

National Exams May 2009

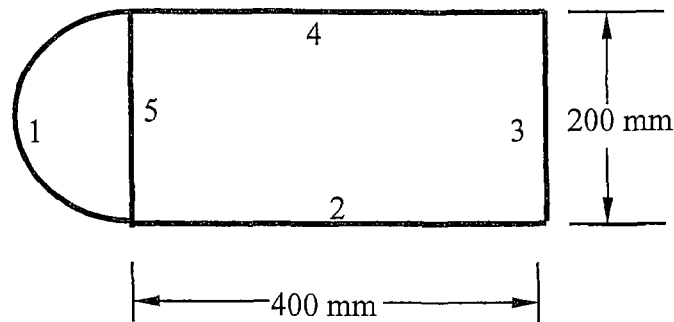
07-Mec-A6-2 Advanced Strength of Materials

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 torsion box shown below is subjected to a constant torque $T = 20000 \text{ N m}$ acting clockwise. The thickness of each wall is as follows $t_1 = 2 \text{ mm}$, $t_2 = 3 \text{ mm}$, $t_3 = 2 \text{ mm}$, $t_4 = 3 \text{ mm}$ and $t_5 = 1.5 \text{ mm}$. Wall 1 is semi-circular
- a- Calculate the shear flow in walls 1, 2, 3, 4 and 5
- b- What is the maximum shear stress and in which wall does it occur?



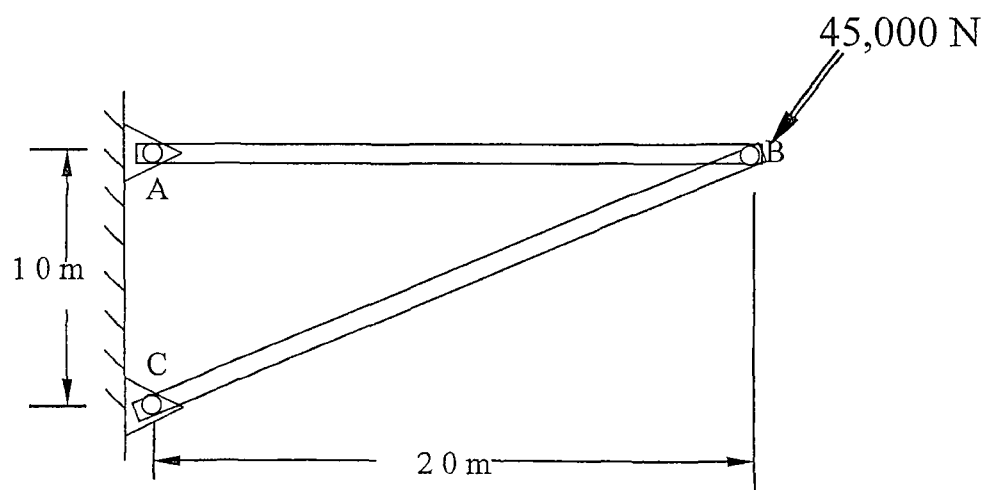
- 2- A state of plane stress is defined by the following stresses

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

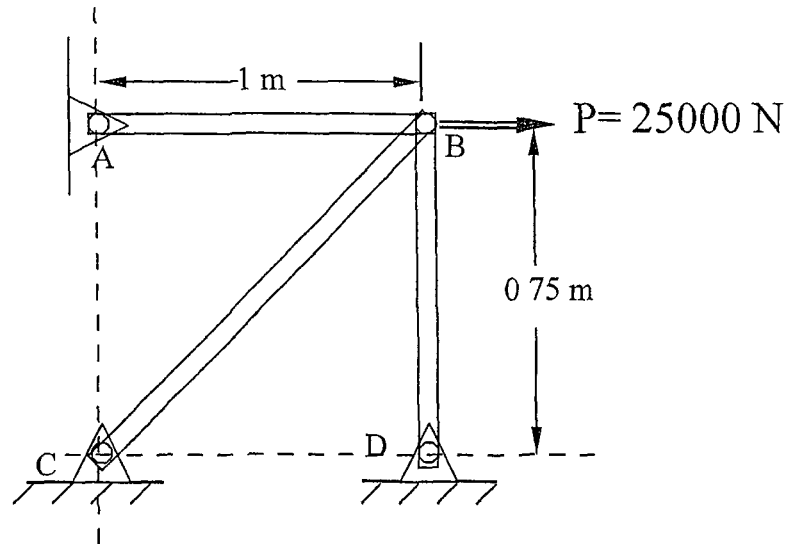
- a- Determine the corresponding principal stresses and principal directions
- b- Will the above stress condition cause yielding according to the Von-Mises Criterion if $\sigma_{\text{yielding}} = 290 \text{ MPa}$?
- c- Determine σ_x and τ_{xy} on an element rotated 40 degrees clockwise from the x -axis

- 3- The frame ABC is made of bars having tubular cross sections with an outer diameter of 55 mm and a wall thickness of 7 mm. AB and BC are made of materials with yielding stresses of 290 MPa and 320 MPa and Young's moduli of 170 GPa and 210 GPa, respectively

- a- Determine the factors of safety against elastic buckling of AB and BC if a compressive force of 45,000 N **making a 60 degree angle with the horizontal** is applied at point B
- b- What would the wall thickness of BC have to be to meet a buckling safety factor of 1.5?

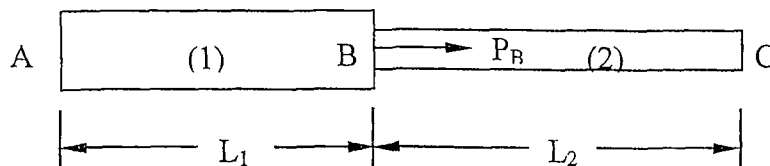


- 4- A 25000 N force is applied horizontally at joint B of the three-element, pin-jointed truss shown below. Each member has a circular cross section of 740 mm^2 and a modulus of elasticity $E = 75 \text{ GPa}$. Use the principle of virtual work to solve for the following:
- the horizontal displacement u at joint B, and
 - the vertical displacement v at joint B.



- 5- A thick-walled cylinder with 0.25 m internal diameter and 0.45 m external diameter is fabricated of a material whose elastic limit is 325 MPa. Let $\nu = 0.30$.
- Determine for an external pressure $p_o = 0$ the maximum internal pressure to which the cylinder may be subjected without exceeding the elastic limit.
 - Determine for an internal pressure $p_i = 0$ the maximum external pressure to which the cylinder may be subjected without exceeding the elastic limit.

- 6- The two-segment rod is rigidly supported at A and C. Leaving your answers as a function of P_B , A_1 , E_1 , L_1 , A_2 , E_2 , and L_2 , determine:
- the displacement at point B, and
 - the internal forces in rods 1 and 2.



7- 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 . All other stresses are zero. The two stresses cause the plate to elongate by 0.15 mm in the x direction and by 0.1 mm in the y direction. If it is known that σ_y is equal to 150 MPa and ν is equal to 0.33 and that all deformations are in the linear-elastic range

- a- Calculate σ_x
- b- Calculate the Young's modulus of the material from which the square is made
- c- Determine the strain in the thickness direction (z-direction)

8- A triaxial state of stress is schematically shown below (only one component of each stress is shown)

- a- Show this state of stress on a properly constructed Mohr circle
- b- Determine the principal stresses corresponding to this state of stress
- c- Determine the maximum shear stress

