

National Exams December 2018

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 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 thin square plate of 1.5 m by 1.5 m 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 0.75 mm in the x direction and by 0.25 mm in the y direction. If it is known that σ_y is equal to 60 MPa and ν is equal to 0.32 and that all deformations are in the linear-elastic range, determine:
- the stress σ_x and the Modulus of elasticity E for the material from which the square is made, and
 - the strain in the thickness direction (z-direction).

- 2- A bar of solid circular cross-section of 55 mm diameter is subjected to a torque, T, and an axial tensile load, P. A rectangular strain gauge rosette attached to the surface of the bar gives the following strain readings: $\epsilon_0 = 230 \times 10^{-6}$, $\epsilon_{45} = -40 \times 10^{-6}$ and $\epsilon_{90} = -120 \times 10^{-6}$ with the 0 degree strain gauge being aligned with the axial direction of the bar. If Young's modulus, E, for the bar is 40 GPa and Poisson's ratio, ν , is 0.3, calculate the magnitude of T and P.

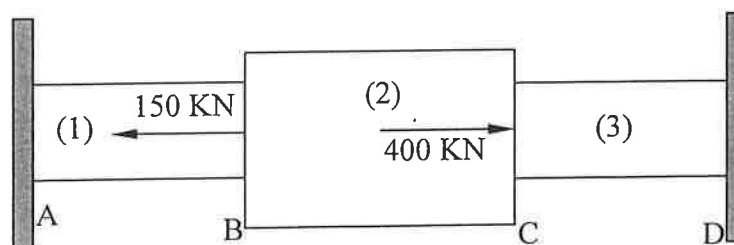
- 3- A thick-walled cylinder with 0.10 m internal diameter and 0.18 m external diameter is fabricated of a material whose elastic limit is 285 MPa and Poisson's ratio $\nu = 0.29$. The cylinder is subjected to an internal pressure 6 times greater than the external pressure. Calculate the allowable internal pressure according to:
- the Von-Mises criterion
 - the maximum shear stress criterion

- 4- A two-dimensional strain field is given by:

$$\epsilon_x = c(-18x^2 + 42y^2) \quad \epsilon_y = c(6x^2 - 30y^2) \quad \gamma_{xy} = 6bxy \quad (b \text{ and } c \text{ are nonzero constants})$$

- What is the relationship between b and c if this field satisfies the strain compatibility conditions?
- Determine the displacements u and v corresponding to this field of strain at point (3,1) if they are zero at point (0,0). Use as a value of 4 for c.

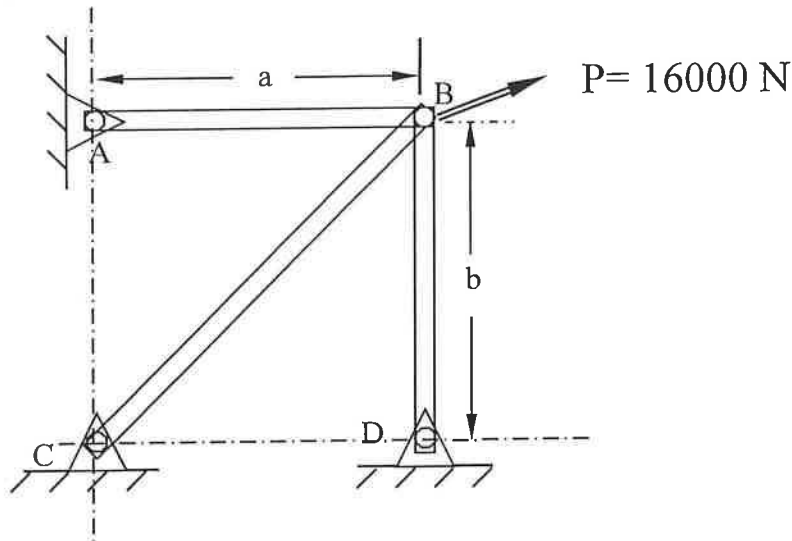
- 5- The rods 1, 2, and 3 shown below are welded together, mounted between two rigid walls and subjected to the two forces shown at joints B and C. Rods 1 and 3 are of the same length, $L_1 = L_3 = 1.5$ m and $L_2 = 2$ m. Rods 1 and 3 are made from a material with $E = 50$ GPa. Rod 2 is made from a material with $E = 30$ GPa. The cross sections are given by: $A_1 = A_3 = 0.01$ m² and $A_2 = 0.025$ m². Determine the displacements of joints B and C.



6- A cantilevered aluminum alloy bar of solid square cross-section (a by a) is subjected to a compressive axial force of magnitude $P = 175$ kN acting at the centroid of the section and a torque $T = 20$ kN.m. This member is to be designed in accordance with the maximum-shear-stress criterion of failure, with a safety factor of 3.

- What is the minimum allowable cross-sectional dimension a if $\sigma_{\text{yielding}} = 350$ Mpa?
- What would the answer be if the load P was applied at the same point but parallel instead of normal to the cross section?

7- A 16000 N force is applied 30° from the horizontal at joint B of the three-element, pin-jointed truss shown below. Cross sections for all members are of 5 cm², $a = 75$ cm, $b = 90$ cm, and $E = 200$ GPa. Determine the horizontal displacement u and the vertical displacement v at joint B



8- Calculate the forces in the members FG, GD and CD of the truss shown in the figure below using the principle of virtual work. All horizontal and vertical members are 0.75 m long and pin joined at points A to G.

