National Exams May 2003

98-Mec-A4 Advanced Strength of Materials

3 Hours Duration

NOTES:

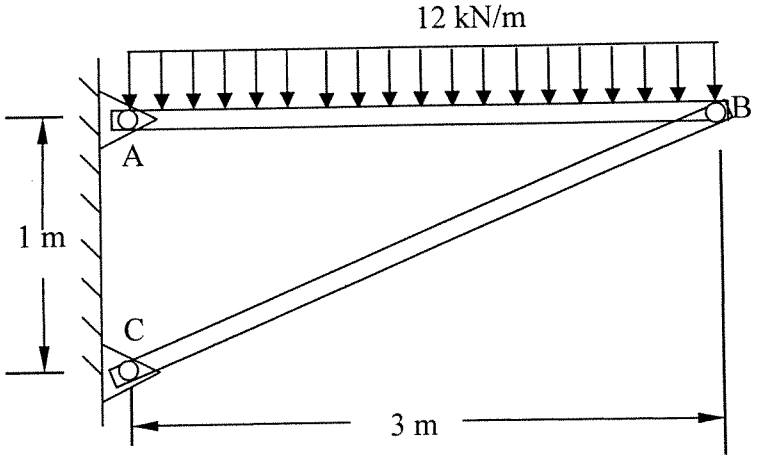
1. If doubts exist as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made;

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

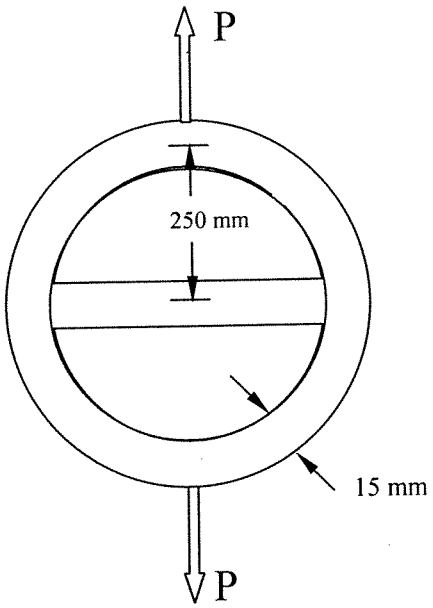
3. Any five of the eight problems constitute a complete paper. If you chose to attempt more than five problems, only the first five problems as they appear in your answer book will be marked.

4. All problems are of equal value.

1. The compression strut BC of the frame ABC in the figure below is a tube 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 a distributed load is applied as shown below. Let E = 180 GPa and $\sigma_{yielding}$ = 280 MPa.



2. The figure below shows a steel ring of 500 mm mean diameter and of uniform rectangular section 85 mm deep and 15 mm thick. A rigid bar is fitted horizontally as shown. Assuming an allowable stress of 150 MPa, determine the maximum tensile force P that can be carried by the ring.

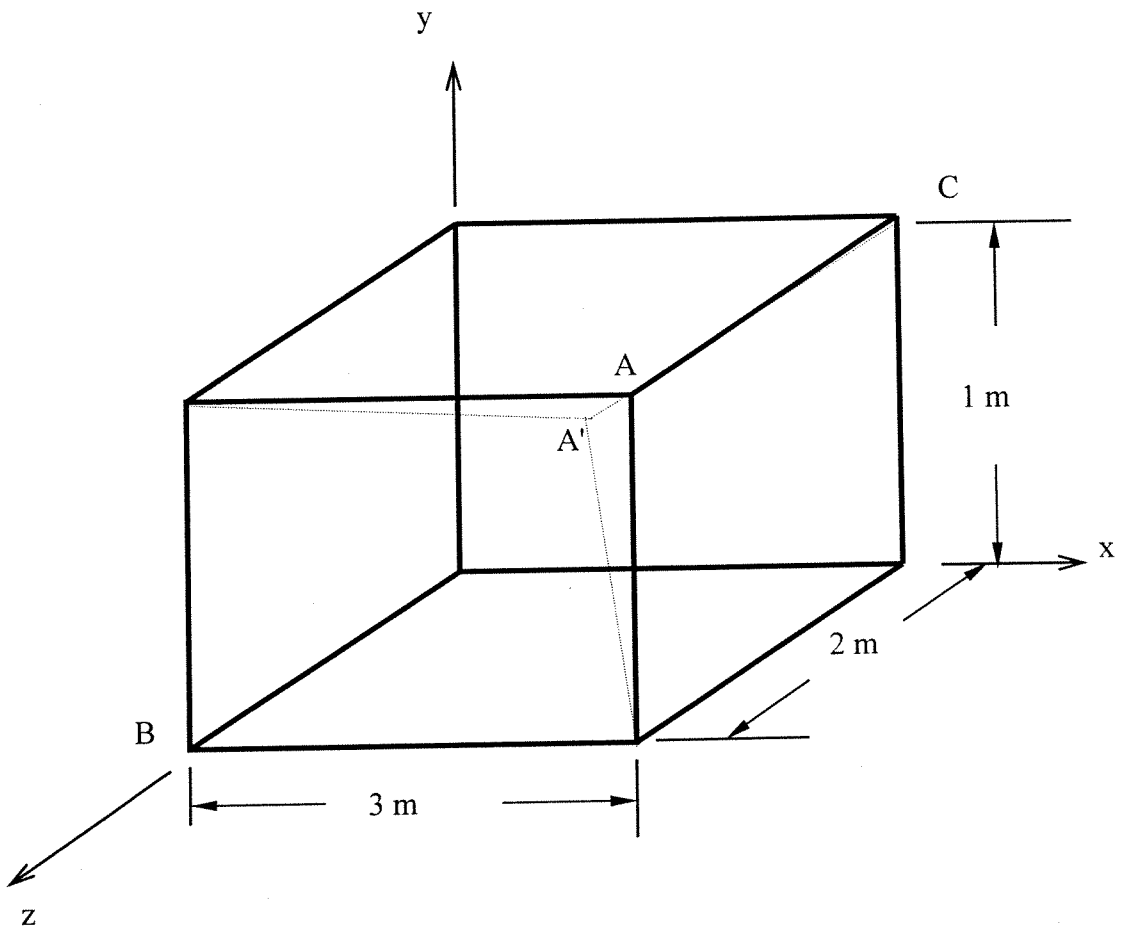


3. Under a given load, the 3 m by 2 m by 1m parallelepiped shown below is deformed by movement of corner point A to a new location A' with coordinates (2.9985, 0.9988, 2.0009). The displacement field is given by

$$u = c_1xyz \qquad v = c_2xyz \qquad w = c_3xyz$$

Where c_1, c_2, c_3 are constants.

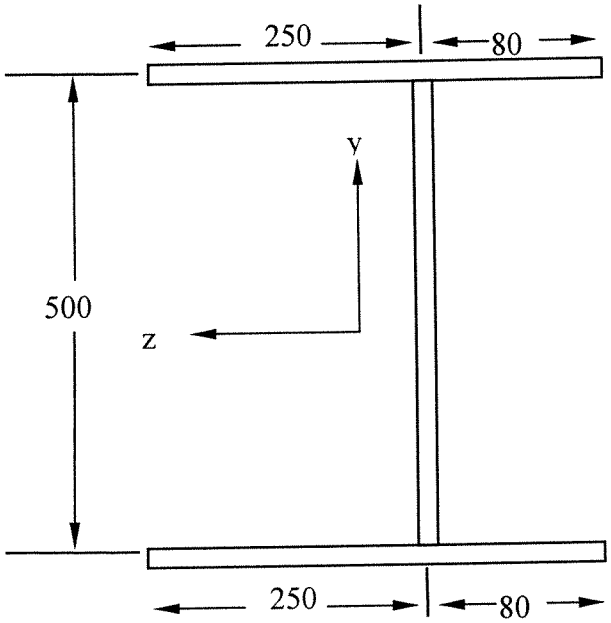
a- Determine ε_y, ε_z, γ_{xy}, γ_{xz} and γ_{yz}
b- Calculate the normal strain in the direction of line AB
c- Obtain the shear strain for perpendicular lines AB and AC.



4. The thin-walled open section shown below is subjected to a vertical downward force of 9000 N acting through the shear center.

a) Plot the shear flow distribution around the walls of the section and determine the magnitude of the maximum shear flow. All of the walls have a thickness of 20 mm. All the dimensions are to the medians of the flanges and webs.

b) Locate the shear center relative to the vertical web.



All dimensions are in mm.

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5. A state of plane stress is defined by the following stresses:

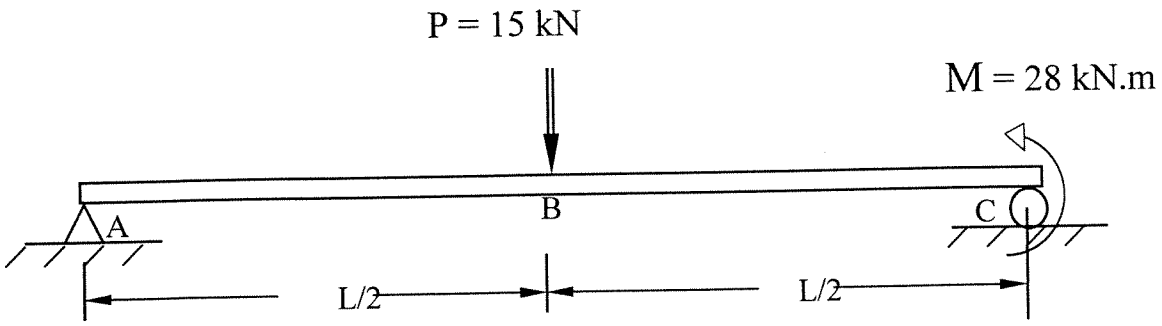
$\sigma_x = 250$ MPa $\quad \sigma_y = 100$ MPa $\quad$ and $\quad \tau_{xy} = -50$ MPa

a- Show this stress state on a Mohr's circle and use the circle to estimate the magnitude of the principal stresses and the maximum shear stress.

b- Recalculate the principal stresses and maximum shear stress using the stress transformation equations.

c- Determine the normal and shear stresses on an element rotated 75 degrees clockwise from the x-axis.

6. Using Castigliano's second theorem, determine the slope at the point of support A and the displacement of point B of the simply supported beam shown below. Take E = 190 GPa, $I = 500 \times 10^6$ mm^4, L = 10 m.



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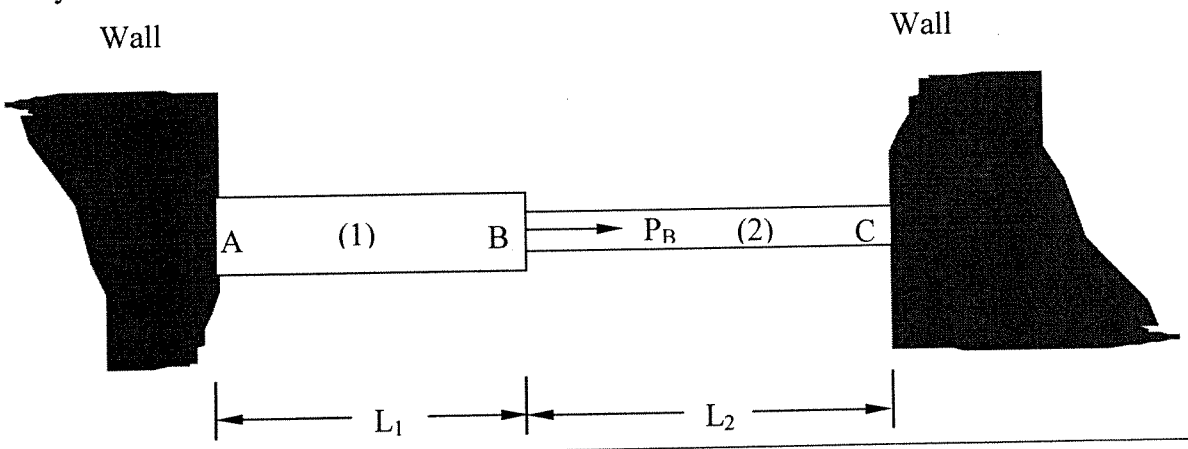
7. For the two-segment rod rigidly supported between the two walls, determine:

a- the displacement at point B, and
b- the internal forces in rods 1 and 2.

Leave your answers as a function of P_B, A_1, E_1, L_1 A_2, E_2, and L_2 .



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8. A thick-walled cylinder with 0.20 m internal diameter and 0.4 m external diameter is fabricated of a material whose elastic limit is 250 MPa and Poisson's ratio $\nu = 0.28$.

a) Determine for an external pressure $p_o = 0$ the maximum internal pressure to which the cylinder may be subjected according to the maximum shear stress theory.

b) Determine for an internal pressure $p_i = 0$ the maximum external pressure to which the cylinder may be subjected according to the maximum distortion energy criterion.
