UNIVERSITY OF SASKATCHEWAN
ME 313.3 – MECHANICS OF MATERIALS I
FINAL EXAM – DECEMBER 12, 2005

Professor A. Dolovich

A CLOSED BOOK EXAMINATION
TIME: 3 HOURS

For Marker's Use Only

LAST NAME (printed): ________________________________ 1. __________

FIRST NAME (printed): ________________________________ 2. __________

STUDENT NUMBER: ________________________________ 3. __________

EXAMINATION ROOM: ________________________________ 4. __________

SIGNATURE: ________________________________ 5. __________

Total: ________

INSTRUCTIONS

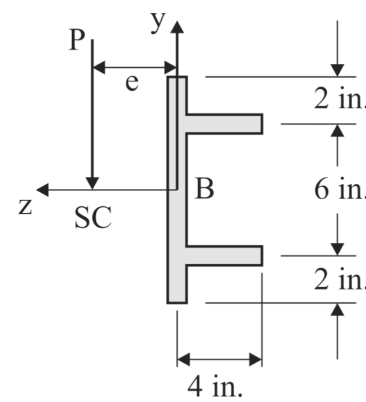
1. The examination consists of 5 questions.
   Answer all five questions.
   The exam is out of 100; each of the questions is worth 20 marks.
   PRINT YOUR NAME AT THE TOP OF EACH PAGE.

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.
   Continuation sheets have been provided within the exam paper.
   In addition, the back of each page may be used as a continuation sheet if required.

1. An extruded beam has the cross section shown. Determine the location of the shear center e. Sketch the shear flow in the cross section as part of your solution. The section has a uniform wall thickness of 0.125 in.



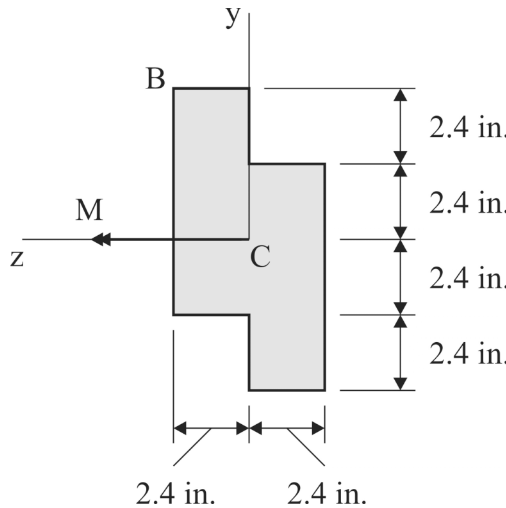
Continuation Sheet - Problem 1

2. A couple $M = 1250 \text{ in} \cdot \text{lb}$ acts on the cross section of a beam, as shown. Determine:

   (a) σ_B (i.e., the normal stress at point B); and

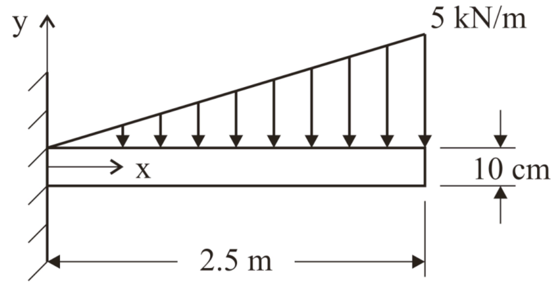
   (b) the angle between the neutral axis (NA) and the z-axis (shown with a sketch).

   Given Data: $I_{yy} = 66.4 \text{ in}^4$, $I_{zz} = 199.1 \text{ in}^4$



Continuation Sheet – Problem 2

3. A cantilever beam with a 5 cm × 10 cm rectangular cross section (with the 5 cm dimension into the page) is subjected to a load varying linearly from zero at x = 0 to 5 kN/m at x = 2.5 m. The beam is made of a linear elastic material with Young's modulus E, and a Poisson's ratio $\nu = 0$. The weight of the beam is negligible.

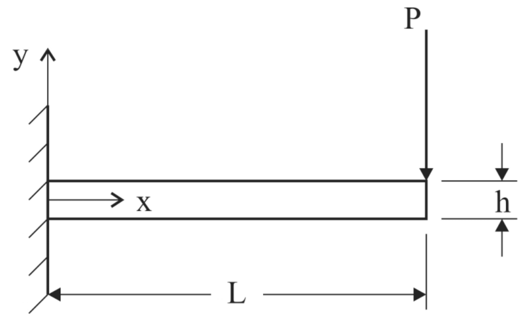


(a) Determine expressions for σ_x, σ_y, and τ_{xy} which satisfy equilibrium and the boundary conditions on both the top and bottom of the beam.

(b) Without using the differential equations of compatibility, determine whether the changes in length of line elements in the x-y plane implied by the stress distribution in part (a) are physically consistent with the changes in angle.

Continuation Sheet for Problem 3

4. A cantilever beam is made of a nonlinear elastic material for which the stress-strain relation is $\sigma = k\varepsilon^{1/7}$. The beam has a rectangular cross section of dimensions b×h, where b is the dimension into the page and b is much smaller than h.

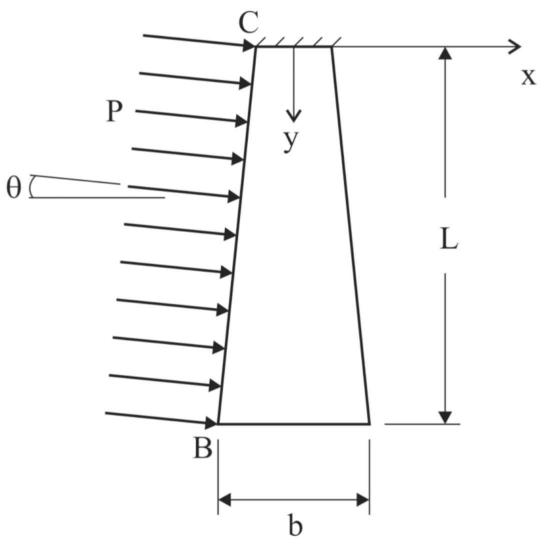


(a) Determine an expression for the stress σ_x in the beam in terms of internal bending moment M, position y, and dimensions b and h. Assume the neutral axis is through the centroid of the cross section.

(b) In class, we derived the expression $\tau = \dfrac{VQ}{It}$ for a beam made of linear elastic material. Now determine the formula (for τ) which replaces this expression in the case of a nonlinear material with $\sigma = k\varepsilon^{1/7}$. Give your final answer in a simple form analogous to the formula $\tau = \dfrac{VQ}{It}$.

Continuation Sheet – Problem 4

5. A trapezoidal plate hanging in a vertical plane is fixed at the top and is subjected to a lateral pressure P = 100 psi, as shown. The plate is made of a material for which the density is β = 0.04 lb/in^3 and the stress-strain relation is $\sigma = k\varepsilon^3$, where $k = 0.5\times10^6$ psi. The plate may be assumed to be in plane stress in the x-y plane, and local effects near the top of the plate may be ignored. YOU ARE REQUIRED TO USE THE COORDINATE SYSTEM SHOWN.



L = 12 in. $\theta = 1°$

b = 1.5 in. P = 100 psi

Plate thickness into page = 0.5 in.

P is perpendicular to boundary BC.

(a) Obtain a formula for the σ_y distribution in the plate. Your formula should be written in terms of only x, y, and numerical values.

(b) Determine the largest and smallest values of σ_y in the plate.

(c) Obtain a formula for τ_{xy} as a function of position along the boundary to which the pressure P is applied.

Continuation Sheet – Problem 5

END OF EXAM