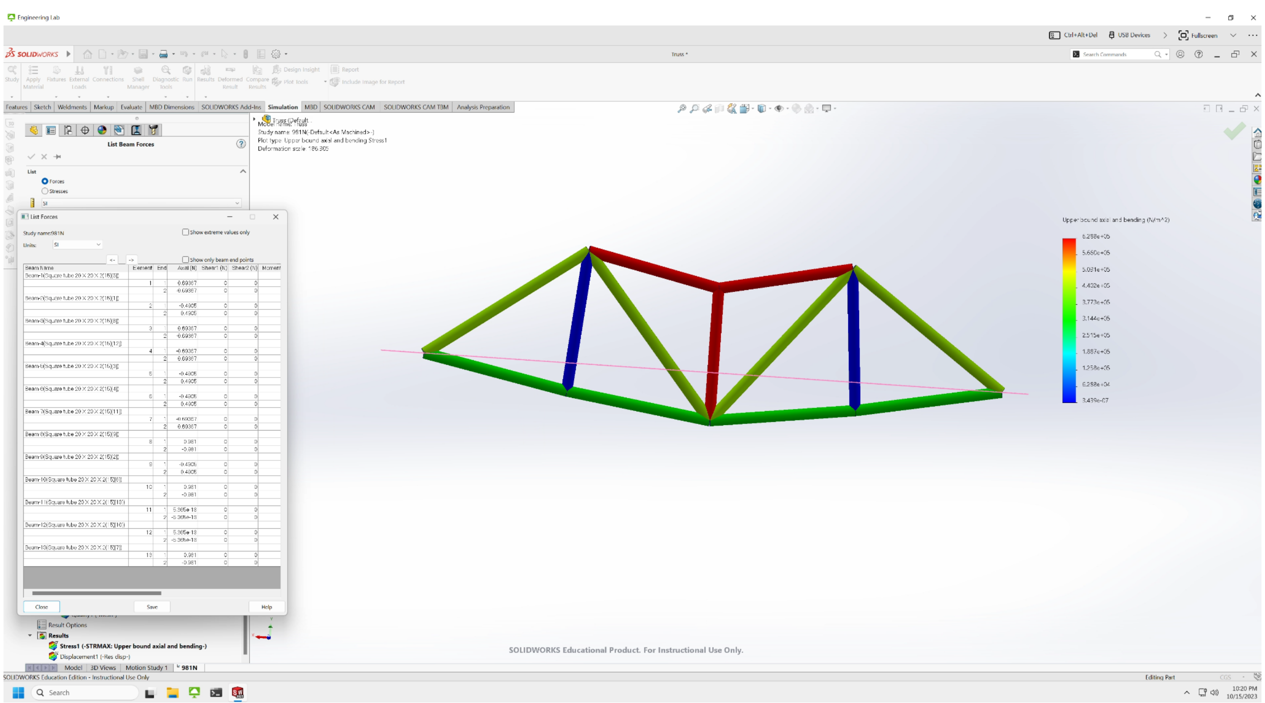


3D model of truss in Solidworks
With joints

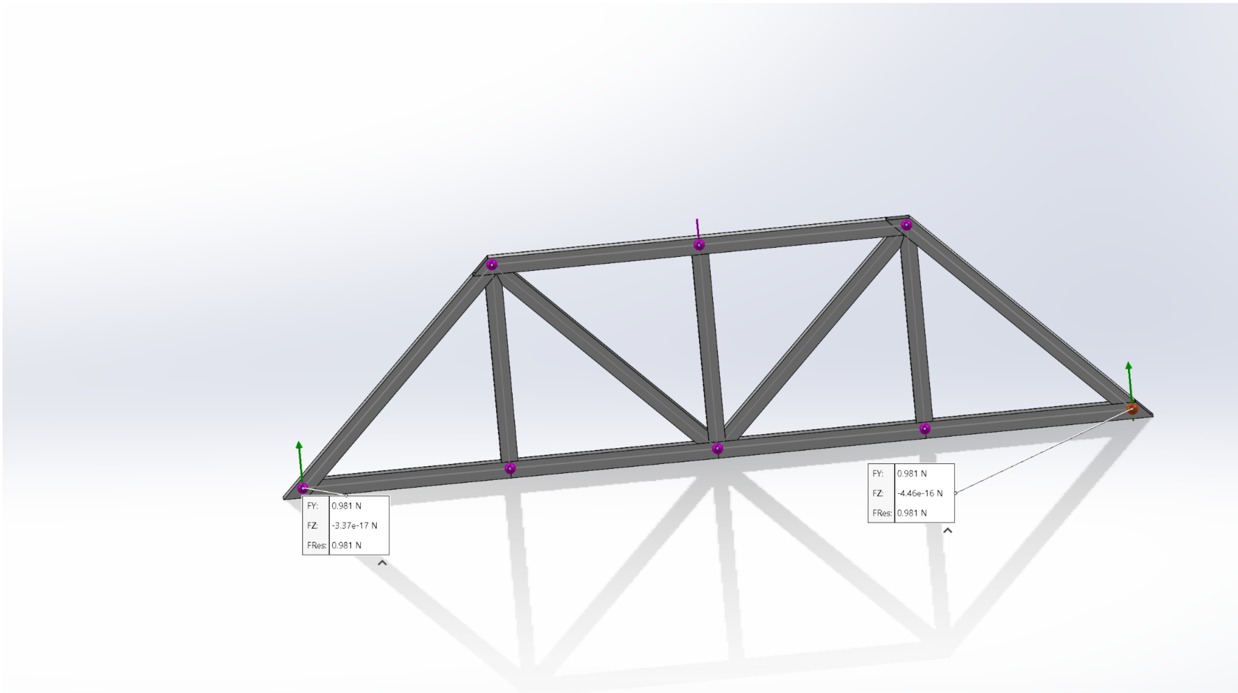
Loading 1 (100g)



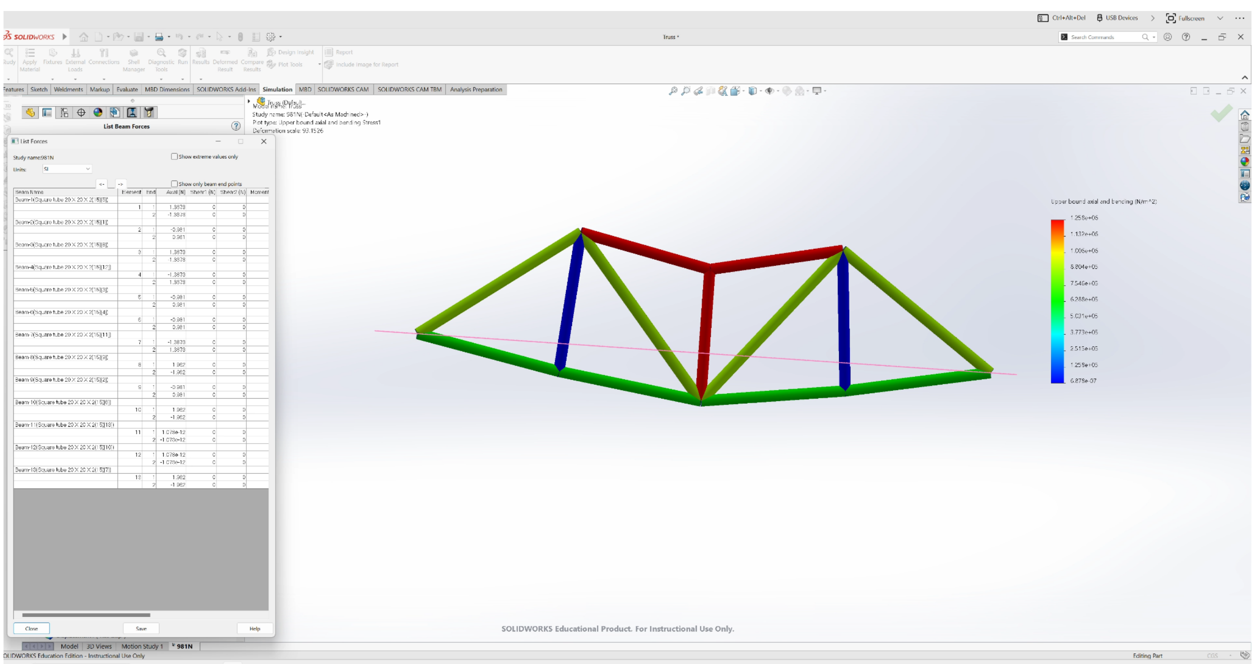
Above: support reactions in Solidworks Below: Member forces in Solidworks



Loading 2: (200g)



Above: support reactions in Solidworks Below: Member forces in Solidworks



Conclusion:

Altogether we were able to effectively calculate and compile data for our custom Hip Truss. We collected data for two separate loading scenarios, one in which 100 grams were placed on the middle joint, and another where 200 grams were placed on the middle joint. We measured the support reactions and internal member forces with three separate methods and then compared our results with error calculations into an excel file. The methods we used included, calculating by hand using the section and joint methods, using an online calculator to simulate our truss, and using Solidworks to accurately recreate and test our truss with FEA. As is reflected in our data, we were able to do all of these calculations with reasonable accuracy with a majority of the error for our math being negligible. However, we also calculated the support reactions via a fourth method, experimental testing, and in this case we were still reasonably close to our idealized model with all errors under 7%. We attribute this error to our own error when we were constructing our truss.

From this project we learned how to use a number of predictive tools including FEA and 2-D Truss analysis. In addition we learned a number of new skills and uses for Solidworks including weldments and simulations. Naturally, the project also provided extra practice with support reactions and internal forces