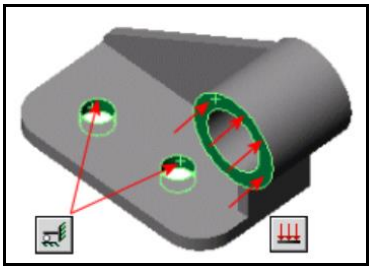
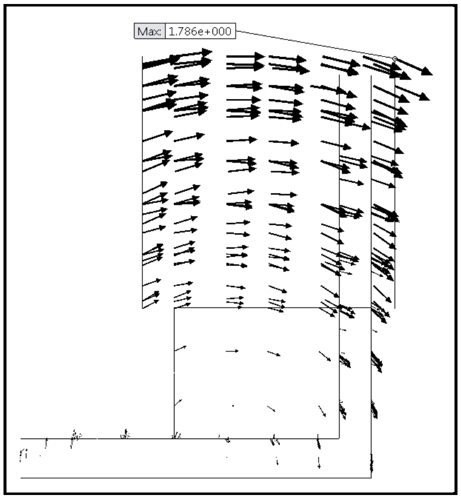
Required Training Files, MECH 417 FEA

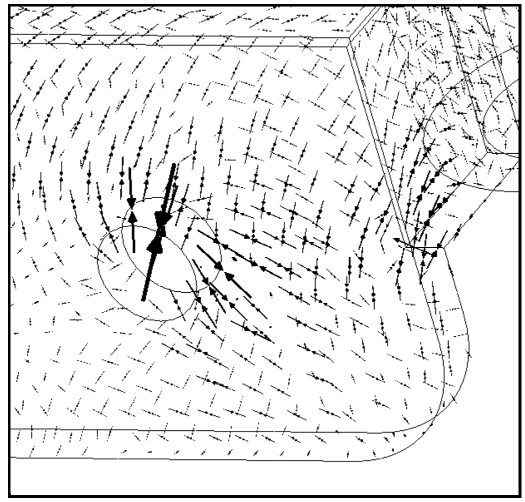
Assigned 2/5/2021. Training Summary Report PDF due via email to the Professor on or before midnight on last class day, 4/27. A complete and correct report conveys 20% of the course grade.

Problem 1: "Analysis of a Part" Tutorial. Completed on _______________.

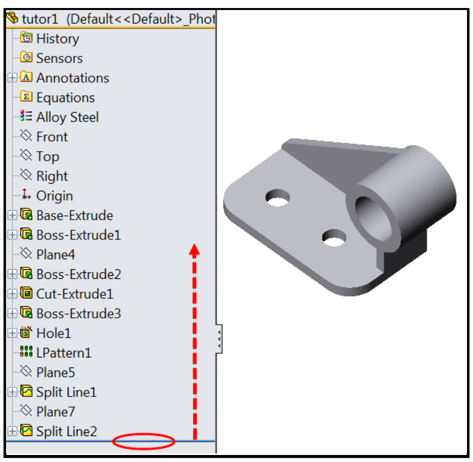
Provide images of your choice of the part mesh, the displacement vectors, and of either the principal stress P1 (maximum tension) or P3 (maximum compression) similar to those below. Also give a discrete color image of the P1 contours on the mesh.

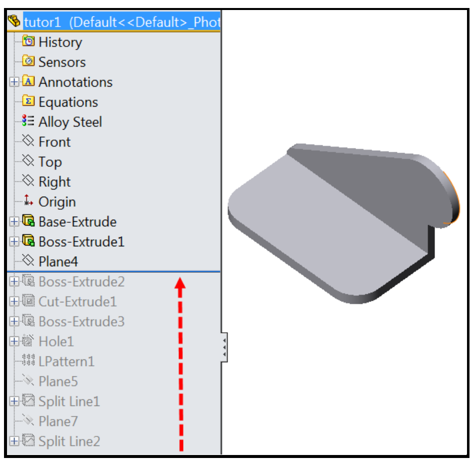






Note: The part construction steps can be seen in the Model tab by rasing the Roll-Back bar step-by-step.



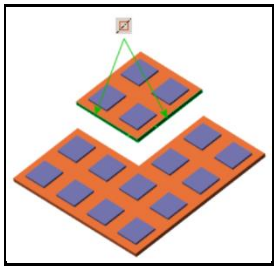


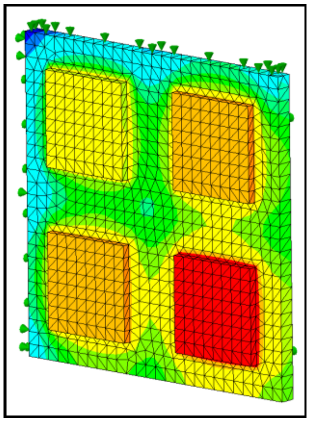
Problem 2: Read the critique of the "Analysis of a Part" Tutorial. Completed on ___________.

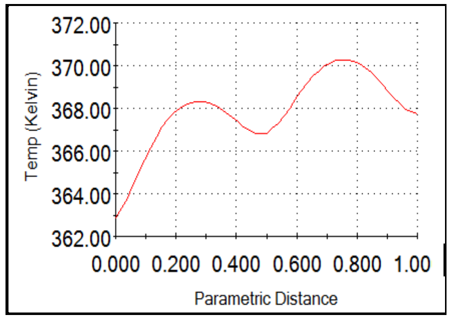
Problem 3: "Thermal Analysis" Tutorial, steady state only. Completed on ______________.

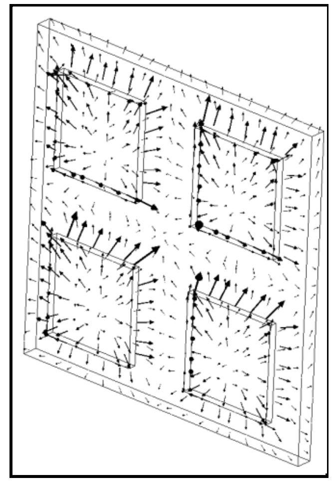
This problem includes the common task of creating a custom material. Sometimes that fails in the Student Version due to attempting to save to a read-only directory. If so, pick a similar standard material. Sometime the temperature dependent conductivity list input fails, if so use a constant average value. The Simulation Help on "Create Custom Material" gives an alternate procedure that sometimes works.

Using view angles of your choice include images of the discrete temperatures on the mesh, temperature graph on an edge, and the heat flux vectors similar to those shown.







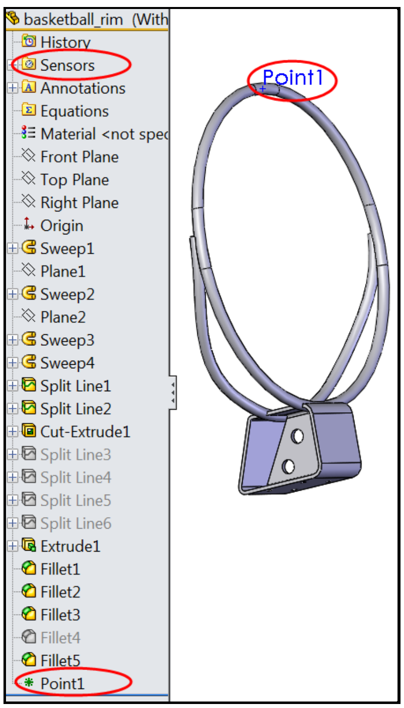


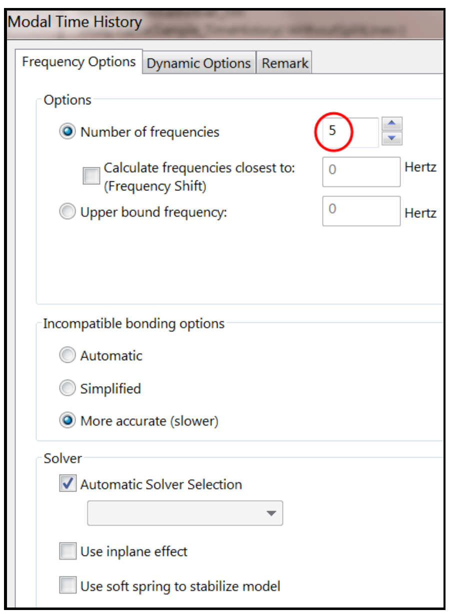
Problem 4: Read the critique of the "Thermal Analysis" tutorial. Completed on ___________.

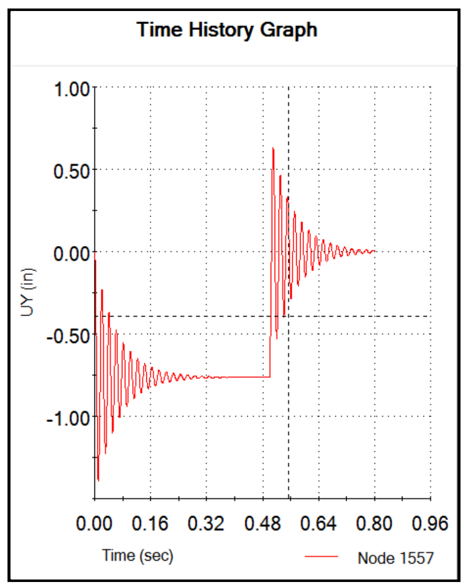
Problem 5: "Time History Analysis of a Basketball Hoop" tutorial. Completed on ___________.

Notes: This and other applications can output the result at any node, but here a Point was input in the Model tab to serve as the single 'sensor' where the time history will be displaced.

This type of time history is based on first computing a limited number of natural mode shapes. The time accuracy depends on the number of modes selected. The default number, set at Run → Properties is just 5. Provide an image of the mesh, and the time history at the sensor. State the number of modes used.

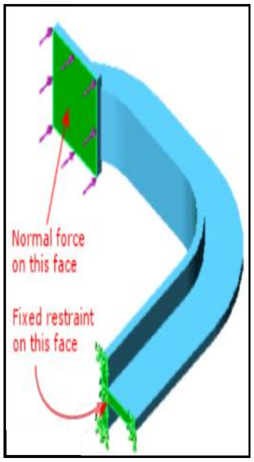


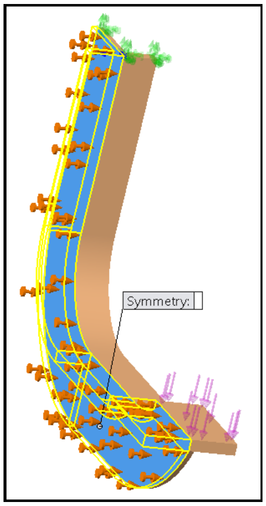


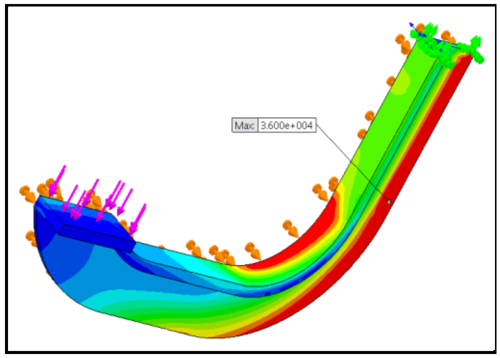


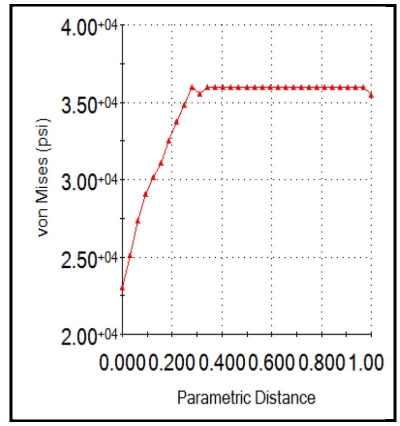
Problem 6: "Elasto-Plastic Analysis of a C-Clamp" tutorial. Completed on ___________.

Since this is a symmetric study ideally a half-symmetry solid should be built in the Model tab causing the applied load to also be cut in half. It is your choice of using a full or a symmetric model. Provide images of your mesh and a line graph of a portion of the von Mises effective stress.



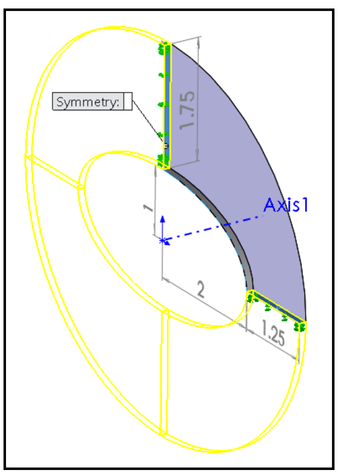


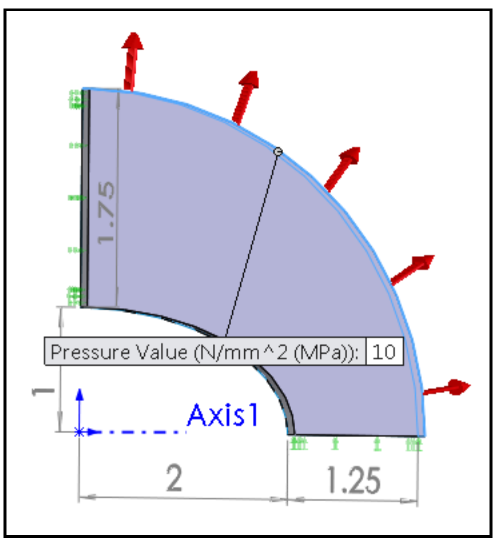


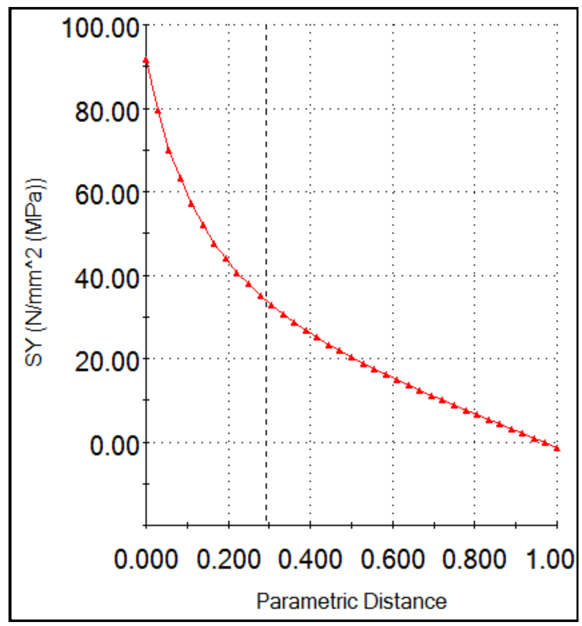


Problem 7. NAFEMS Benchmark "Elliptic Membrane under Pressure". Completed on ___________.

Since the SWS surface model display of the applied pressure is unclear, at the Model tab roll-back the "Body delete" and keep the original solid part and its vertical and horizontal symmetry planes. Also support the back face as a symmetry plane (since only pressure is applied, otherwise also use half thickness, and half of other loads). "Exclude from Analysis" the original surface model and keep the solid. Include images of your mesh and a graph of normal stress component SY leading up to the verification point.

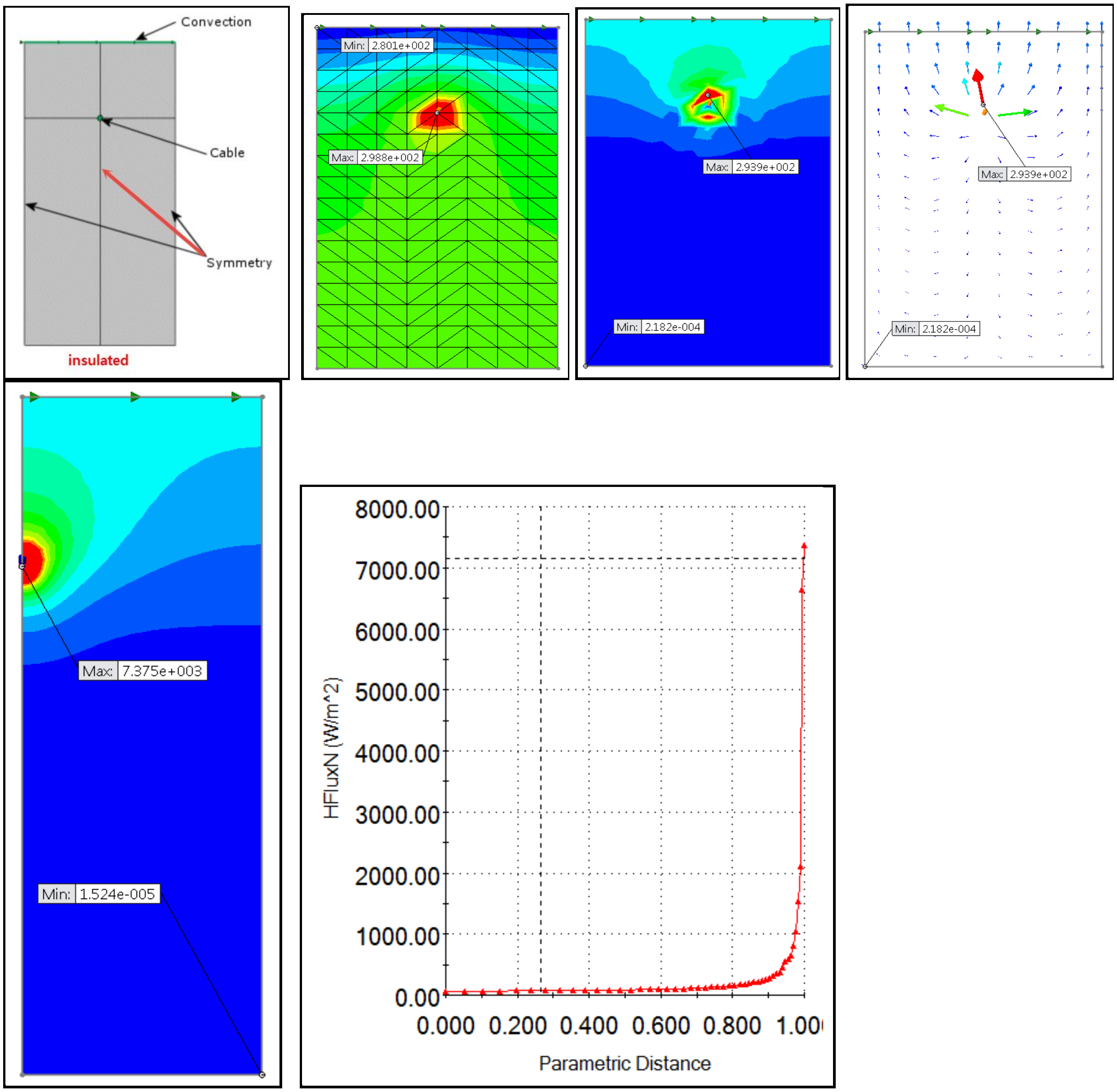






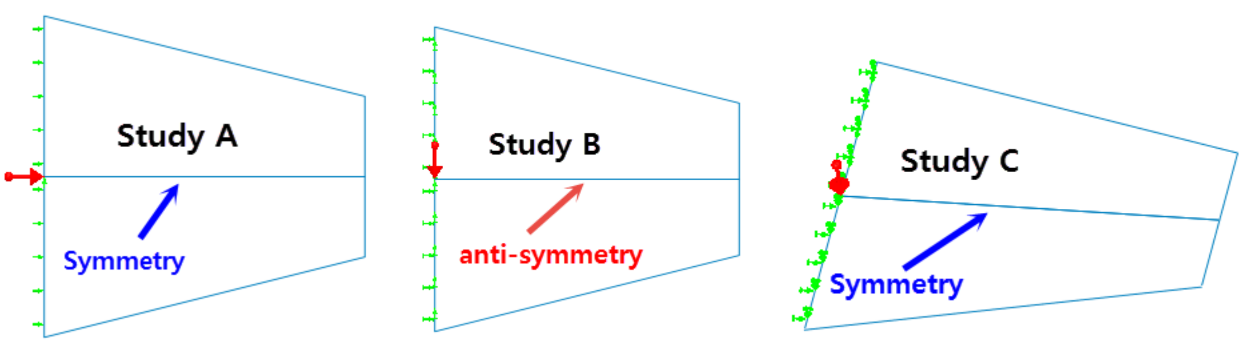
Problem 8. Benchmark "Heat Conduction Due to Heating Cables". Completed on ___________.

A series of heating cables have been placed in a conducting medium *and repeat every 2 m which means there is another symmetry plane.* A point source is a singularity with a theoretical infinite temperature gradient. Wiggles in the contours of the temperature and/or the more important heat flux magnitude imply a poor mesh. The mesh needs element size control at the cable point. If using the third vertical symmetry plane the model and the heat power need to be halved. Include images of your mesh and a graph of the temperature or heat flux magnitude from the top down to the cable. Also include an image of black heat flux vectors.

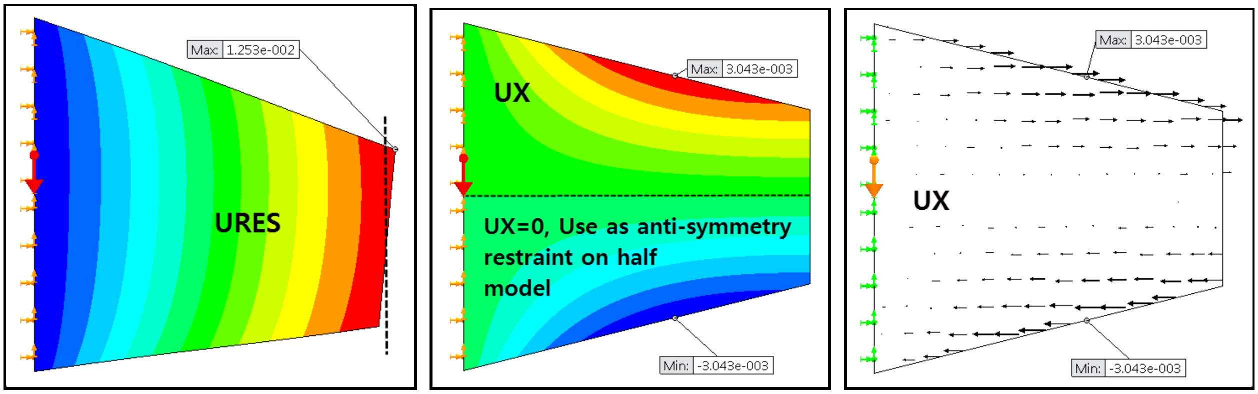


Problem 9. NAFEMS "Tapered Geometry - Gravity Loading" verification, part B. Completed on ___________.

This is a tapered cantilever where Study A and C have a with a center horizontal symmetry line (plane). However, this Study B has horizontal symmetry only for the shape, material, and restraints. The gravity load, displacements, and stresses are anti-symmetric with respect to that plane. Each symmetry or anti-symmetry plane (see Prob. 11) allows a study to be cut in half so a finer mesh can be used. However, an abundance of computer power can allow a novice to still obtain the correct results.

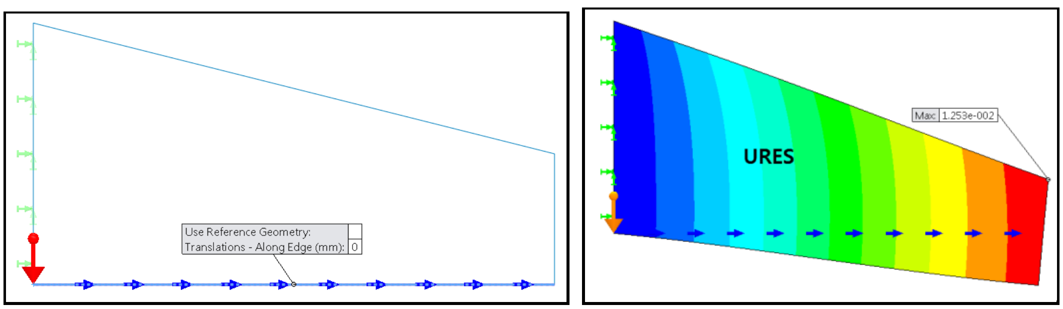


Run the supplied Study B; provide and contour image of any displacement and any stress of interest similar to those below:



Note that for this Study B anti-symmetry mode components parallel to the anti-symmetry plane and in the bottom half have the same values, but opposite sign as those in the top half. Also, the components normal to the plane have the same value and sign on both sides of the plane. Some FEA codes have the option to use those features to show the full model results even though only half was used. Run the full provided study and then make an anti-symmetric study.

In the Model tab, right-click on the Mirror feature and 'Suppress' it; or move the Roll-Back bar one level to obtain just the top half of the trapezoid. In Study B, confirm the left restraints and insert a new restraint to set UX to zero on the bottom anti-symmetry edge.

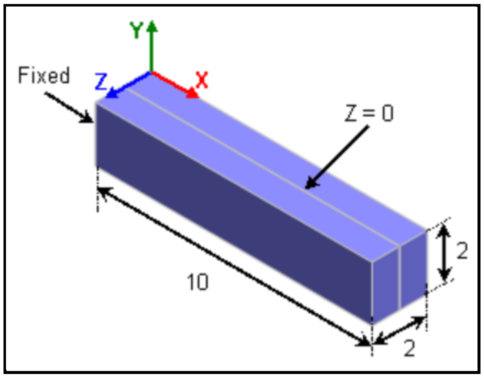


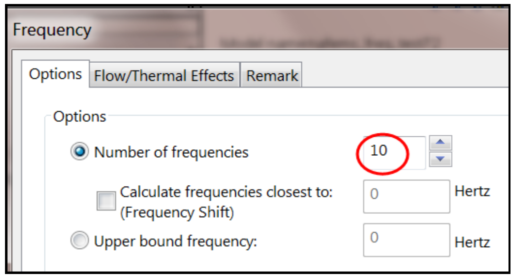
Studies A and C could be run as half symmetry model also by setting UY to zero on the bottom edge instead.

Problem 10. NAFEMS "Modes of vibration of a cantilevered solid beam". Completed on ___________.

This study is not stated clearly. The comparison results are from two-dimensional (planar) Theory of Elasticity. Thus, it excludes body out of plane motions (including torsional), that will be addressed below, by setting displacement component UZ to zero on the center plane of the *assembly* of two halves. Actually, an assembly is not necessary, and only either half of the part is required for the comparison given.

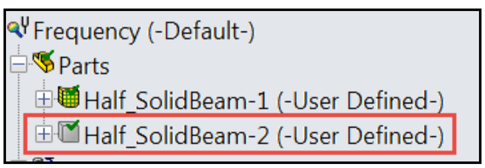
In the 2D frequency study right-click on the study name pick Properties and set number of frequencies to 10 since 6 are wanted and the default number is 5. For convenience the theory results (which include Poisson Ratio effects) are listed below.

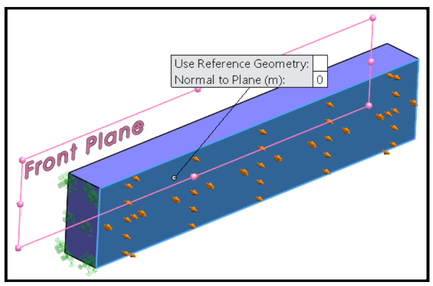




Frequency	2D Theory (Hz)
1	16.007
2	87.226
3	125.96
4	209.56
5	351.11
6	375.81

To efficiently use just a half-solid to approximate the 2D theory, right-click on the Half_SolidBeam-2 and “Exclude from Analysis” in the assembly. Edit the symmetric fixture and change its color. Mesh the part and run the eigenproblem. In Results right-click on each mode plot and pick Edit Definition →Advanced Options → Normalize Mode Shape for the range 0 to 1 (Most FEA systems normalize displacements from -1 to 1, but there are a few additional choices.). Then Right click Results to List Resonant Frequencies to compare to the above 2D table. The main differences in the frequencies are due to Poisson ratio effects in the directions normal to the vertical symmetry plane.





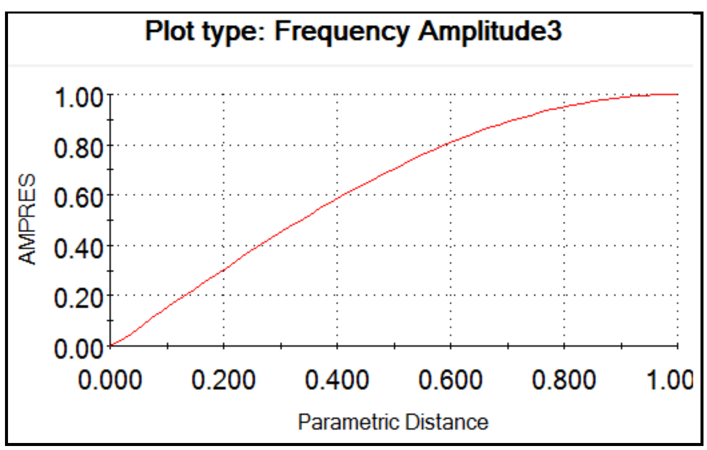
List Modes

Study name:Frequency

Mode No.	Frequency(Rad/sec)	Frequency(Hertz)
1	99.246	15.795
2	535.04	85.153
3	789.3	125.62
4	1275.5	203
5	2120.9	337.56
6	2353.4	374.56
7	3018.8	480.45
8	3862.8	614.78
9	3917.2	623.43
10	4763.1	758.06

However, to see the true modes of a solid cantilever beam the out of plane displacements of the full model must be re-activated. In the assembly study, right-click on the excluded part, and select “Include in Analysis” to restore the model to a full solid. In addition, right click on the symmetry restraint and “Suppress” it so all of the normal displacements are active. Check the end Fixture to assure it includes both end faces. Running the full solid study now shows new modes that were suppressed before; some of which are marked with the red boxes.

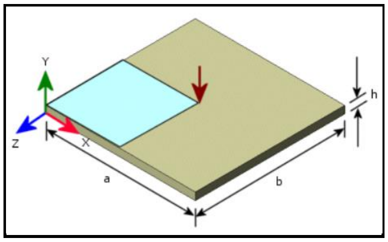
Mode No.	Frequency(Rad/sec)	Frequency(Hertz)
1	99.361	15.814
2	99.376	15.816
3	445.61	70.921
4	535.22	85.183
5	535.31	85.197
6	789.79	125.7
7	1274.9	202.91
8	1275.1	202.94
9	1336.5	212.71
10	2118	337.09

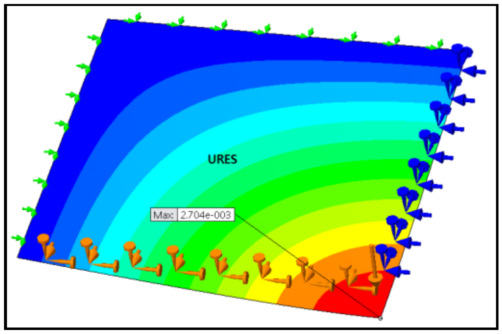


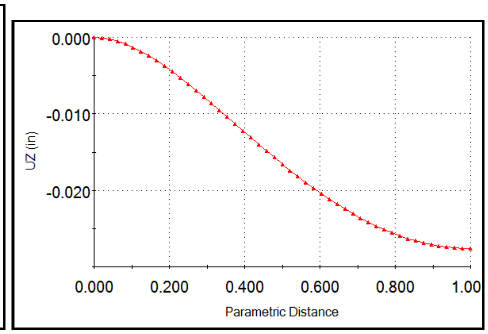
Supply images of two such mode shapes, omitting the AMPRES color-bar. Remember that each such deformed shape is amplified for viewing. You may have to right-click the plot name and pick Edit-Definition →Deformed Shape → User defined to get a realistic looking shape. Provide a graph of one of the normalized displacement amplitudes for one of the red box modes. Also, right-click a mode shape and select Animate to see if that enhances your understanding (no image required).

Problem 11: “Simply Supported Rectangular Plate” benchmark. Completed on ___________

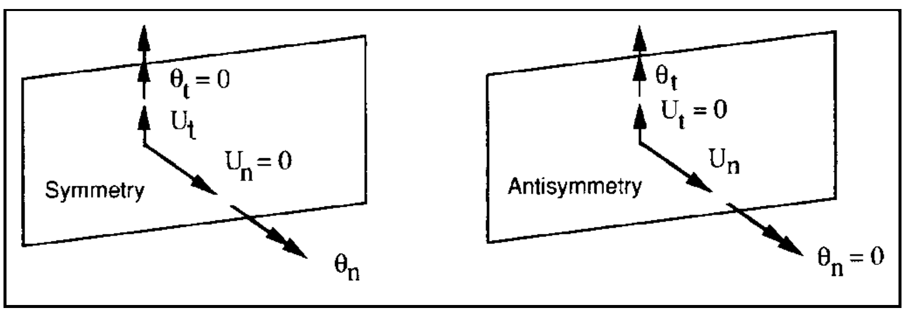
This study uses two vertical symmetry planes to create a one-quarter model of a square plate with a center point load. Actually, this plate also has symmetry about both diagonal lines; so a one-eighth model should be used.



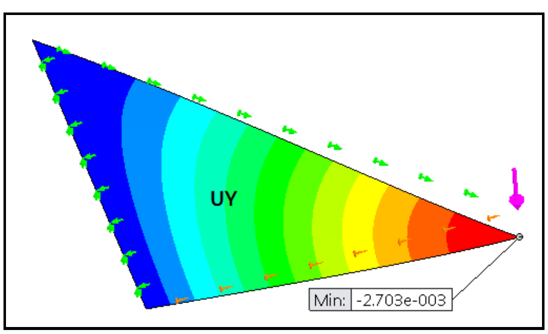


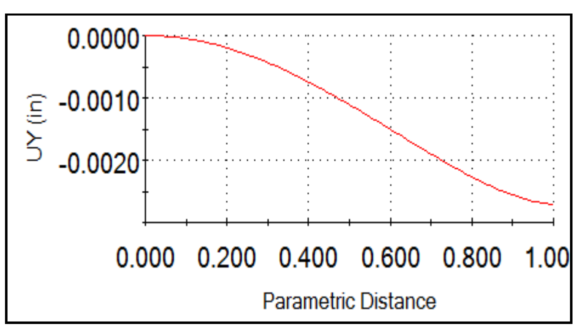


In structural mechanics, a displacement vector can have three displacement and three rotational components. A plane of symmetry, or anti-symmetry, requires three of the six components to be zero as sketched below. On a plane of symmetry the normal displacement is zero, as are the two rotational components in the plane. Conversely, on a plane of anti-symmetry the rotation normal to the plane is zero, as are the two displacement components tangent to a plane. Not all element types have all six DOF, but users should be in the habit of applying all the displacement conditions when in doubt about which DOF are active in a FEA system (SW ignores non-active BC).



Create the smaller triangular-shaped 1/8 model surface by inserting a new line between the load point and square corner.





12 Ranking: State the numbers of the training problems that were most, and least, useful and stare why.

(MECH 517 students will complete additional training based on their areas of interest.)