Ansys Mechanical Linear and Nonlinear Dynamics

WS 03.1: Plate with Hole

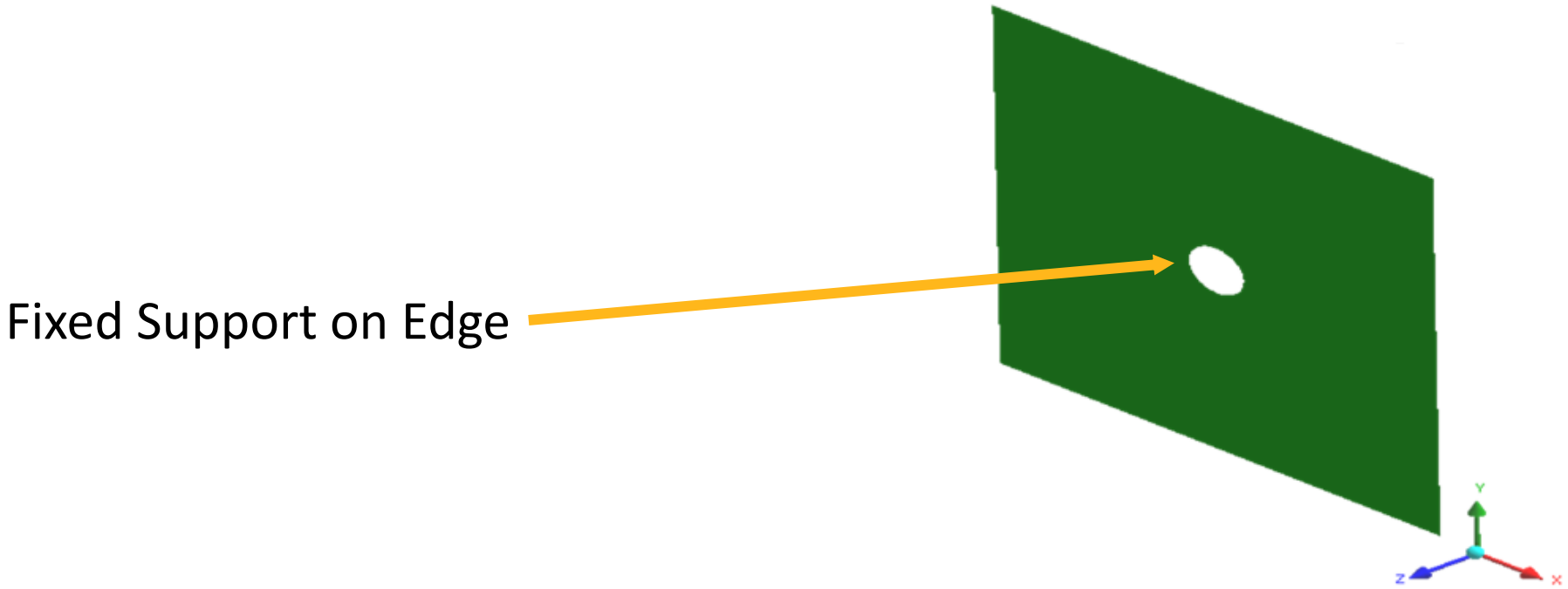
Release 2022 R2

Please note:

- These training materials were developed and tested in Ansys Release 2022 R2. Although they are expected to behave similarly in later releases, this has not been tested and is not guaranteed.
- The screen images included with these training materials may vary from the visual appearance of a local software session.
- Although some workshop files may open successfully in previous releases, backward compatibility is somewhat unlikely and is not guaranteed.

Workshop 03.1 - Goals

- Upon completion of this workshop, you will be able to set up a Modal analysis and review the mode shapes and participation factor summaries.
  - Our goal is to determine the first 10 natural frequencies and mode shapes for the plate with the hole shown.
  - The plate is manufactured of Aluminum and is fully constrained as though it is welded to a rigid shaft at the hole.

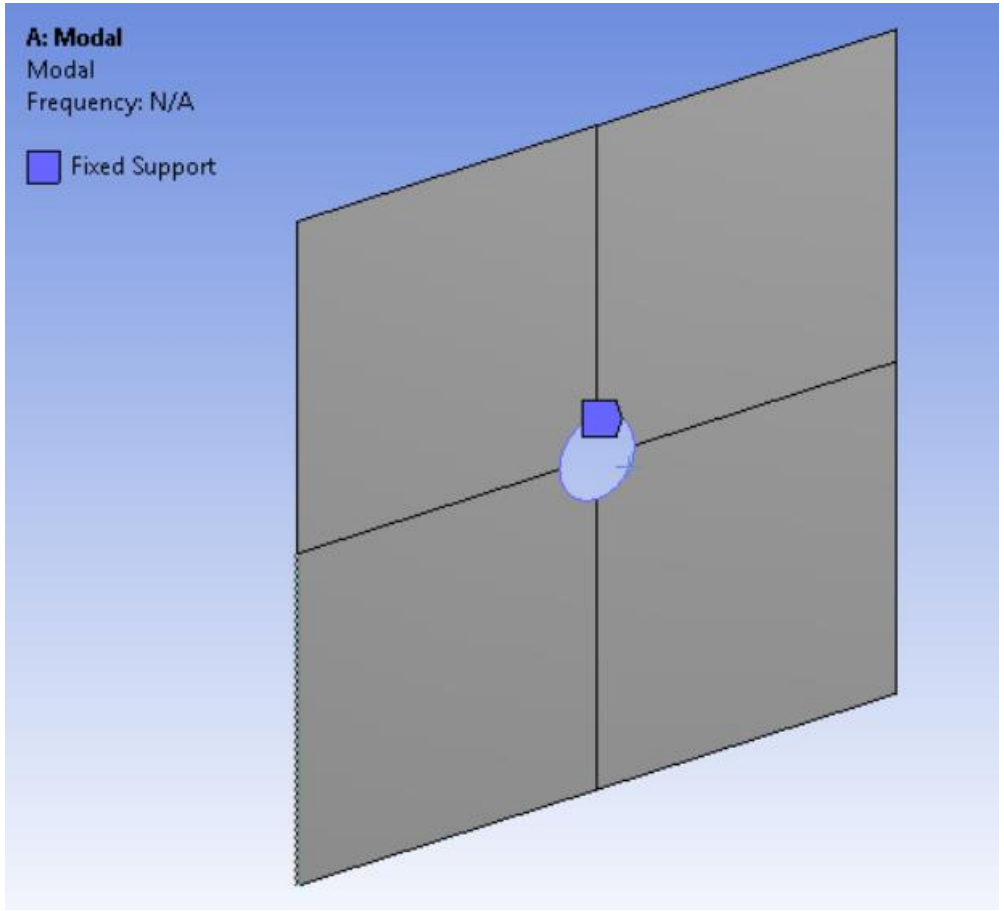


Workshop 03.1 – General Model Setup

- Begin a new Workbench session and, from the project schematic, insert a new Modal Analysis system.
- Import the Geometry file "**plate.iges**"
- Edit the Engineering Data cell.
  - add Aluminum Alloy from the General Materials library to Engineering Data
- Edit the Model cell to open the Mechanical application
  - Units:
    - US Customary (in, lbm, lbf, °F, s, V, A)
    - Degrees
    - RPM
  - Part thickness – 0.1 inch
  - Assign Part material – Aluminum Alloy

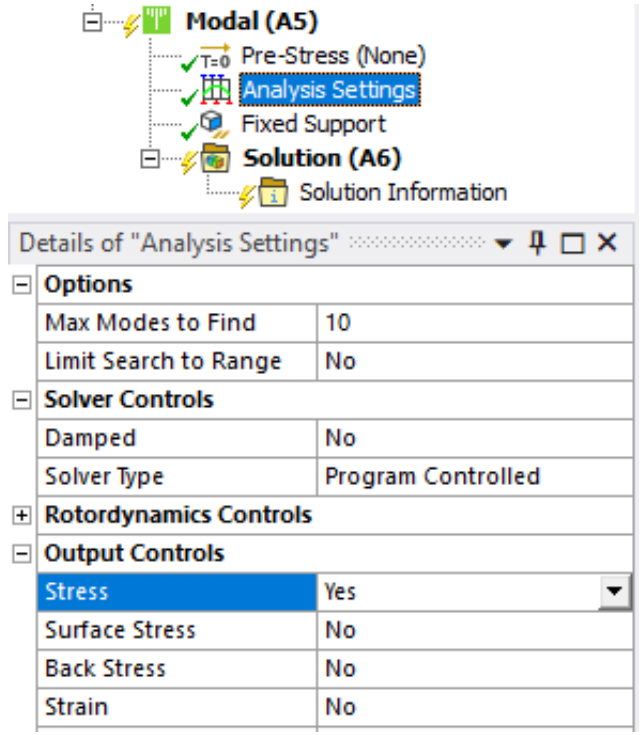
Workshop 03.1 – General Model Setup

- Constrain the center hole (edges) with a Fixed Support
- Loads are not required when setting up Modal analyses



Workshop 03.1 – Modal Solution

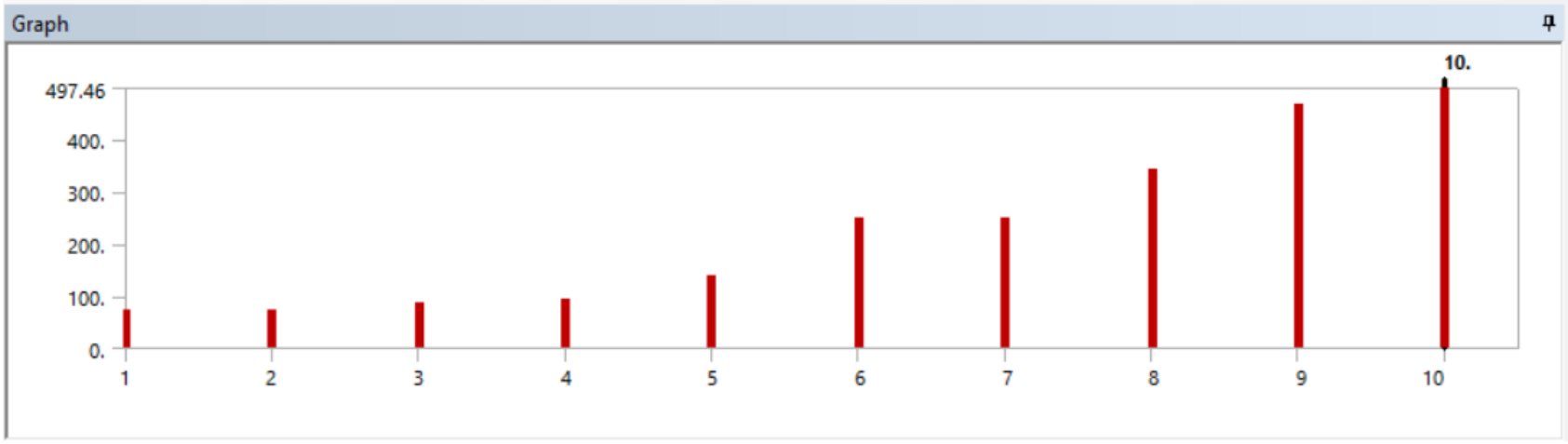
- Check the Details of Modal Analysis Settings:
  - set Max Modes to Find to 10
  - set Calculate Stress “Yes”
- If you only desire mode frequencies and mode shapes, you don’t need to calculate stress—it will save time to skip these calculations.
  - Output controls are assigned automatically when performing downstream analyses (Harmonic, Random, etc.) that use the results of a modal analysis
- Solve the Modal analysis.

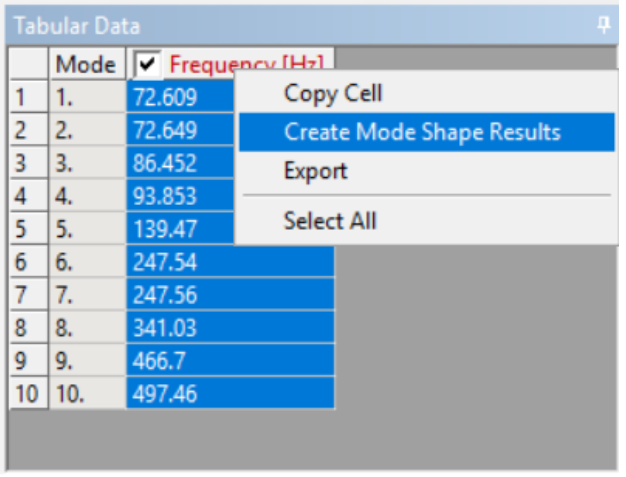


Workshop 03.1 - Results

Note: your result magnitudes may vary slightly throughout this workshop due to mesh and software release differences.

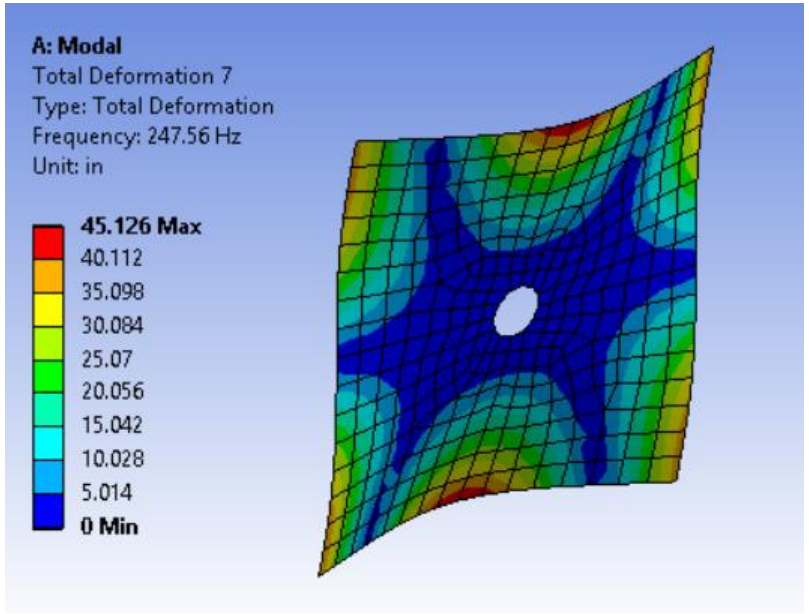
- After the solution is complete, review the mode shapes for each frequency.
  - Select the Solution branch of the outline
  - Select the Frequency column of the Tabular Data
  - Right-mouse-button, Create Mode Shape Results
  - Evaluate Results

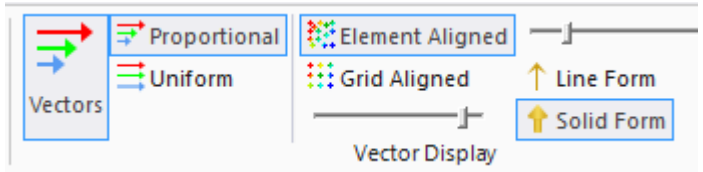


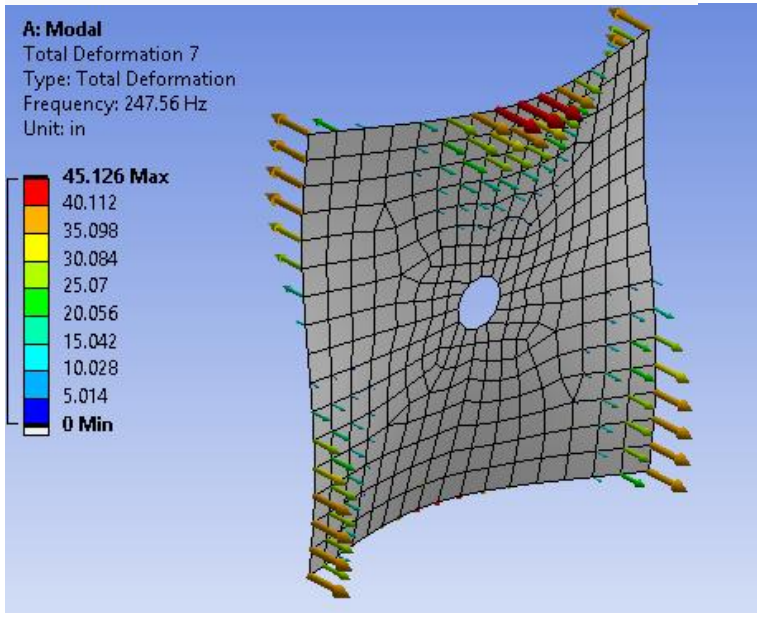


Workshop 03.1 - Results

- Reviewing each mode shape allows a greater understanding of how a structure might respond to a forcing function of a given frequency.
  - You can also Animate the mode from the Graph window, or
  - Switching to Vector display may also provide additional insight into the mode shape.

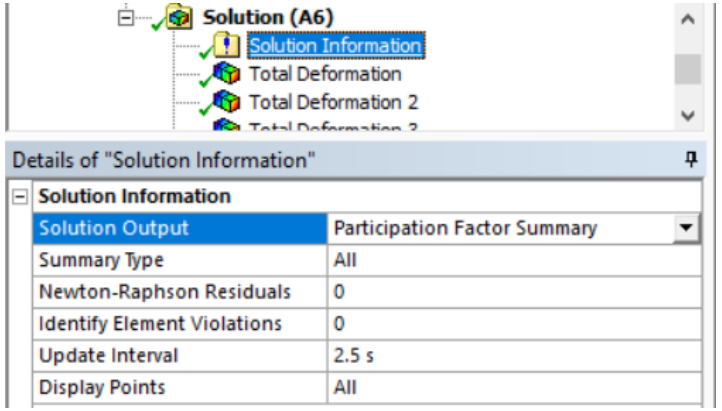






Workshop 03.1 - Results

- Review Participation Factors and Effective Masses
  - If you will be performing downstream analyses such as random vibration, response spectrum, etc., Participation Factors are useful for understanding which mode shapes may be excited by a forcing function in a given direction.
  - Available under Solution Information
    - Solution Output set to “Participation Factor Summary”



Workshop 03.1 - Results

- Modes 3 and 8 highlighted below have the largest participation factors of any modes in the translation Z direction
  - Translational excitations of any kind in the Z direction are likely to excite modes of vibration at 86 Hz and 341 Hz

Participation Factor

Mode	Frequency [Hz]	X Direction	Y Direction	Z Direction	Rotation X	Rotation Y
1	72.609	-1.4182e-018	-1.176e-018	-7.1565e-006	-0.11644	0.17344
2	72.649	-6.745e-019	1.3062e-018	2.8654e-005	0.17343	0.11643
3	86.452	-3.0254e-018	-2.421e-018	5.3485e-002	-1.0795e-004	-3.0281e-005
4	93.853	-2.3255e-018	4.8668e-018	2.3053e-005	-4.058e-005	4.9349e-005
5	139.47	1.7328e-018	-3.7495e-019	3.0373e-006	-4.5345e-005	-4.3605e-005
6	247.54	-5.7388e-018	-7.9978e-018	2.2194e-006	5.8115e-004	2.1509e-002
7	247.56	5.864e-018	2.1977e-018	2.4087e-006	2.1513e-002	-5.6428e-004
8	341.03	-2.4035e-017	2.8263e-017	-1.8662e-002	6.2826e-006	1.6353e-005
9	466.7	-6.4544e-014	9.2306e-014	-1.5481e-005	2.3082e-005	7.9242e-007

Workshop 03.1 - Results

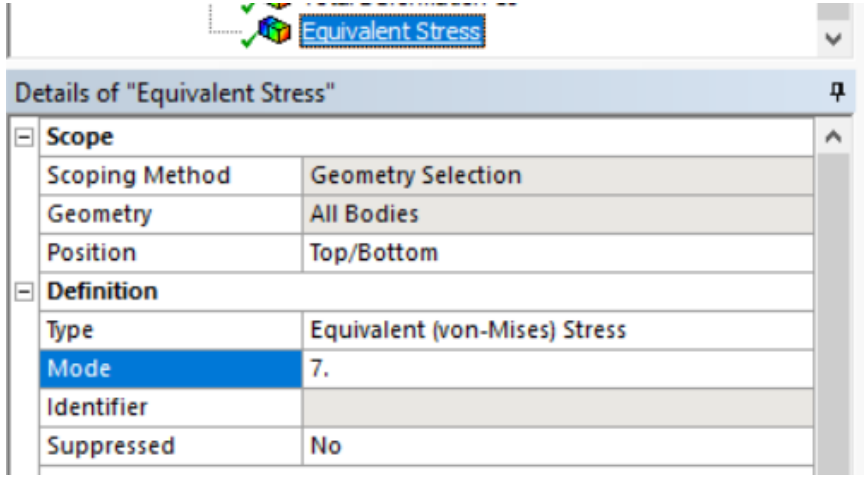
- Likewise, Modes 3 and 8 highlighted below also show the largest Ratios of Effective Mass to Total Mass in the Z direction
  - Modes 3 and 8 account for approximately 87% of the mass of the structure.
  - It's often desirable to have at least 90% of the mass of the structure represented by the modes in order to obtain accurate response calculations when performing downstream analyses such as response spectrum and random vibration.

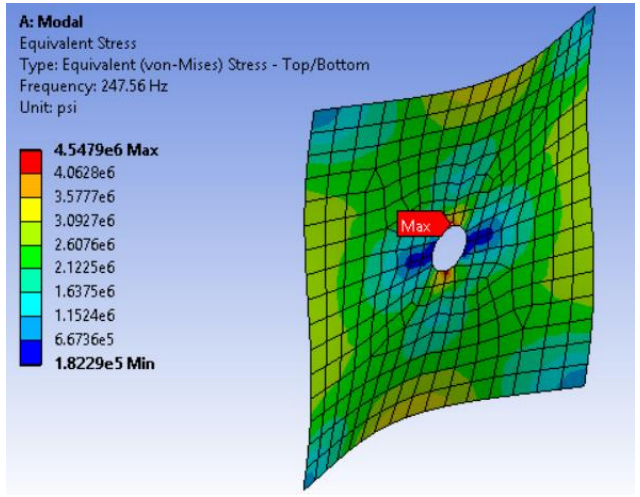
Ratio of Effective Mass to Total Mass

Mode	Frequency [Hz]	X Direction	Y Direction	Z Direction	Rotation X	Rotation Y
2	72.649	1.2334e-034	4.6253e-034	2.2258e-007	0.6716	0.3027
3	86.452	2.4814e-033	1.5889e-033	0.77552	2.6019e-007	2.0474e-008
4	93.853	1.4661e-033	6.4211e-033	1.4408e-007	3.6769e-008	5.4378e-008
5	139.47	8.1403e-034	3.8114e-035	2.5009e-009	4.5911e-008	4.2454e-008
6	247.54	8.9282e-033	1.7341e-032	1.3354e-009	7.5412e-006	1.033e-002
7	247.56	9.3223e-033	1.3094e-033	1.5728e-009	1.0334e-002	7.1095e-006
8	341.03	1.566e-031	2.1655e-031	9.442e-002	8.8133e-010	5.9708e-009
9	466.7	1.1294e-024	2.3099e-024	6.4974e-008	1.1896e-008	1.402e-011
10	497.46	1.3405e-023	1.1275e-023	1.6974e-008	7.5113e-003	2.1296e-004
Sum		1.4535e-023	1.3585e-023	0.86994	0.99218	0.98489

Workshop 03.1 - Comments

- Remember:
  - Displacements, stresses, strains, etc. reported with mode shapes are “relative” and do not reflect the actual magnitudes.
  - The actual magnitudes will depend on the energy input to the system (i.e. on the forcing function) along with any damping that may exist.
    - Insert an Equivalent Stress result for Mode 7
    - *If* the structure were vibrating at 247 Hz, the stress distribution would appear as shown in the image below
    - Useful for determining *where* peak stresses may occur for a given mode of vibration





End of presentation