National Exams May 2002

Mec-A4 Advanced Strength of Materials

3 Hours Duration

NOTES:

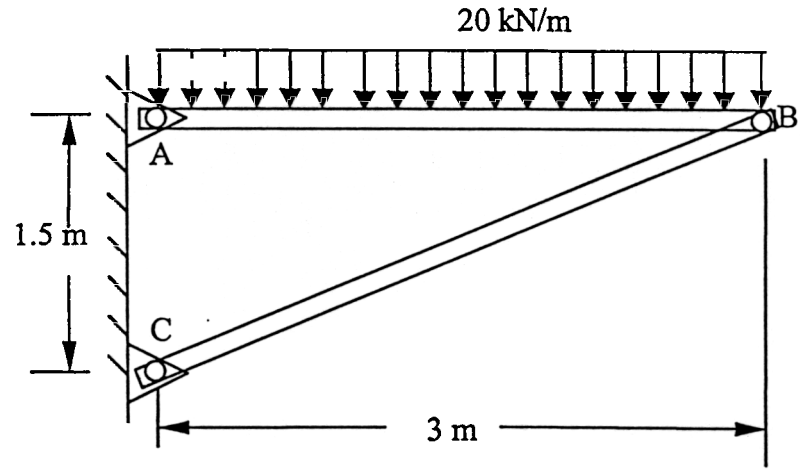
1. If doubts exist as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. Any non-communicating calculator is permitted. This is an open book exam.

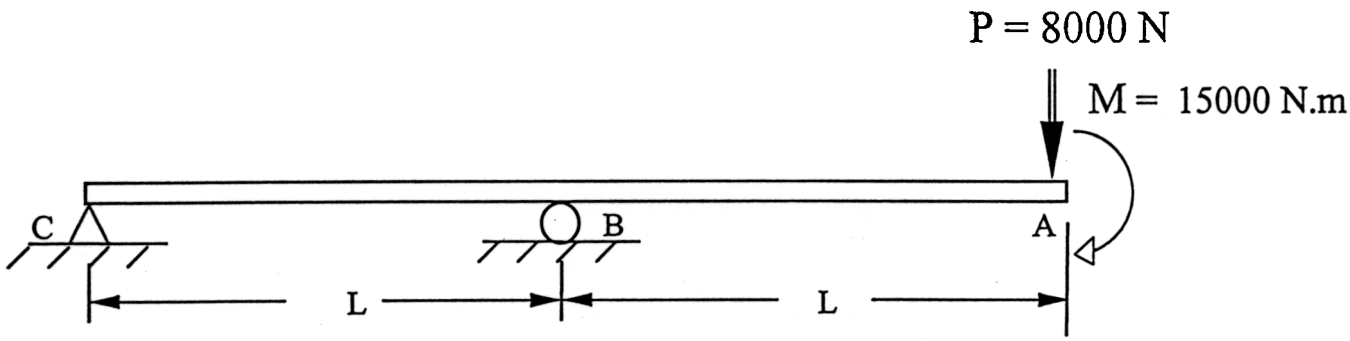
3. Any five of the eight problems constitute a complete paper. If you choose to attempt more than five problems, only the first five problems as they appear in your answer book will be marked.

4. All problems are of equal value.

1- The steel compression strut BC of the frame ABC in the figure below is a steel tube with an outer diameter of 65 mm and a wall thickness of 8 mm. Determine the factor of safety against elastic buckling of BC if a distributed load is applied as shown below. Let E = 210 GPa and $\sigma_{yielding}$ = 300 MPa.




2- Using Castigliano's second theorem, determine the displacement and slope of the free end A of the beam shown below. Take E = 210 GPa, I = 950x10$^6$ mm$^4$, L = 6 m .




3- A thick-walled cylinder with 0.1 m internal diameter and 0.15 m external diameter is fabricated of a material whose elastic limit is 340 MPa and Poisson's ratio $\nu$ = 0.25. The cylinder is subjected to an internal pressure four times greater than the external pressure. Calculate the allowable internal pressure according to:

a) the maximum shear stress theory, and

b) the energy of distortion theory.

4- A two-dimensional strain field is given by

$$\varepsilon_x = c(-3x^2+7y^2) \qquad \varepsilon_y = c(x^2-5y^2) \quad \gamma_{xy} = 16cxy$$

where c is a nonzero constant.

a) Prove that this set of strains satisfies the compatibility conditions.
b) Determine the displacements u(x,y) and v(x,y) corresponding to this field of strain.

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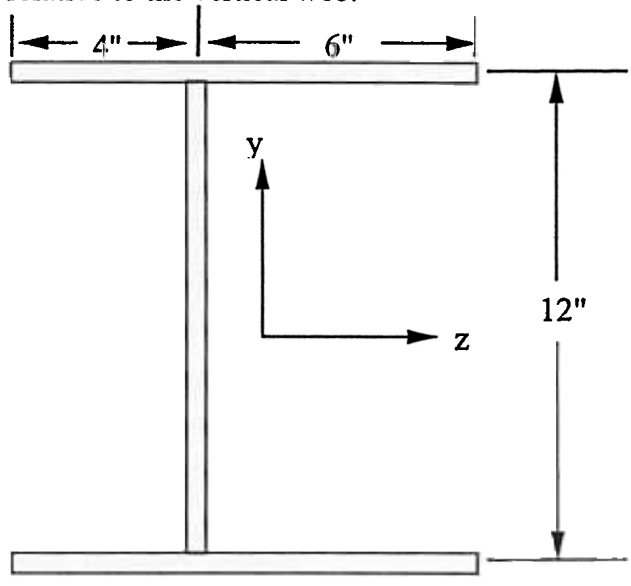
5- The thin-walled open section shown below is subjected to a vertical upward force of 800 lbf acting through the shear center. Upper and lower flanges have a thickness of 0.2 inch and the vertical web has a thickness of 0.3 inch. All the dimensions shown below are median distances.

a) Plot the shear flow distribution in the thin walls of the section and determine the magnitude and location of the maximum shear stress.
b) Locate the shear center relative to the vertical web.

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6- A three element rosette is mounted on a thin steel specimen with a Young's modulus of 210 GPa and a Poisson's ratio of 0.3. The rosette provides the following readings along the 0, 60 and 120 degree directions respectively:

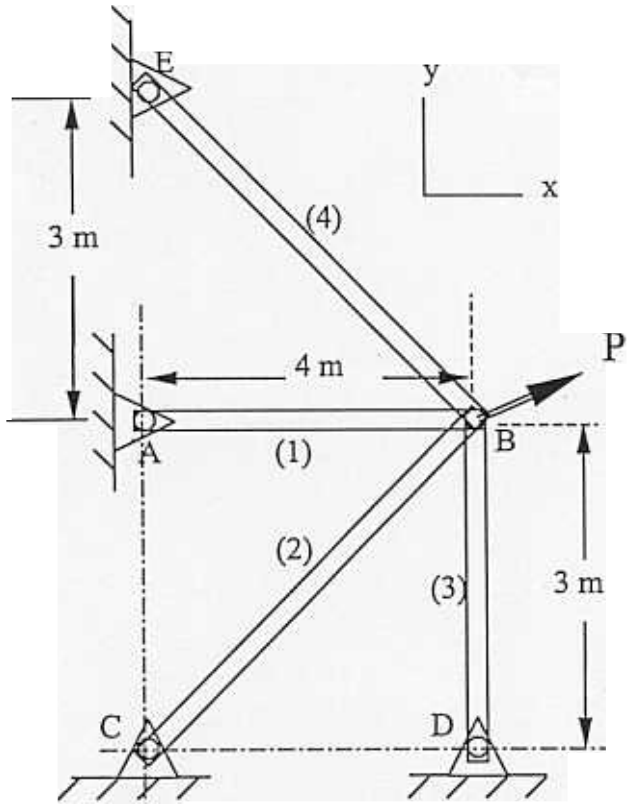
$$\varepsilon_0 = 300\ \mu \qquad \varepsilon_{60} = 1300\ \mu \qquad \varepsilon_{120} = 800\ \mu$$

a) From these readings, calculate $\varepsilon_x$, $\varepsilon_y$ and $\gamma_{xy}$.

b) Determine the principal strains $\varepsilon_1$ and $\varepsilon_2$ and the principal directions.

c) Using the generalized Hooke's law, calculate $\sigma_x$, $\sigma_y$ and $\tau_{xy}$.

7- The force P is applied at joint B of the four-member structure below, at a 30° angle from the horizontal line. Each member has a cross section area A and a modulus of elasticity E . Use an energy method of your choice to determine the member forces $F_1$ to $F_4$ in terms of A, E and P.

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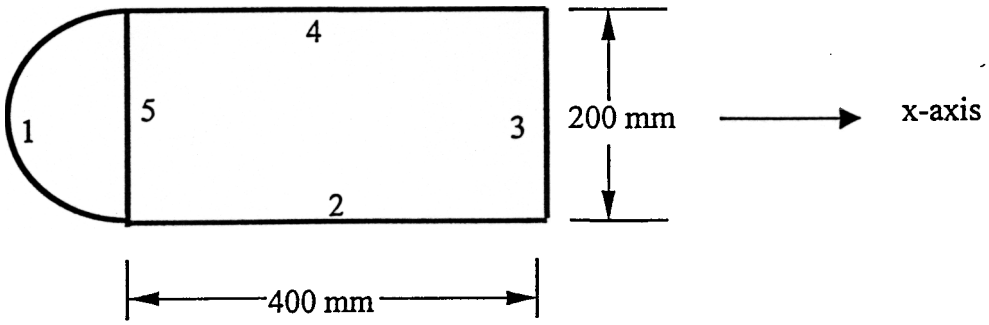
8- The torsion box shown below is symmetric with respect to the x-axis and is subjected to a constant torque T = 25000 N.m acting clockwise.

a) Calculate the shear flow in walls 1, 2, 3, 4 and 5. The thickness of each wall is as follows: $t_1 = 2$ mm, $t_2 = 3$ mm, $t_3 = 2$ mm, $t_4 = 3$ mm and $t_5 = 1.5$ mm. Wall 1 is semi-circular.

b) What is the maximum shear stress and in which wall does it occur?




ALL DIMENSIONS SHOWN ARE MEDIAN DISTANCES