National Exams May 2017

**16-Mec-A7** 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 thick-walled cylinder with 0.20 m internal diameter and 0.32 m external diameter is fabricated of a material whose yielding strength $\sigma_{yield}$ is 315 MPa and Poisson's ratio $\nu$ is 0.29. The cylinder is subjected to an internal pressure ten times greater than the external pressure. Calculate the allowable internal pressure according to:

a. The Von-Mises failure criterion
b. The Tresca failure criterion

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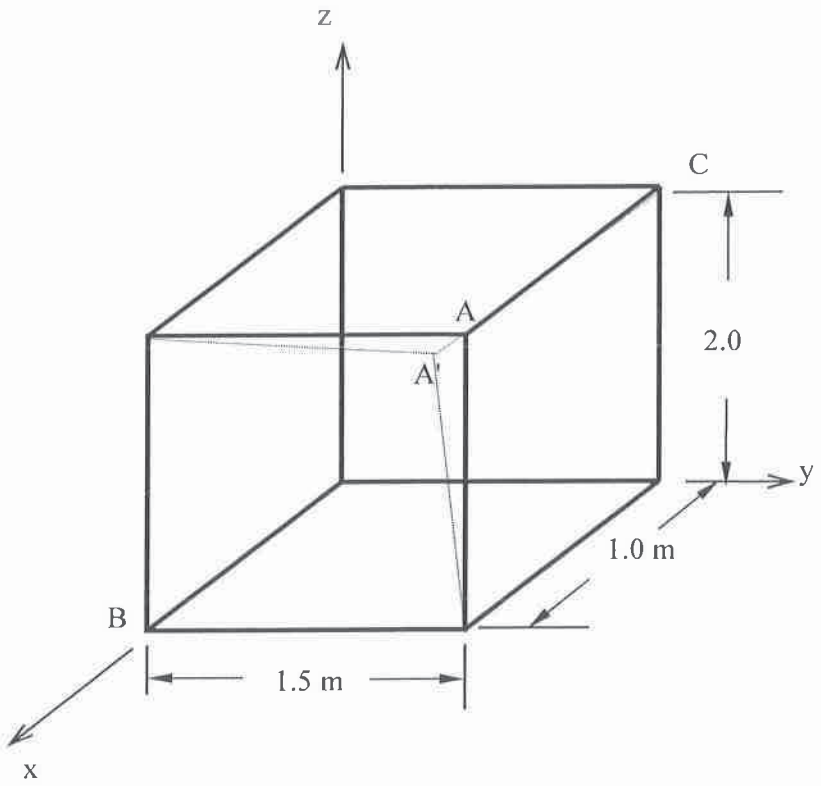
2. Under a given load, the 1.0 m by 1.5 m by 2.0 m parallelepiped shown below is deformed by movement of corner point A to a new location A' with coordinates (0.9958, 1.4980, 1.9992). If the displacement field is given by: $u = c_1xyz$ $v = c_2xyz$ $w = c_3xyz$

a. Determine $\varepsilon_x$, $\varepsilon_y$, $\varepsilon_z$, $\gamma_{xy}$, $\gamma_{xz}$ and $\gamma_{yz}$
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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3. A thin metallic alloy plate is subjected to the following stresses:

$\sigma_x = 180$ MPa $\sigma_y = 160$ MPa and $\tau_{xy} = -100$ MPa

a. If the yielding strength of the alloy is 402 MPa, what is the factor of safety against yielding according to the Von Mises Criterion?
b. Answer (a) using the maximum shear stress criterion.

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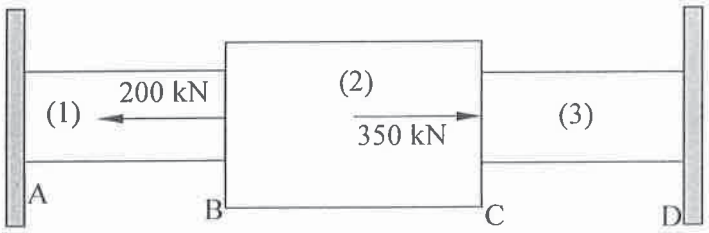
4. The rods 1, 2, and 3 shown below are welded together, mounted between two rigid walls and subjected to the two forces shown at joints B and C. Rods 1 and 3 are of the same length, $L_1 = L_3 = 1.0$ m and rod 2 has a length $L_2 = 1.8$ m. Rods 1 and 3 are made from a material with E = 70 GPa. Rod 2 is made from a material with E = 100 GPa. The cross sections are given by: $A_1 = A_3 = 11 \times 10^3$ mm$^2$ and $A_2 = 17 \times 10^3$ mm$^2$. Determine the displacements of joints B and C.

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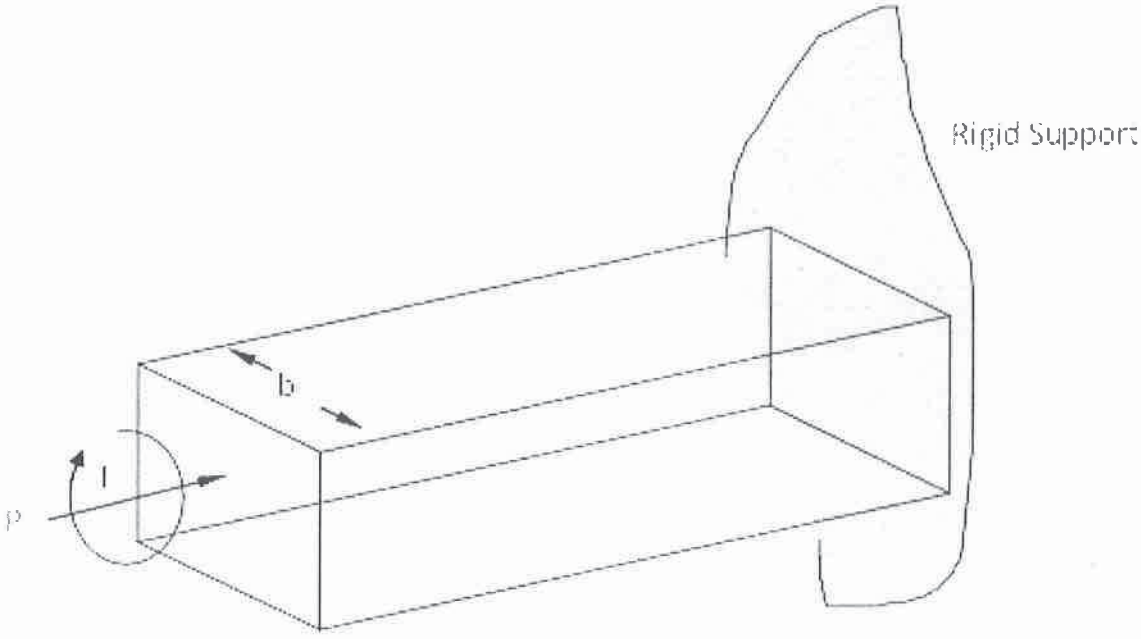
5. A metallic alloy bar of solid square cross-section ($\sigma_{yielding} = 350$ MPa) is subjected to a compressive axial force of magnitude P = 171 kN acting at the centroid of the section and a torque T = 19 kN.m. as shown in the figure below. This member is to be designed in accordance with the Tresca failure criterion, with a safety factor of 5.

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?



6. A three element rosette is mounted on a thin elastic plate with a Young's modulus of 75 GPa and a Poisson's ratio of 0.32. The rosette provides the following readings along the 0, 45 and 90 degree directions respectively:

$$\varepsilon_0 = 800\ \mu \qquad \varepsilon_{45} = 600\ \mu \qquad \varepsilon_{90} = 400\ \mu$$

a. From these readings, calculate the strains $\varepsilon_{x'}$, $\varepsilon_{y'}$ and $\gamma_{xy'}$ along the +60 degree direction.
b. Determine the principal strains $\varepsilon_1$ and $\varepsilon_2$ and the principal directions.
c. Determine $\sigma_x$, $\sigma_y$ and $\tau_{xy}$ .

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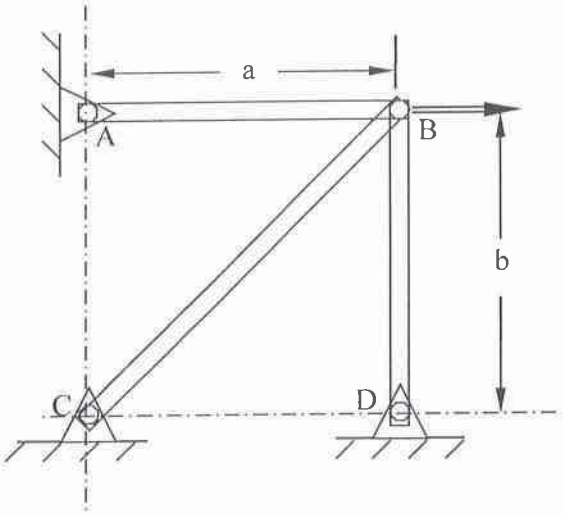
7. A 58000 N force is applied horizontally at joint B of the three-element, pin-joined truss shown below. Cross sections for all members are of 12 $cm^2$, a = 100 cm, b = 120 cm and E = 180 GPa. Determine the horizontal displacement u and the vertical displacement v at joint B

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8. Determine the magnitude and direction (up or down) of the force P if the displacement at A is not to exceed 10 mm (down). Take E = 210 GPa and I = 995x$10^6$ $mm^4$.