# ME 478 FINITE ELEMENT ANALYSIS – Spring 2012

## Project #2 - Due May 4

Consider a thin plate loaded in tension with a hole through it (Figure 1). The plate has a length $l$ = 1.0 meters, width $w$ = 0.4 meters, thickness $t$ = 0.01 meters, and a central hole with diameter $d$ = 0.2 meters. The plate is made of steel with an *elastic modulus* $E$ = 2.07 x $10^{11}$ N/m$^2$ and *Poisson's ratio* $v$ = 0.29. A tensile loading is applied as a pressure $p$ = 1.0 N/m$^2$ along the vertical edges of the plate. The goal of this project is to determine the *stress concentration factor* $K_t$ as a function of $d/w$ using ANSYS. You will then compare your results with published results.

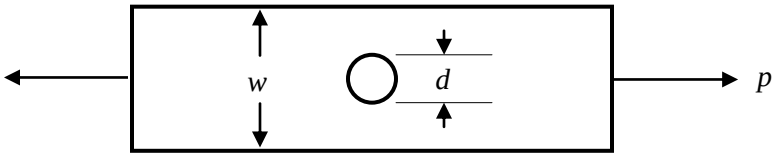


**Figure 1**. Thin plate with central hole.

In your model, use 2D quadrilateral 8-node solid elements (PLANE82). As a savvy FEM engineer, you should be on the lookout for conditions of symmetry that you can exploit. In the plate model, you can take advantage of its doubly-mirrored symmetry by cutting the model down to a a quarter-section of the plate with a quarter-circle. When reducing a model by exploiting its symmetry, you will need to use *rollers* as the boundary condition at the cut surface.

## Results

1. What do the deformed shape and the stress fields $\sigma_x$, $\sigma_y$, $\tau_{xy}$, and principal stress $\sigma_1$ look like?
2. Stress variations in the isotropic, homogeneous plate should be smooth and continuous across the elements. If your result shows otherwise, the stress solution is not correct. Fix these 'rough' results by refinement using meshing control (discussed in Ref (1), pages 706-709), but do it without overloading too much of the computer's memory.
3. What is the effect of mesh refinement on your model?
4. After refinement, check your maximum stress in ANSYS against the expected maximum stress for a plate with a hole using the published stress concentration factor $K_t$ found in Refs. (2) or (3). If they're not identical, compute the percent error.
5. For the round hole, determine the stress concentration factor $K_t$ as a function of $d/w$. Compare your results with published results.
6. How sensitive is your result to i) mesh density? ii) Poisson's ratio?
7. If you were designing a structure with different hole types (square, oval, diamond), but having the same characteristic length as the circle diameter $d$, what shape would you choose and why?

**References:**


1. Moaveni, S. 2008. Finite element analysis : theory and application with ANSYS. Pearson Prentice Hall, Upper Saddle River, N.J.
2. Dowling, N. E. 2007. Mechanical behavior of materials : engineering methods for deformation, fracture, and fatigue. Pearson/Prentice Hall, Upper Saddle River, N.J.
3. Peterson, R. E. 1974. Stress concentration factors; charts and relations useful in making strength calculations for machine parts and structural elements. Wiley, New York.