ME478 – Project 4
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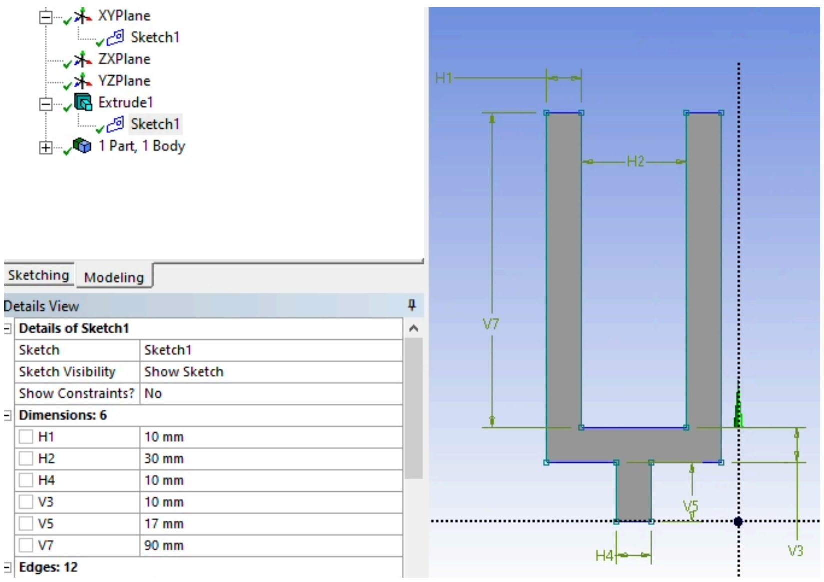
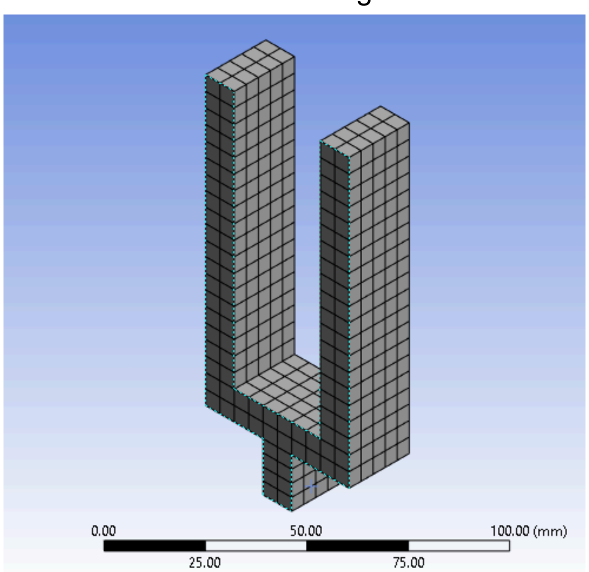
1) Design a functional tuning fork for the tone A above middle C (A4, 440Hz). Use any material and geometry that you think is appropriate. Determine the first six natural frequencies and mode shapes.

A Structural Steel tuning fork was created using the cross-sectional geometry shown below, with a thickness of 21 mm.



A quadratic mesh with an element size of 5 mm was constructed, and a fixed support placed onto the bottom of the tuning fork.



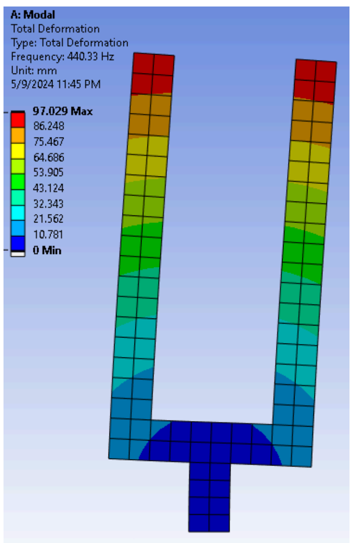
The modal analysis was subsequently performed, yielding a fundamental frequency (mode 1) of 440.33 Hz. The values of the first six natural frequencies are listed below:

Tabular Data

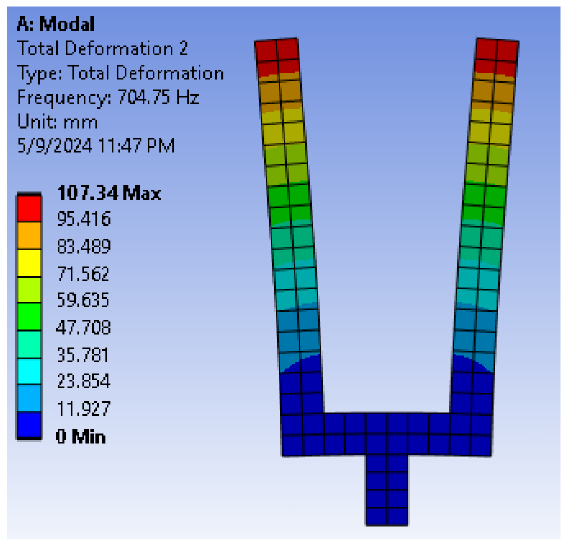
	Mode	Frequency [Hz]
1	1.	440.33
2	2.	704.75
3	3.	821.88
4	4.	1003.2
5	5.	2513.8
6	6.	3082.

The corresponding mode shapes are shown below:

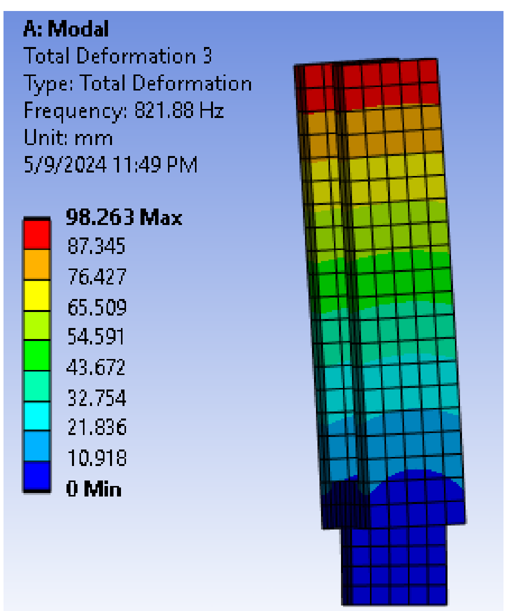
Mode 1:



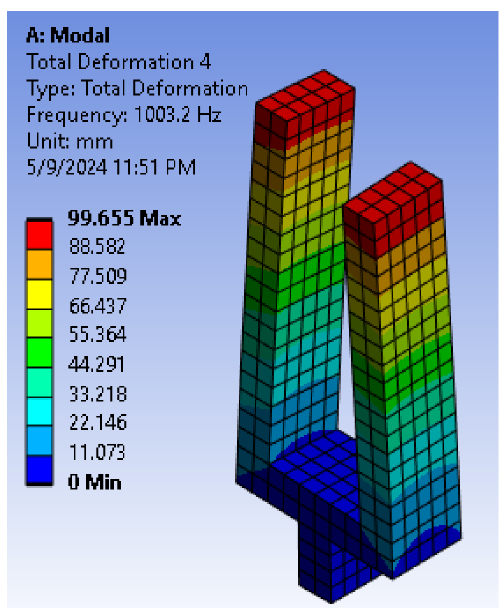
Mode 2:



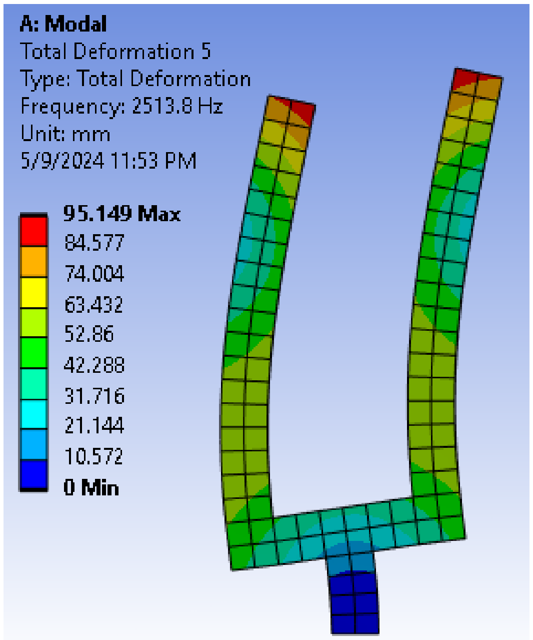
Mode 3:



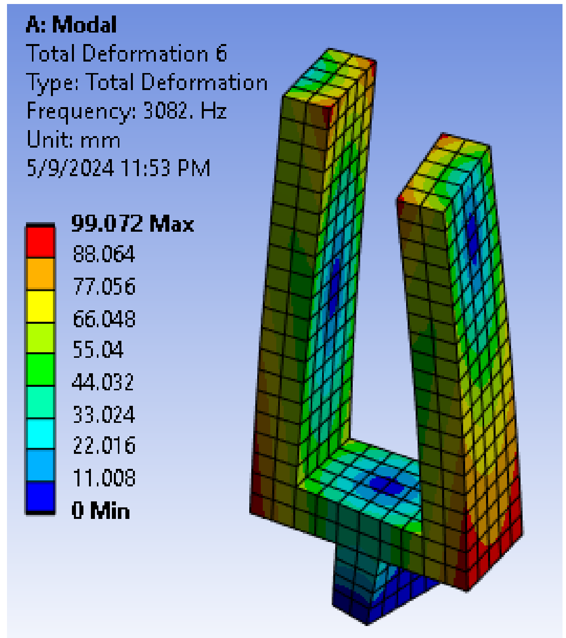
Mode 4:



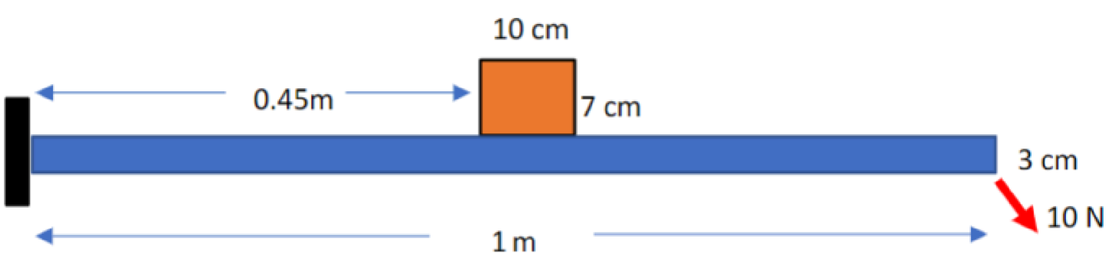
Mode 5:



Mode 6:

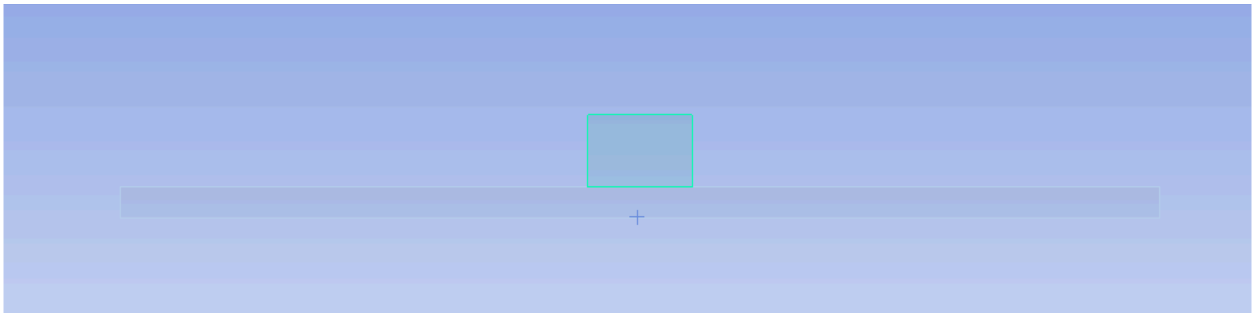


2) Obtain the frequency response of the total displacement right bottom tip of the aluminum beam for 0 to 500Hz. Use plane stress with a dimension into the plane of 5 cm. The orange titanium block is rigidly mounted to the beam and the angle of the force is 45 degrees.

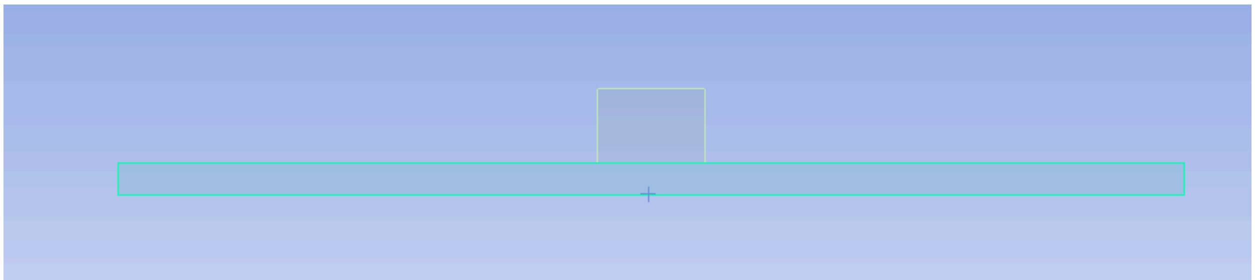


**2D analysis was used

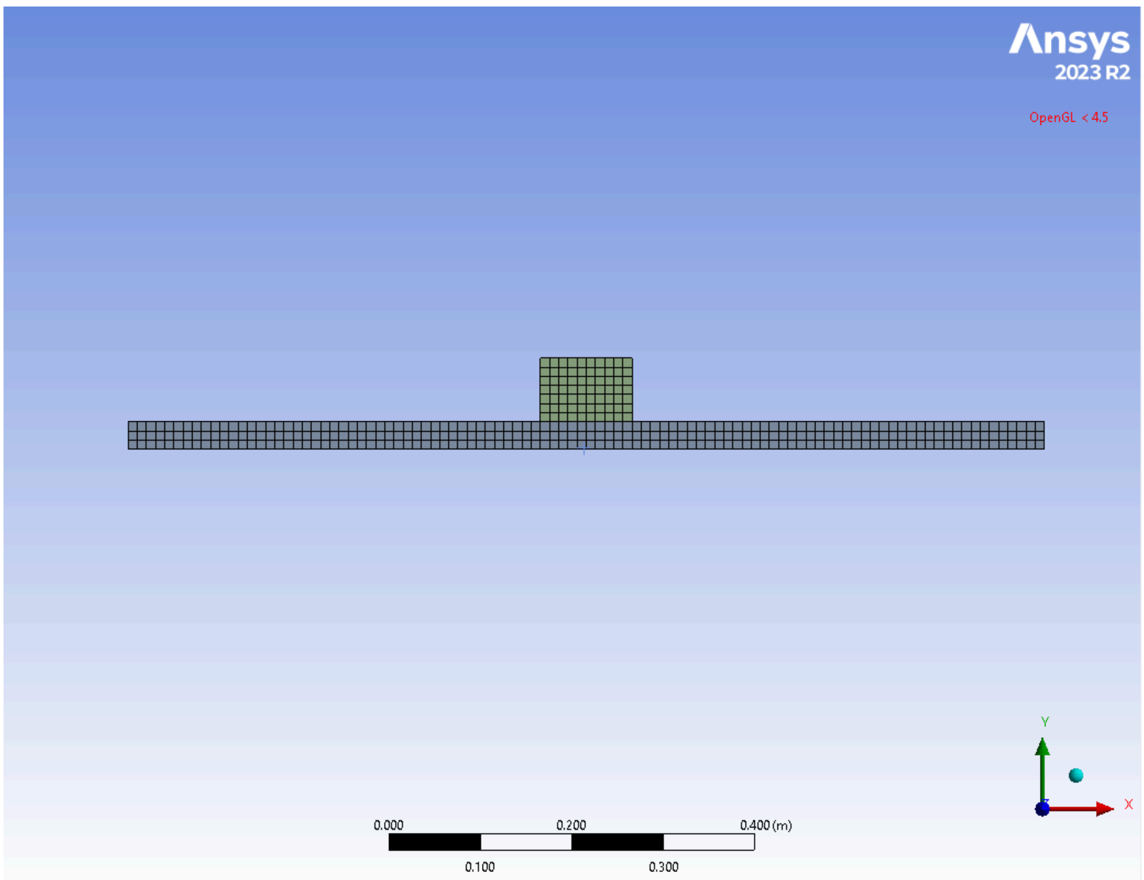
Top block is assigned a material of Titanium using a density of 4540 kg-m^(-3), 116000000000 Pa, and a poisson's ratio of 0.36.



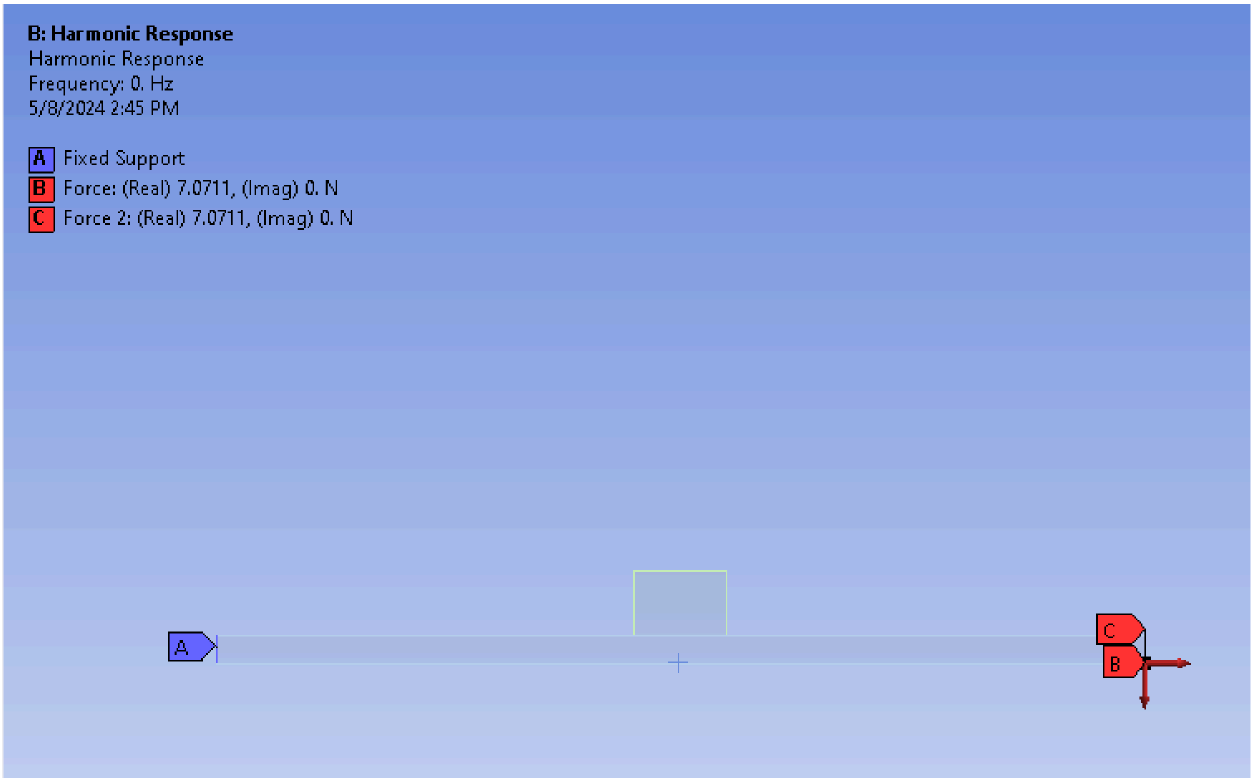
Bottom block is assigned a material of structural steel using the properties in Ansys.



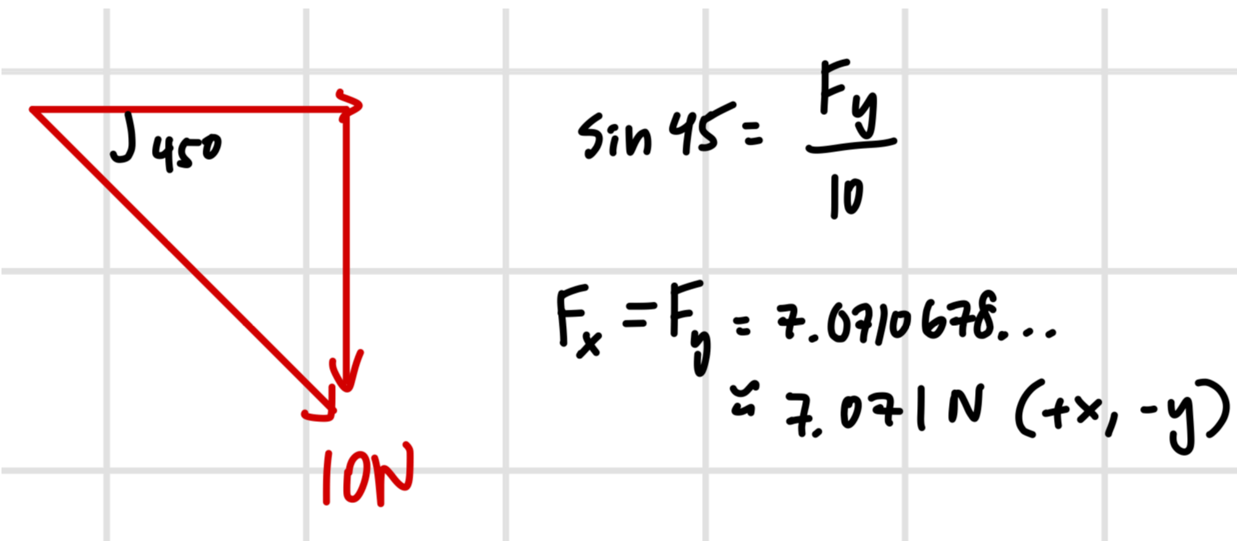
Created mesh with quadratic element and mesh size of .01 m



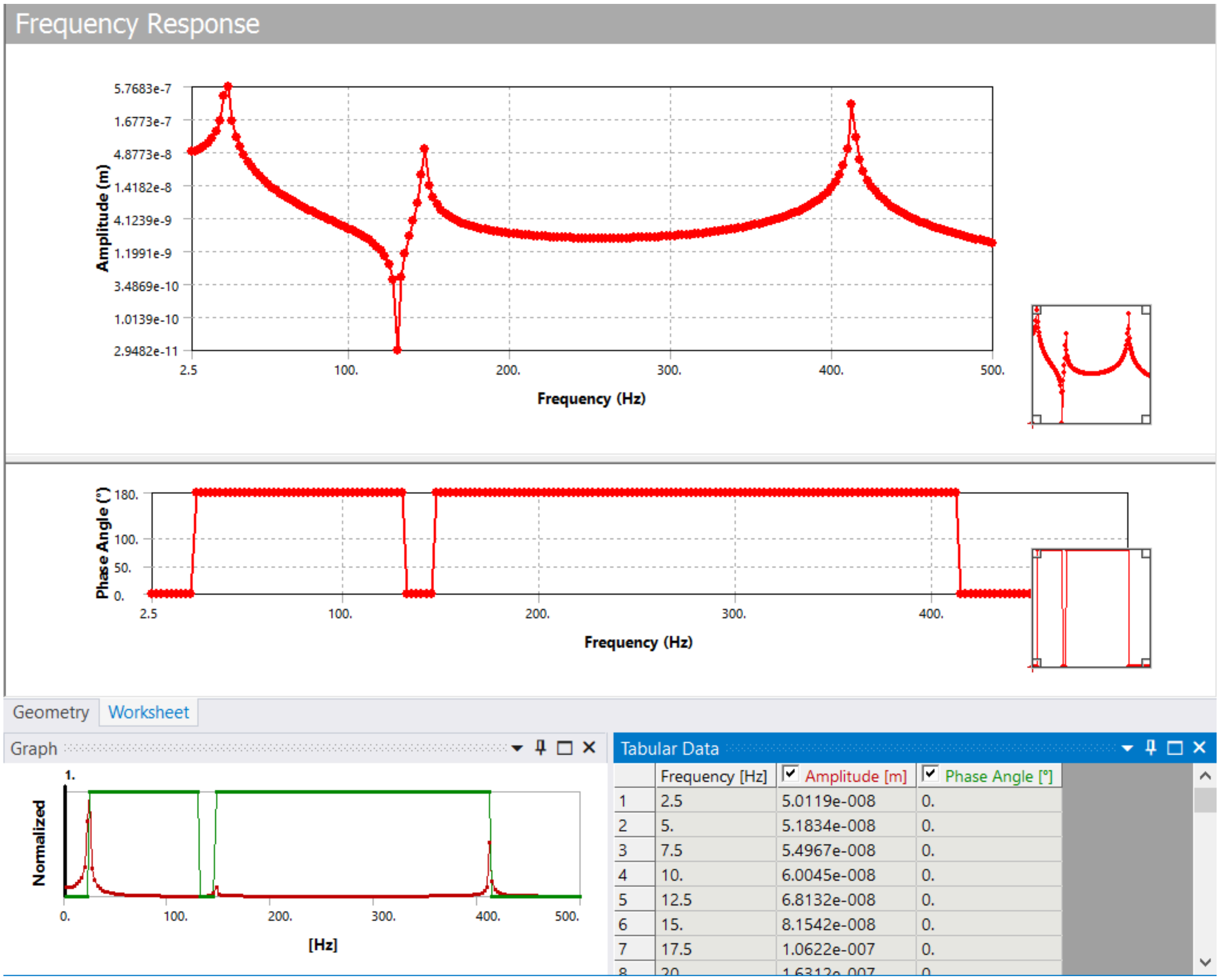
Applied a fixed support on the left edge of the beam, and a force of 10N broken into the x and y components.



The following calculation was done to find the forces in the x and y components:

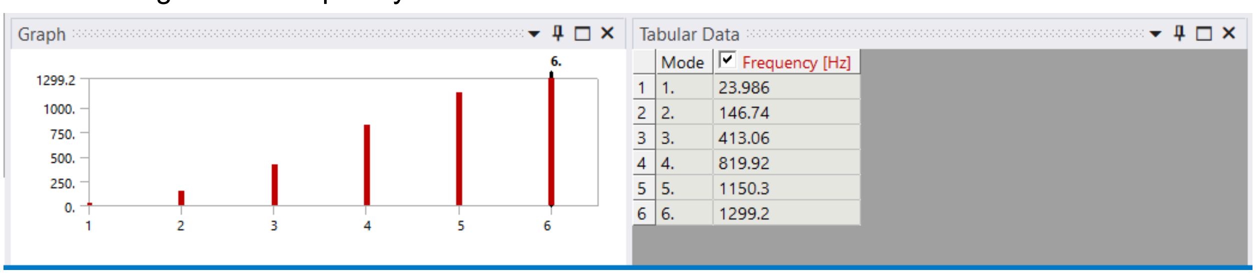


The following frequency response was obtained:



	Frequency [Hz]	Amplitude [m]	Phase Angle [°]
1	2.5	5.0119e-008	0.
2	5.	5.1834e-008	0.
3	7.5	5.4967e-008	0.
4	10.	6.0045e-008	0.
5	12.5	6.8132e-008	0.
6	15.	8.1542e-008	0.
7	17.5	1.0622e-007	0.

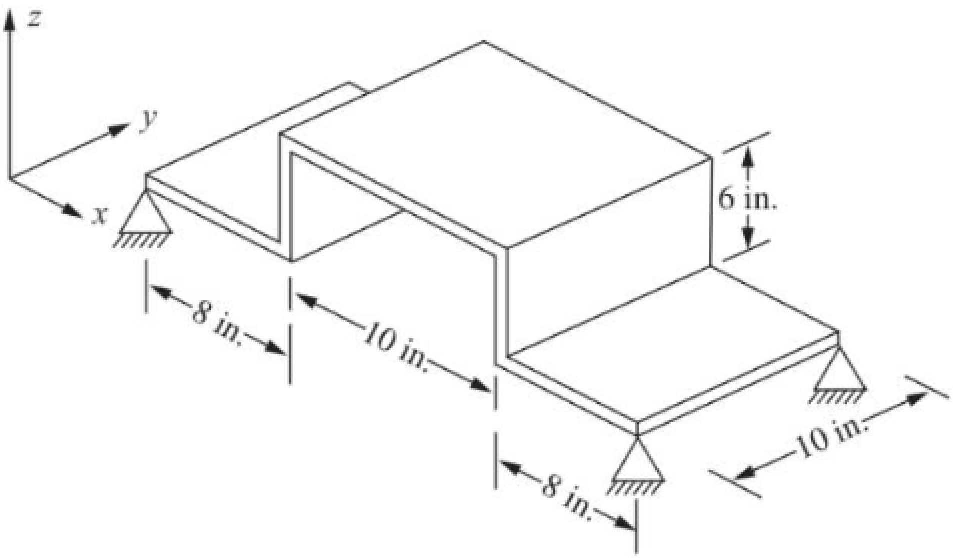
The following natural frequency was obtained:



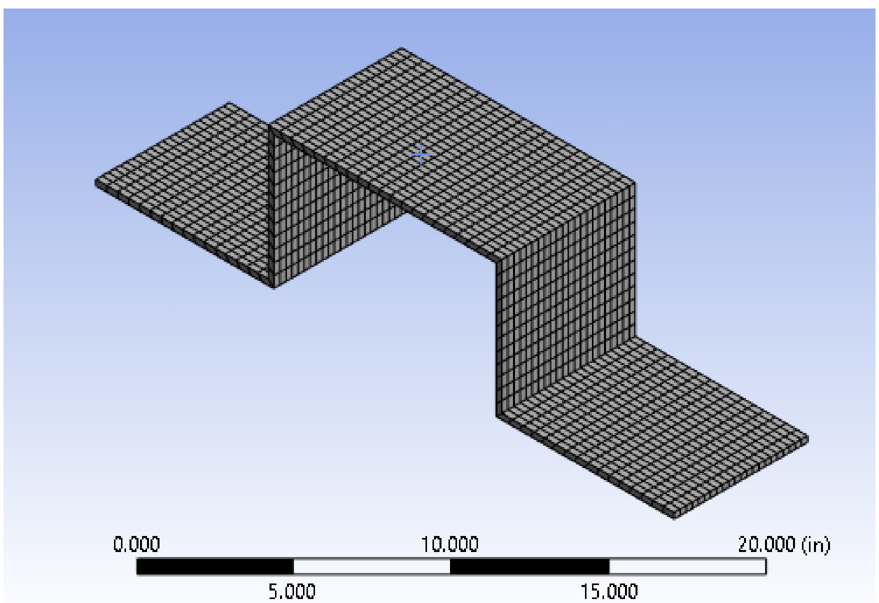
	Mode	Frequency [Hz]
1	1.	23.986
2	2.	146.74
3	3.	413.06
4	4.	819.92
5	5.	1150.3
6	6.	1299.2

3) In Problem 12.6 assume that the uniform pressure is varying sinusoidally. Obtain the frequency response of the vertical displacement of the center of the top plate. The frequency range should include the six lowest natural frequencies.

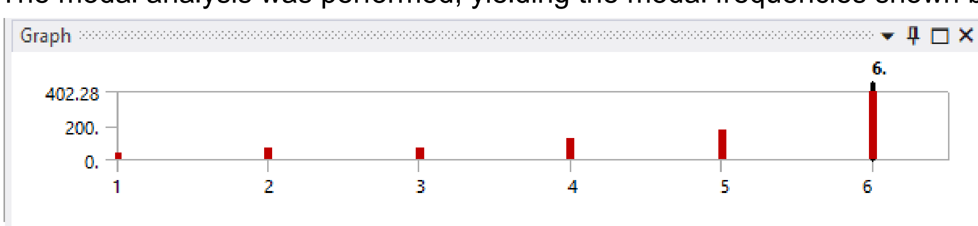
The geometry was created as shown below as a thin object with a uniform thickness of 0.25 in:



Fixed supports were placed on either edge of the object as shown in the diagram above, then a quadratic mesh with an element size of 0.5 in was created.



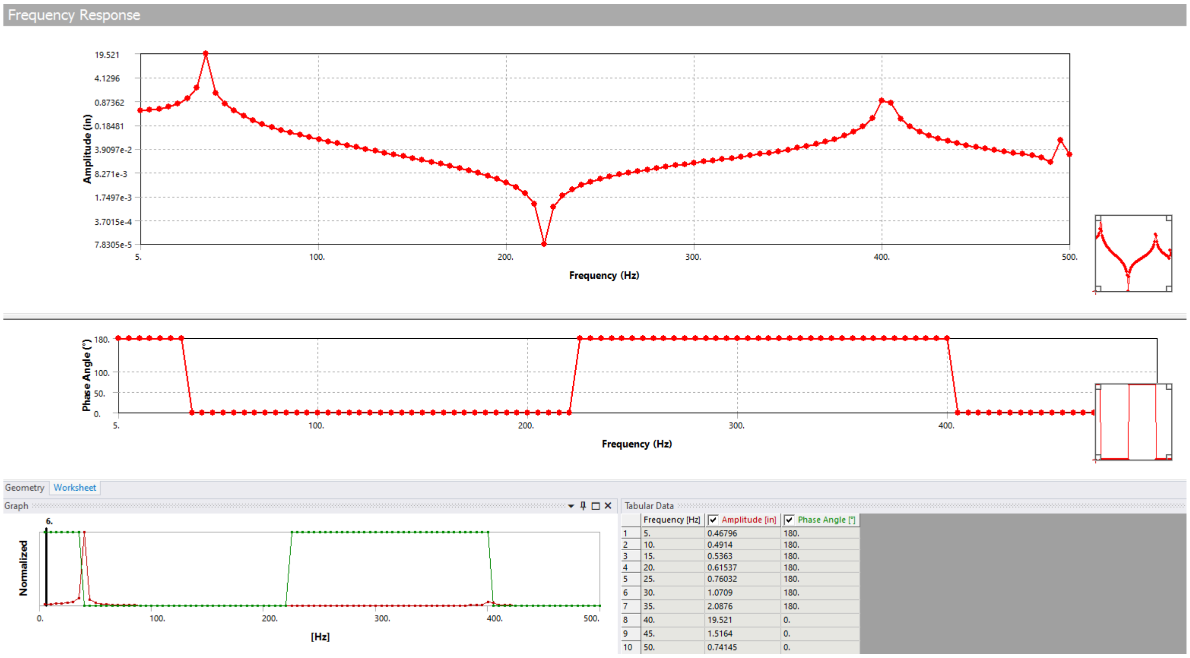
The modal analysis was performed, yielding the modal frequencies shown below.



Tabular Data

	Mode	Frequency [Hz]
1	1.	39.547
2	2.	62.606
3	3.	68.936
4	4.	124.19
5	5.	171.77
6	6.	402.28

The modal frequency range for the first six natural frequencies are between 0 and 500 Hz, which is the range we will analyze for the frequency response. The frequency response/Bode plot of displacement on the middle of the top surface, obtained using the same fixed supports, and 100 solution intervals or every sampled 5 Hz is:



	Frequency [Hz]	Amplitude [in]	Phase Angle [°]
1	5.	0.46796	180.
2	10.	0.4914	180.
3	15.	0.5363	180.
4	20.	0.61537	180.
5	25.	0.76032	180.
6	30.	1.0709	180.
7	35.	2.0876	180.
8	40.	19.521	0.
9	45.	1.5164	0.
10	50.	0.74145	0.