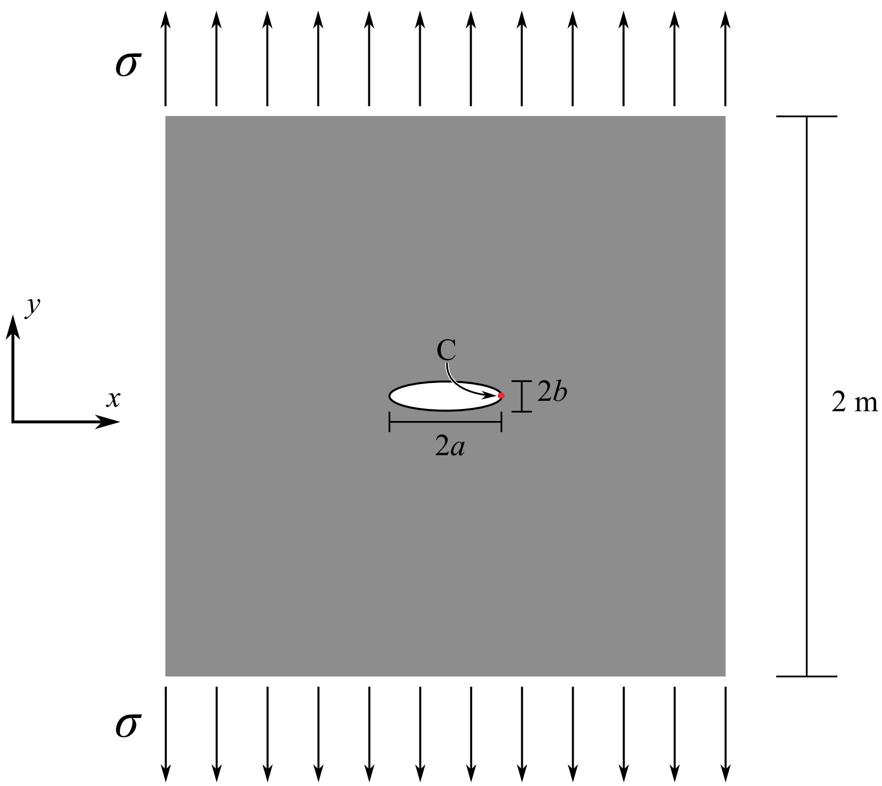
Institute for Aerospace Studies
UNIVERSITY OF TORONTO

AER 1403 2021F: Project 2
Due: 17 December 2021
Value: 30%

Finite Element Analysis of Elliptical Holes in Plates

The goal of this project is to understand stress concentrations around elliptical holes in plates. Consider a steel plate 2 m square and 1 mm thick with an elliptical hole in the centre, as shown below:



The steel in the plate has Young's modulus E = 210 GPa and Poisson's ratio ν = 0.3. The plate is subject to a far-field stress σ = 200 MPa. At the centre of the plate is an elliptical hole. The centre of the hole is in the exact centre of the plate, so that the plate has two axes of symmetry. This means that it is necessary to model only one quarter of the plate and to impose appropriate symmetry constraints. The major axis of the ellipse, a in the figure, is a constant 0.1 m. The minor axis of the ellipse, b in the figure, varies from 0.2 m to 0.01 m. Case 0 is for a circular hole, where $a = b$. The critical location in this analysis is indicated by the red circle at point C: this is where the maximum stress σ_{yy} occurs. You must analyse a series of cases throughout the range of b and determine the maximum stress σ_{yy} at C in each case. It will be necessary to analyse at least six cases to complete this satisfactorily, with b both less than and greater than a. Do not use any existing codes, commercial software, or online packages to do any of this project. All results must be the product of code that you have written yourself. To complete this project, submit, in electronic form through Quercus, the following:

i. the code you use to generate the solution in a form that allows it to be run conveniently;
ii. a convergence study showing that your finite element solution has converged;
iii. for case 0, a table containing the physical coordinates of all the nodes associated with each element;
iv. for case 0, a table containing the displacements of all nodes;
v. for case 0, a plot showing simultaneously the undeformed and deformed shape of the plate using appropriate scaling and showing the outlines of the elements;
vi. for case 0, a contour plot of the von Mises equivalent stress in the plate;
vii. for case 0, a contour plot of σ_{yy} in the region near the elliptical hole;
viii. for the case where σ_{yy} at C is largest, a contour plot of σ_{yy} in the region near the elliptical hole;
ix. a plot of the relationship between the length of the minor axis b and the maximum stress σ_{yy} at location C;
x. a comparison of your results to theoretical results for similar cases; and
xi. a discussion of your results and how they might influence design decisions.

The project must be submitted through Quercus by 11:59 PM on December 17.