UNIVERSITY OF SASKATCHEWAN
ME 313.3 – MECHANICS OF MATERIALS I
MIDTERM EXAM – OCTOBER 27, 2005

Professor A. Dolovich

A CLOSED BOOK EXAMINATION
TIME: 2 HOURS

For Marker's Use Only

LAST NAME (printed): _____ 1. _____

FIRST NAME (printed): _____ 2. _____

STUDENT NUMBER: _____ 3. _____

EXAMINATION ROOM: _____

SIGNATURE: _____

Total: _____

INSTRUCTIONS

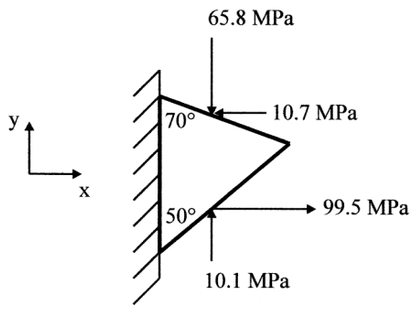
1. The examination consists of 3 questions.
   Answer all three questions.
   The exam is out of 60; each of questions 1, 2, and 3 is worth 20 marks.
   PRINT YOUR NAME AT THE TOP OF EACH PAGE.

2. This is a closed book exam.
   Calculators are permitted.
   A list of formulas will be provided separately.

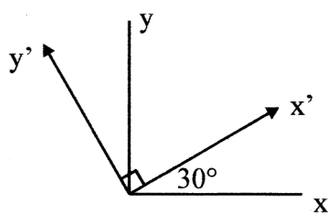
3. SHOW YOUR WORK CLEARLY.
   Give final answers to 3 significant figures.

4. Your answers are to be given in the space below the question.
   The back of the page may be used as a continuation sheet if required.

1. The triangular plate is in a uniform state of plane stress. The applied forces per area (to 3 significant figures) on two edges are as shown. Determine σ_{xx}, σ_{yy}, and τ_{xy} in the plate.



2. For a state of plane stress, $\sigma_{xx} = -100$ MPa, $\sigma_{yy} = 250$ MPa, and $\tau_{xy} = -50$ MPa, where the x and y axes are as shown. Using Mohr's circle, determine:



   (a) the in-plane principal stresses σ_{max} and σ_{min} shown on a properly oriented element;

   (b) the maximum shearing stress shown on a properly oriented element (together with any other stresses on that element); and

   (c) $\sigma_{x'x'}$, $\sigma_{y'y'}$, and $\tau_{x'y'}$ all shown on a properly oriented element.

   All relevant points must be clearly labeled on your sketch of Mohr's circle.

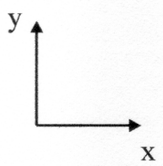
3. Each of parts (a) through (e) is worth 4 marks.

(a) Using an appropriate sketch, derive the equation

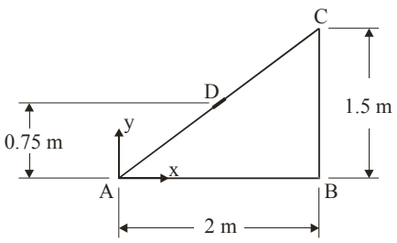
$$\frac{\partial \sigma_{xx}}{\partial x} + \frac{\partial \tau_{xy}}{\partial y} + B_x = 0$$

from first principles.

(b) At a point in a loaded body, it is known that the loading has caused a line element in the x-direction to change angle by 0.005 degrees clockwise, and a line element in the y-direction to change angle by 0.007 degrees clockwise. Both angular changes have occurred within the x-y plane. Calculate the rigid body rotation (within the x-y plane) at the point in question.



Parts (c) and (d) refer to a triangle ABC (shown below) which is scribed on the surface of a



member prior to loading. The interior angle at B is originally 90°. Following application of the load, the displacement field is given by

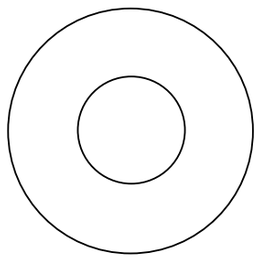
$$u = c_1 x^2 + c_2 y^2$$
$$v = c_3 x^2 + c_4 y$$

where $c_1 = 0.0001\ m^{-1}$, $c_2 = 0.0002\ m^{-1}$, $c_3 = -0.0003\ m^{-1}$, $c_4 = 0.0004$ and x, y, u, and v are in meters. Assume the field to be geometrically linear.

(c) Determine the change in interior angle at corner B (in degrees) caused by the loading. Clearly state whether it is an increase or decrease in angle.

(d) Determine the rigid body rotation in the x-y plane at point D. Give your answer in degrees. Clearly state whether it is clockwise or counterclockwise.

(e) You are working for an oil and gas company, and you are asked to develop a computer code for analyzing thick-walled cylindrical pressure vessels (including pipes).



Cross-Section of Cylindrical Pressure Vessel

As part of this project, it is deemed necessary to write the strain-displacement equations in polar coordinates. You are to assume that the state of strain in each cross-section of the cylinder is 2-D and <u>symmetric about the center</u>. Using a sketch or two and the fundamental, physical definition of normal and shearing strain, determine the strain-displacement relations in polar coordinates. That is, write ε_{rr}, $\varepsilon_{\theta\theta}$, and $\gamma_{r\theta}$ in terms of u_r and u_θ, where u_r is the displacement in the radial direction and u_θ is the displacement in the θ direction. Note the strain field is not uniform in the radial direction.