



National Exams December 2002

Mec-A4 Advanced Strength of Materials

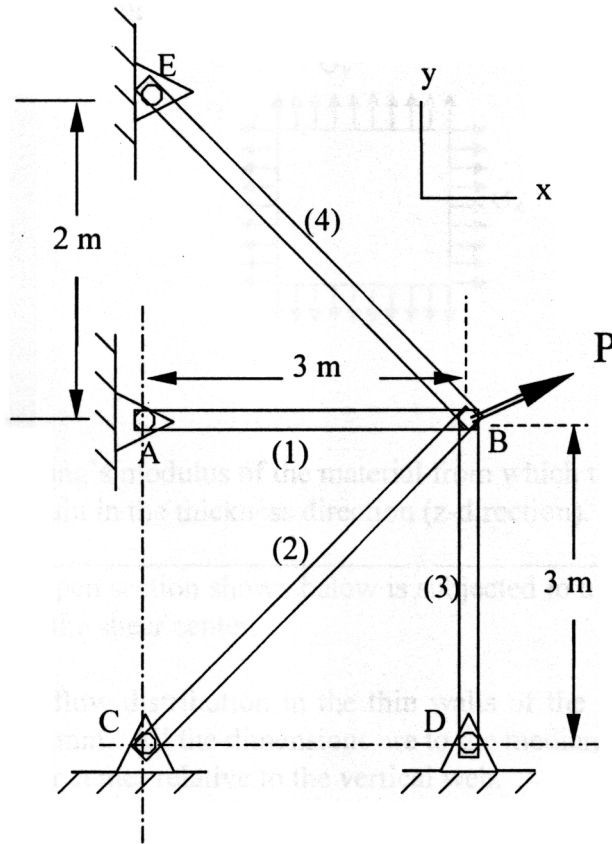
3 Hours Duration

NOTES:

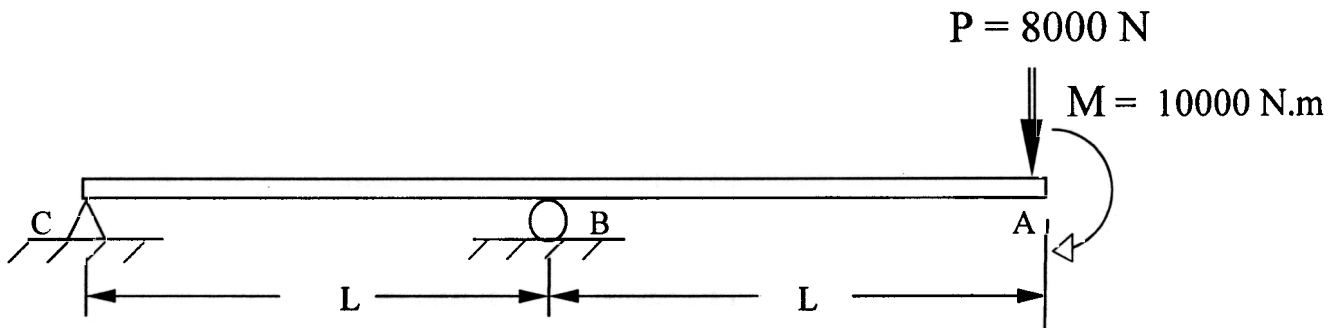
If doubts exist as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made;

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.

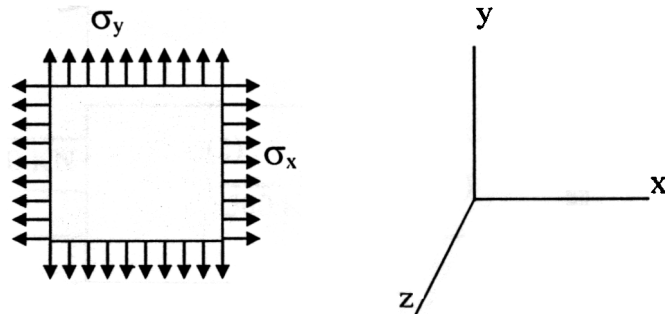
- The force P is applied at joint B of the four-member structure below, at a 20° angle from the horizontal line. Each member has a cross section area A and a modulus of elasticity E . Use an energy method of your choice to determine the member forces F_1 to F_4 .
Use $A = 100 \text{ mm}^2$ $E = 200 \text{ GPa}$ $P = 5000 \text{ N}$



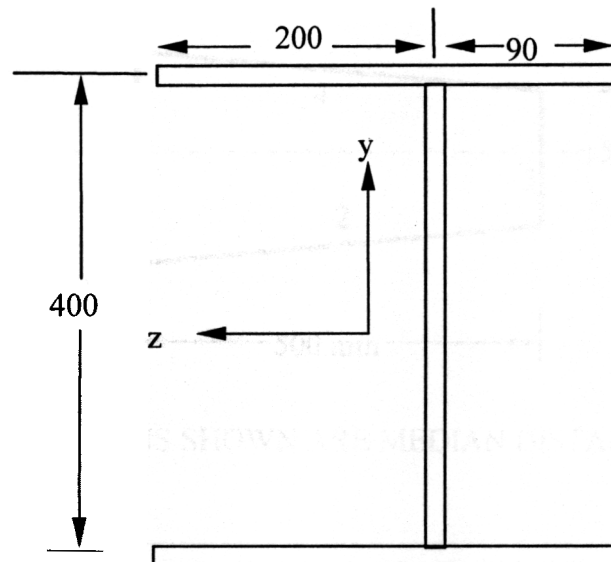
- Determine the slope at the point of support A and the displacement of point B of the simply supported beam shown below. Take $E = 200 \text{ GPa}$, $I = 150 \times 10^6 \text{ mm}^4$, $L = 8 \text{ m}$.



3. A thin square plate of one meter by one meter is subjected to a state of plane stress represented by uniform normal stresses σ_x and σ_y as illustrated below. All other stresses are zero. The two stresses shown cause the plate to elongate by 0.2 mm in the x direction and by 0.1 mm in the y direction. If it is known that σ_y is equal to 100 MPa and the Poisson's ratio ν is equal to 0.28 and that all deformations are in the linear-elastic range:

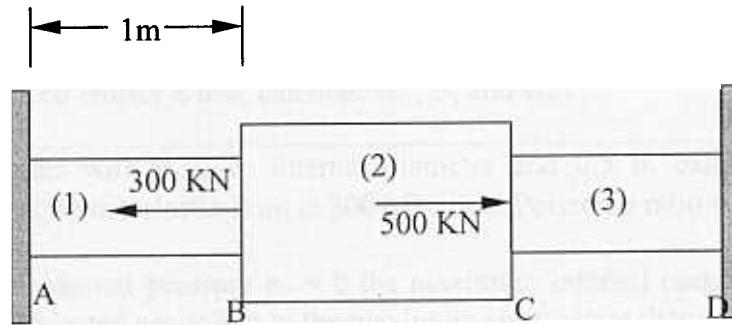


- Calculate σ_x
 - Calculate the Young's modulus of the material from which the square is made
 - Determine the strain in the thickness direction (z-direction).
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4. The thin-walled open section shown below is subjected to a vertical downward force of 8000 N acting through the shear center.
- Find the shear flow distribution in the thin walls of the section. All of the walls have a thickness of 50 mm. All the dimensions are to the medians of the flanges and webs.
 - Locate the shear center relative to the vertical web.

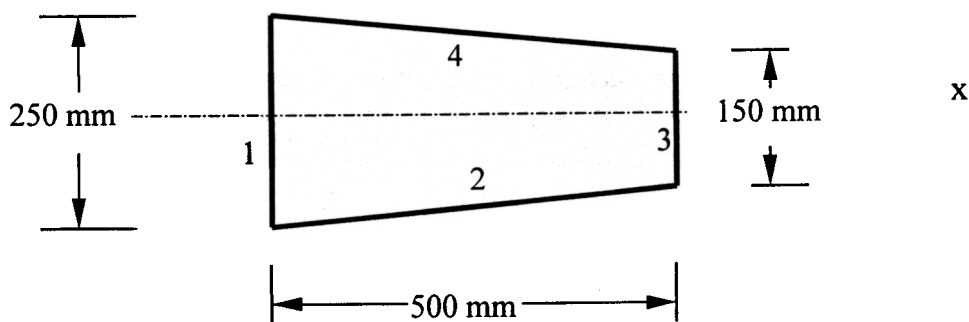


All dimensions are in mm

5. 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 $E = 200 \times 10^9$ Pa. Rod 2 is made from a material with $E = 70 \times 10^9$ Pa. The cross sections are given by: $A_1 = A_3 = 30 \times 10^3$ mm² and $A_2 = 50 \times 10^3$ mm². Determine the displacements of points B and C.



6. The torsion box shown below is symmetric with respect to the x-axis and is subjected to a constant torque $T = 250000$ N.m acting clockwise.
- Calculate the shear flow q in walls 1, 2, 3 and 4. The thickness of each wall is as follows: $t_1 = 2$ mm, $t_2 = 4$ mm, $t_3 = 3$ mm, $t_4 = 5$ mm.
 - What is the maximum shear stress and in which wall does it occur?
 - Calculate the twist per unit length of the box. Let G of the material be 50 GPa.



ALL DIMENSIONS SHOWN ARE MEDIAN DISTANCES

7. A three element rosette is mounted on a thin steel specimen with a Young's modulus of 200 GPa and a Poisson's ratio of 0.3. The rosette provides the following readings along the 0, 60 and 120 degree directions respectively:

$$\varepsilon_0 = 150 \mu \quad \varepsilon_{60} = 400 \mu \quad \varepsilon_{120} = 450 \mu$$

- a) From these readings, calculate ε_x , ε_y and γ_{xy} .
 - b) Determine the principal strains ε_1 and ε_2 and the principal directions.
 - c) Using the generalized Hooke's law, calculate σ_x , σ_y and τ_{xy} .
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8. A thick-walled cylinder with 0.30 m internal diameter and 0.5 m external diameter is fabricated of a material whose elastic limit is 300 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.
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