

National Exams December 2012

**07-Mec-A6-2** Advanced Strength of Materials

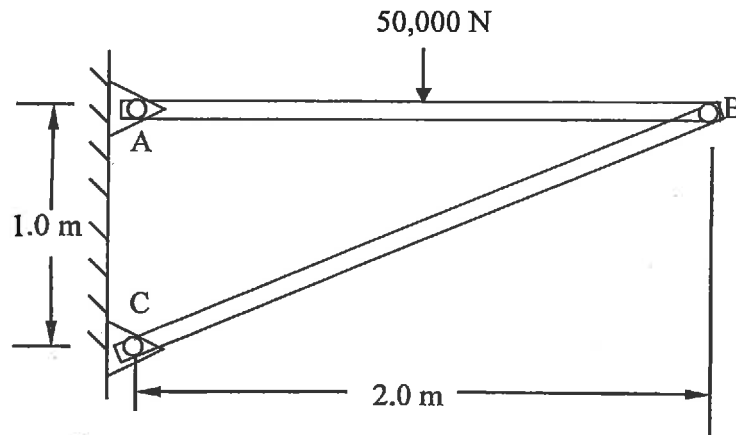
3 Hours Duration

NOTES:

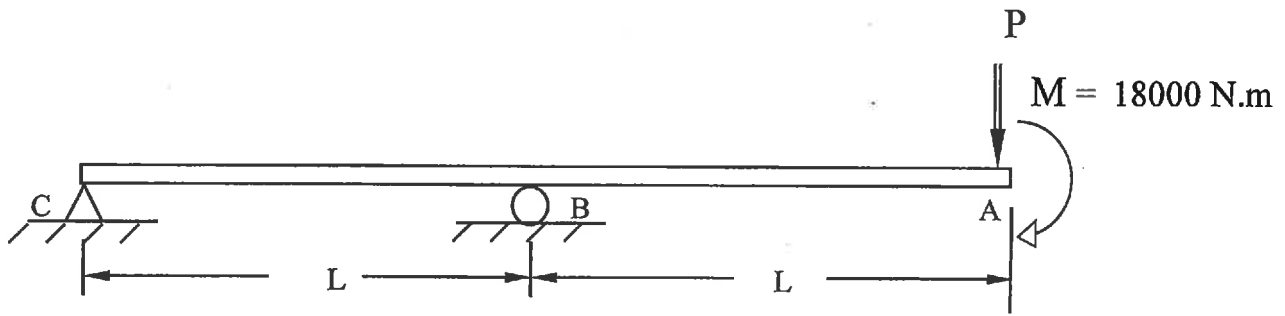
1. If doubts exist as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
2. Any non-communicating calculator is permitted. This is an open book exam.
3. Any five of the eight problems constitute a complete paper. If 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 of tubular cross section with an outer diameter of 50 mm and a wall thickness of 5 mm.

- Determine the factor of safety against elastic buckling of BC if the 50,000 N load shown below is applied at the mid point between A and B. Let  $E = 210 \text{ GPa}$  and  $\sigma_{\text{yielding}} = 300 \text{ MPa}$ .
- What is the wall thickness that BC can have if the buckling safety factor was 3?



2- Determine the magnitude and direction (up or down) of the force  $P$  applied at point A of the beam below if the displacement at A was not to exceed 2 mm (down). Take  $E = 210 \text{ GPa}$ ,  $I = 750 \times 10^6 \text{ mm}^4$ ,  $L = 4 \text{ m}$ .



3- A thick-walled cylinder with 0.24 m internal diameter and 0.40 m external diameter is fabricated of a material whose elastic limit is 250 MPa and Poisson's ratio  $\nu = 0.28$ . The cylinder is subjected to an internal pressure five times greater than the external pressure. Calculate the allowable internal pressure according to:

- the maximum shear stress theory, and
- the energy of distortion theory.

4- A two-dimensional strain field is given by

$$\epsilon_x = c(-3x^2 + 7y^2) \quad \epsilon_y = c(x^2 - 5y^2) \quad \gamma_{xy} = bxy$$

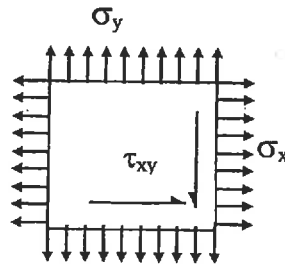
where b and c are nonzero constants.

- What is the relationship between b and c for this field to satisfy the strain compatibility conditions?
- Determine the displacements  $u(x,y)$  and  $v(x,y)$  corresponding to this field of strain.

5- The state of plane stress shown below is defined by the following stresses:

$$\sigma_x = 200 \text{ MPa} \quad \sigma_y = 50 \text{ MPa} \quad \text{and} \quad \tau_{xy} = -100 \text{ MPa}$$

- Show this state of stress on a properly constructed Mohr's circle.
- Will the above stress condition cause yielding according to the maximum shear stress theory? Assume  $\sigma_{\text{yielding}} = 220 \text{ MPa}$ .
- Determine  $\sigma_{x'}$  and  $\tau_{xy'}$  on an element rotated 30 degrees clockwise from the x-axis.

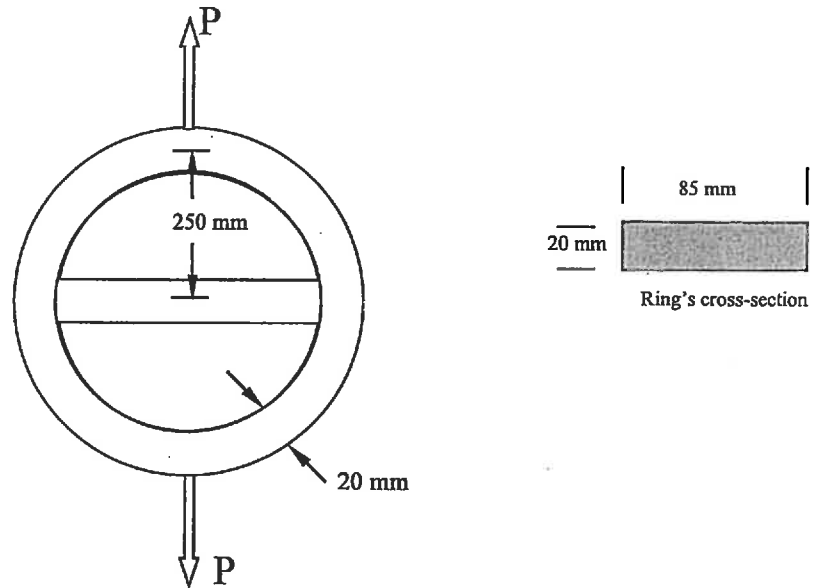


6- A three element rosette is mounted on a thin steel specimen with a Young's modulus of 190 GPa and a Poisson's ratio of 0.3. The rosette provides the following readings along the 0, 60 and 120 degree directions respectively:

$$\epsilon_0 = 500 \mu \quad \epsilon_{60} = 1000 \mu \quad \epsilon_{120} = 600 \mu$$

- From these readings, calculate the strains  $\epsilon_{x'}$ ,  $\epsilon_{y'}$  and  $\gamma_{xy'}$  along the +45 degree direction.
- Determine the principal strains  $\epsilon_1$  and  $\epsilon_2$  and the principal directions.
- Using the generalized Hooke's law, calculate  $\sigma_x$ ,  $\sigma_y$  and  $\tau_{xy}$ .

7- The figure below shows a steel ring of 250 mm mean radius and a uniform rectangular section of 85 mm wide and 20 mm thick. A rigid bar is fitted horizontally as shown. Assuming an allowable stress of 230 MPa, determine the maximum tensile force  $P$  that can be carried by the ring.



8- The rods 1, 2, and 3 shown below are welded together, mounted between two rigid walls and subjected to the two forces shown at points B and C. The rods are all of the same length, namely  $L = 1$  m. Rods 1 and 3 are made from a material with  $E = 70 \times 10^9$  Pa. Rod 2 is made from a material with  $E = 120 \times 10^9$  Pa. The cross sections are given by:  $A_1 = A_3 = 40 \times 10^3$  mm<sup>2</sup> and  $A_2 = 80 \times 10^3$  mm<sup>2</sup>. Determine the displacements of points B and C.

