National Exams May 2015

07-Mec-A6-2 Advanced Strength of Materials

3 Hours Duration

NOTES:

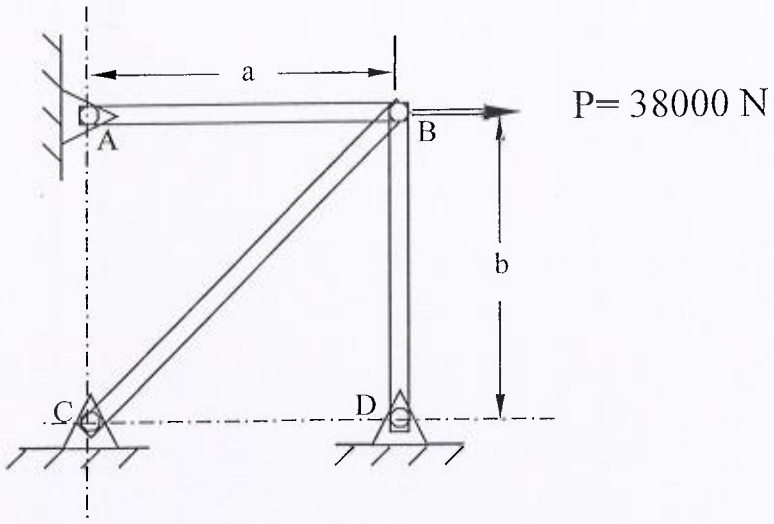
1. If doubts exist as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

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. A 38000 N force is applied horizontally at joint B of the three-element, pin-joined truss shown below. Cross sections for all members are of 9 cm^2 , a = 80 cm , b = 100 cm and E = 180 GPa. Determine the horizontal displacement u and the vertical displacement v at joint B



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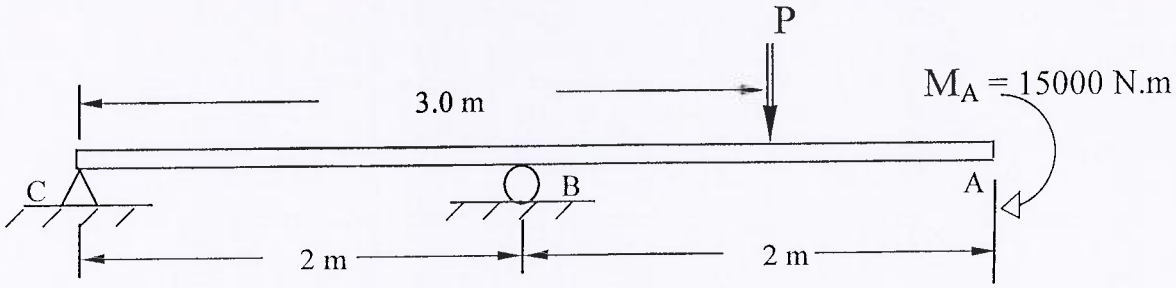
2. Determine the magnitude and direction (up or down) of the force P if the displacement at A is not to exceed 7 mm (down). Take E = 180 GPa and I = 805×10^6 mm^4.



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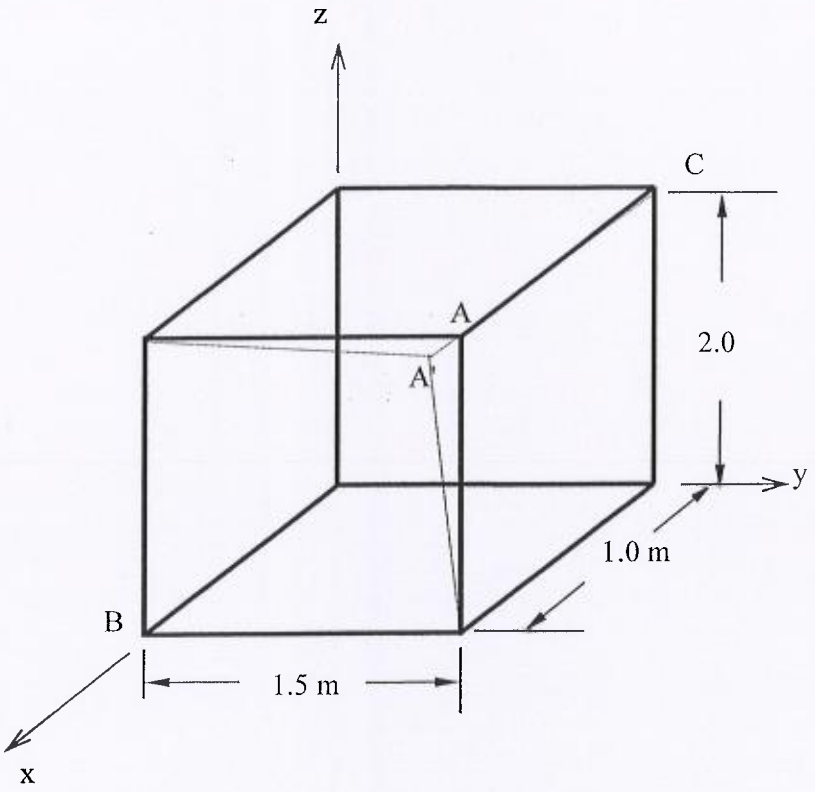
3. A thick-walled cylinder with 0.22 m internal diameter and 0.36 m external diameter is fabricated of a material whose elastic limit is 330 MPa and Poisson's ratio ν = 0.31. The cylinder is subjected to an internal pressure six times greater than the external pressure. Calculate the allowable internal pressure according to:

a. the maximum shear stress failure criterion, and
b. the Von-Mises failure criterion.

4. Under a given load, the 1.0 m by 1.5 m by 2.0 m parallelepiped shown below is deformed by movement of corner point A to a new location A' with coordinates (0.9955, 1.4982, 1.9997). If the displacement field is given by: $u = c_1xyz$ $v = c_2xyz$ $w = c_3xyz$

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



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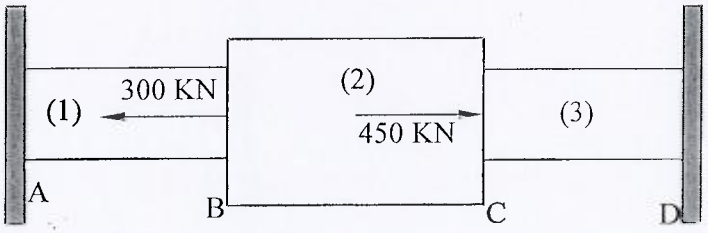
5. The rods 1, 2, and 3 shown below are welded together, mounted between two rigid walls and subjected to the two forces shown at joints B and C. Rods 1 and 3 are of the same length, $L_1 = L_3 = 1.5$ m and rod 2 has a length $L_2 = 2.0$ m. Rods 1 and 3 are made from a material with E = 145 GPa. Rod 2 is made from a material with E = 77 GPa. The cross sections are given by: $A_1 = A_3 = 12x10^3$ mm^2 and $A_2 = 20x10^3$ mm^2. Determine the displacements of joints B and C.



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

$$\sigma_x = 180 \text{ MPa} \qquad \sigma_y = 80 \text{ MPa} \qquad \text{and} \qquad \tau_{xy} = -60 \text{ MPa}$$

a. Assuming $\sigma_{yielding} = 275$ MPa, will this stress condition cause yielding according to the Von Mises Criterion?
b. Determine $\sigma_{x'}$ and $\tau_{xy'}$ on an element rotated 60 degrees clockwise from the x-axis.

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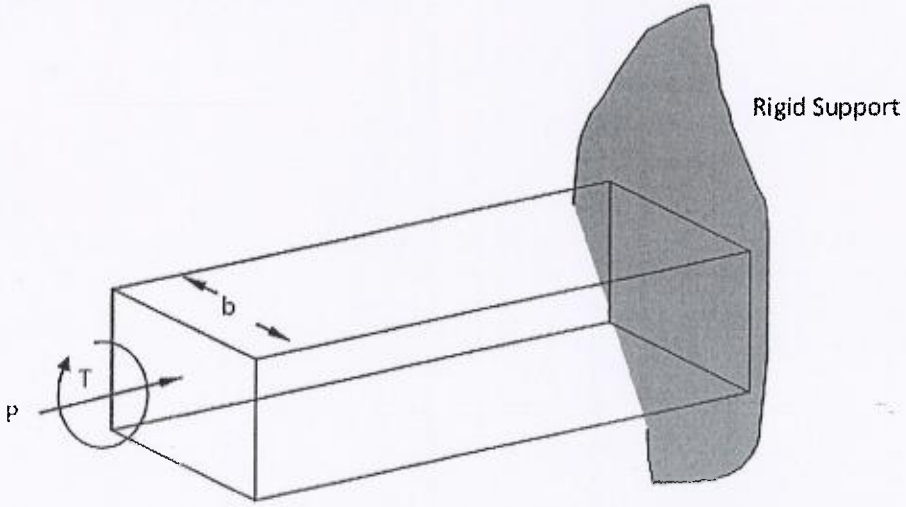
7. A metallic alloy bar of solid square cross-section ($\sigma_{yielding} = 310$ Mpa) is subjected to a compressive axial force of magnitude P = 195 KN acting at the centroid of the section and a torque T = 17 KN.m. as shown in the figure below. This member is to be designed in accordance with the maximum-shear-stress failure criterion, with a safety factor of 3.

a. What is the minimum allowable cross-sectional dimension b?
b. What would your answer be if the load P was applied at the same point but parallel instead of normal to the cross section?



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8. A three element rosette is mounted on an thin elastic plate with a Young's modulus of 60 GPa and a Poisson's ratio of 0.35. The rosette provides the following readings along the 0, 45 and 90 degree directions respectively:

$$\varepsilon_0 = 600\ \mu \qquad \varepsilon_{45} = 400\ \mu \qquad \varepsilon_{90} = 500\ \mu$$

a. From these readings, calculate the strains $\varepsilon_{x'}$, $\varepsilon_{y'}$ and $\gamma_{xy'}$ along the +45 degree direction.
b. Determine the principal strains ε_1 and ε_2 and the principal directions.
c. Determine σ_x, σ_y and τ_{xy}.