UNIVERSITY OF SASKATCHEWAN
ME 323.3 – MECHANICS OF MATERIALS II
MIDTERM EXAM – FEBRUARY 12, 2009

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: ________________________________ 4. __________

SIGNATURE: ____

Total:

INSTRUCTIONS

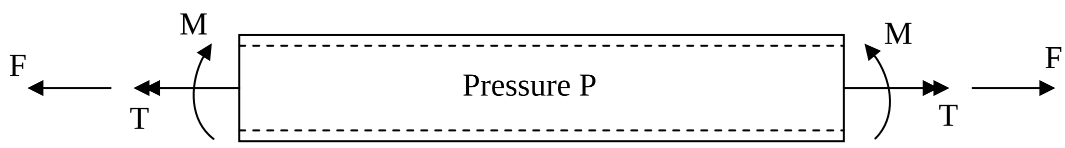
1. The examination consists of 4 questions.
   Answer all FOUR questions.
   The exam is out of a total of 50 marks.
   The number of marks for each question is given in brackets.
   PRINT YOUR NAME AT THE TOP OF EACH PAGE.

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

3. SHOW YOUR WORK NEATLY AND CLEARLY.
   Give final answers to 3 significant figures.
   Neatly place a box around each final answer.

4. Your solutions 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.

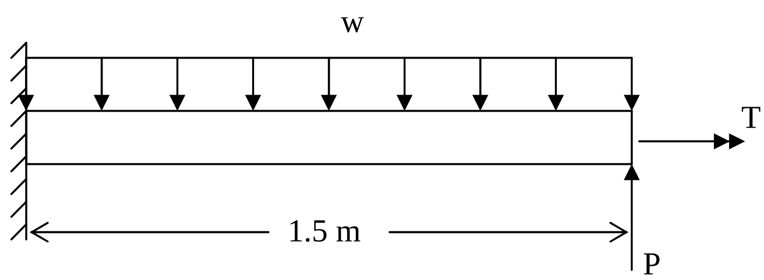
(15) 1. A thin walled pipe has closed ends and is subjected to an internal pressure P = 3 MPa, a torsional load T = 12 kN·m, an axial load F = 20 kN, and bending moment M = 15 kN·m, as shown. The pipe has inner diameter d_i = 230 mm, outer diameter d_o = 240 mm, and is made of a ductile material with yield point σ_{yp} = 120 MPa.



Determine the safety factor according to the von Mises criterion. Use thin wall pressure vessel theory for this problem. Assume the highest von Mises stress occurs at the outer radius of the pipe.

Continuation Sheet - Problem 1

(15) 2. A solid, uniform circular rod of length 1.5 m is fixed at one end, and is subjected to torque T = 2 kN·m and transverse load P = 12 kN, as shown. The rod is also subjected to a uniformly distributed load w = 10 kN/m, as shown.



If the rod is made of a ductile material with yield stress σ_{yp} = 250 MPa, determine the required diameter according to the Tresca theory to achieve a safety factor SF = 2.0. Assume that the only significant stresses are the normal stress due to the maximum bending moment and the shearing stress due to the torque.

Continuation Sheet - Problem 2

(14) 3. A solid aluminum shaft of diameter d = 100 mm initially fits perfectly within a brass cylinder of nominal inner diameter d_i = 100 mm and outer diameter d_0 = 150 mm. Initially, there is no significant gap between the shaft and the cylinder, and the initial interface pressure is zero. The length of contact between the shaft and cylinder is L = 250 mm.

The aluminum has Young's modulus E_a = 70 GPa, Poisson's ratio ν_a = 0.36, and thermal expansion coefficient $\alpha_a = 23.6\times10^{-6}$/°C.

The brass has Young's modulus E_b = 105 GPa, Poisson's ratio ν_b = 0.35, and thermal expansion coefficient $\alpha_b = 20.9\times10^{-6}$/°C.

If the assembly is subjected to a temperature increase ΔT = 30°C and the static coefficient of friction between the aluminum and the brass is μ_s = 0.4, determine the force F necessary to cause axial motion between the mating parts at the new temperature.

Continuation Sheet - Problem 3

(6) 4. Using words and diagrams, give the physical meaning of each term on the left hand side of the differential equation

$$\frac{d\sigma_r}{dr} + \frac{\sigma_r}{r} - \frac{\sigma_\theta}{r} = 0 .$$

Continuation Sheet - Problem 4