National Exams May 2018

16-Mec-A7 Advanced Strength of Materials

3 Hours Duration

NOTES:

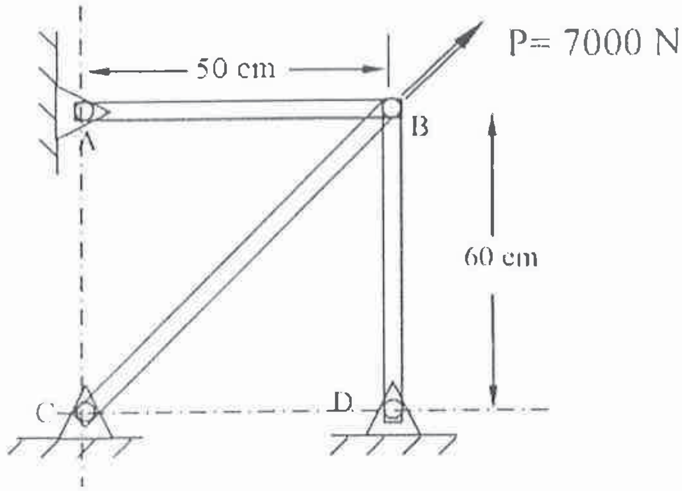
1. If doubts exist as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. Any non-communicating calculator is permitted. This is an open book exam.

3. Any five 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 7000 N force is applied co-linear to element BC of the three-element, pin-joined truss shown below. Cross section area for all members is 7.5 cm^2 and modulus is E=70 GPa. Determine the horizontal displacement $\mathbf{u}_B$ and the vertical displacement $\mathbf{v}_B$ of joint B



2- A thick-walled cylinder with 0.10 m internal diameter and 0.15 m external diameter is fabricated of a material whose yield strength is 400 MPa and Poisson's ratio $\nu = 0.3$. The cylinder is subjected to an internal pressure seven times greater than the external pressure. Calculate the allowable internal pressure according to:

a) the maximum shear stress criterion

b) the Von-Mises criterion

3- A two-dimensional strain field is given by

$$\varepsilon_x = c(-3x^2+7y^2) \qquad \varepsilon_y = c(x^2-5y^2) \quad \gamma_{xy} = bxy$$

where b and c are nonzero constants.

a) What is the relationship between b and c that satisfy the strain compatibility conditions?

b) Determine the corresponding displacements u(x,y) and v(x,y) as a function of c, at point (4,6) if they're both 0 at point (0,0)

4- A thin isotropic square plate of 1.8 m by 1.8 m is subjected to uniform plane stresses σ_x and σ_y. All other stresses are zero. The two stresses cause the plate to elongate by 0.18 mm in the x direction and by 0.75 mm in the y direction. If it is known that $\sigma_x = 50$ MPa, the material's Young's modulus E = 200 GPa, and that all deformations are in the linear-elastic range, determine:

a) σ_y and Poisson's ratio ν

b) the magnitude and direction of the principal stresses if a shear stress τ_{xy}= 100 MPa is superimposed on the above two stresses.

5- A cantilevered aluminum alloy bar of solid square cross-section (**b** by **b**) is subjected to a compressive axial force of magnitude P = 95 KN acting at the centroid of the section and a torque T = 10 KN.m. This member is to be designed according to the maximum shear stress criterion, with a safety factor of 2.

a) What is the minimum allowable cross-sectional dimension **b** if $\sigma_{yielding} = 390$ MPa?

b) What would your answer be if the Von-Mises criterion is used?

6- A three element rosette is mounted on a thin elastic plate with a Young's modulus of 90 GPa and a Poisson's ratio of 0.28. The rosette provides the following readings along the 0, 45 and 90 degree directions respectively:

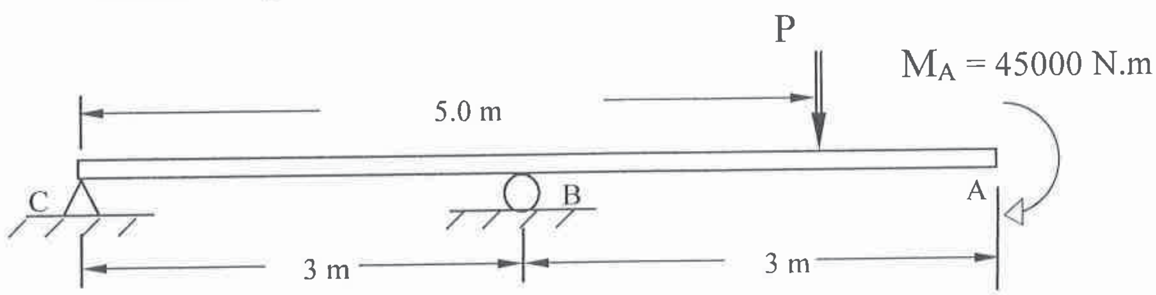
$$\varepsilon_0 = 600\ \mu \qquad \varepsilon_{45} = 400\ \mu \qquad \varepsilon_{90} = 300\ \mu$$

a) From these readings, calculate the strains $\varepsilon_{x'}$, $\varepsilon_{y'}$ and $\gamma_{xy'}$ along the +60 degree direction.

b) Determine the principal strains ε_1 and ε_2 and the principal directions.

c) Determine the yield strength of the plate if the resulting principal stresses are predicted to cause the onset of yielding according to the maximum shear stress criterion.

7- Using Castigliano's theorem, determine the magnitude and direction (up or down) of the force P if the displacement at A is not to exceed 15 mm (down). Use E = 200 GPa and I = $250\text{x}10^7$ mm^4.



8- The beam cross section shown below is subjected to an upward vertical force of 3000 N acting at its shear centre. (Wall thickness is uniform at 3 mm and height and width dimensions are with respect to the median lines of the section)

a) Determine and plot the resulting flexural shear flow in the two flanges and the web.

b) Determine the location of the shear centre of the beam.

c) Determine the location and magnitude of the maximum shear stress in the cross section