National Exams May 2011

07-Mec-A6-2 Advanced Strength of Materials

3 Hours Duration

NOTES:

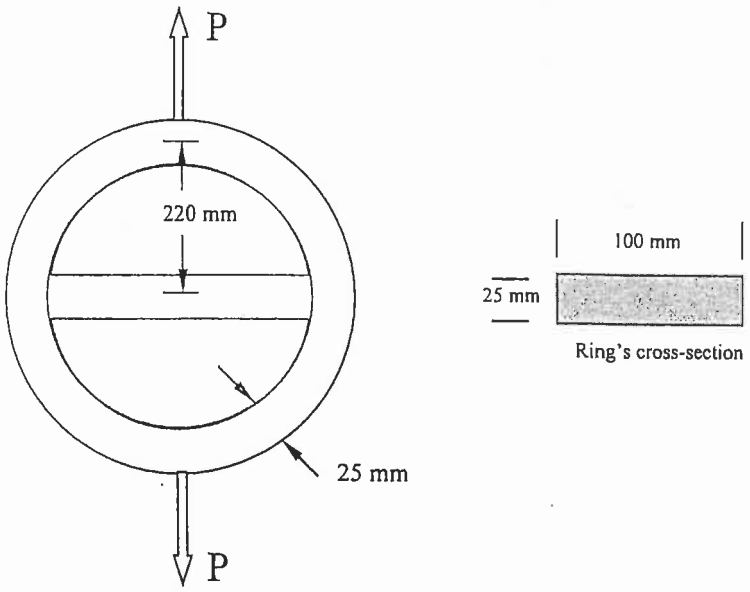
1. If doubts exist as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

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 figure below shows a steel ring of 220 mm mean radius and a uniform rectangular section of 100 mm wide and 25 mm thick. A rigid bar is fitted horizontally as shown. Assuming an allowable stress of 300 MPa, determine the maximum tensile force P that can be carried by the ring.



2- A thick-walled cylinder with 0.20 m internal diameter and 0.30 m external diameter is fabricated of a material whose elastic limit is 400 MPa and Poisson's ratio $\nu = 0.28$. The cylinder is subjected to an internal pressure eight times greater than the external pressure. Calculate the allowable internal pressure according to:

a) the maximum shear stress theory, and

b) the energy of distortion theory.

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.

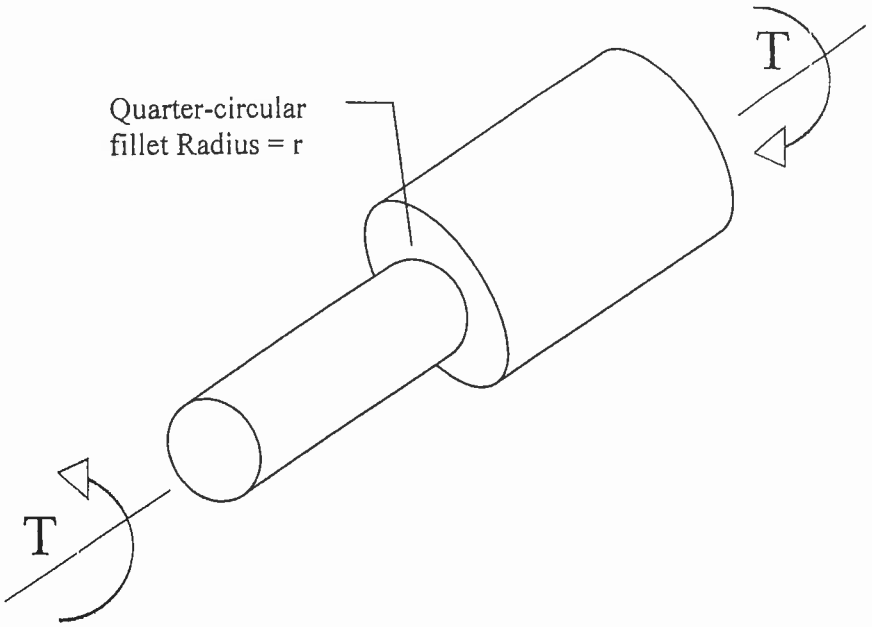
a) What is the relationship between b and c for this field to satisfy the strain compatibility conditions?

b) Determine the displacements u(x,y) and v(x,y) corresponding to this field of strain if one boundary condition at x=y=0 corresponds to zero u and v displacements.

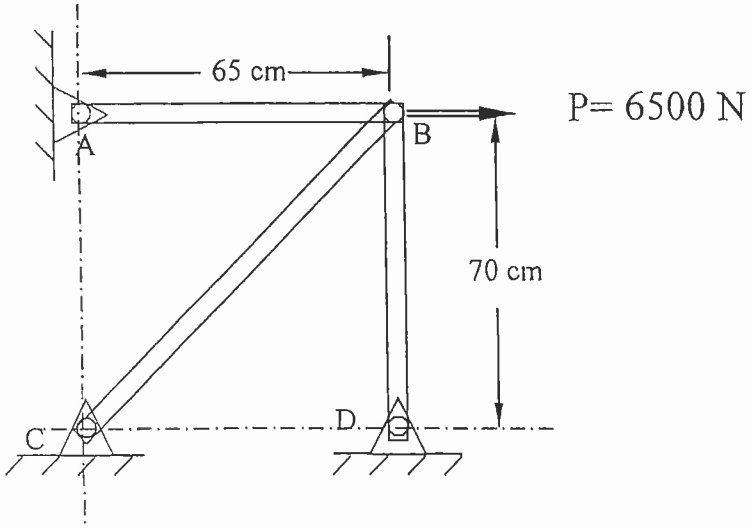
4- A stepped torsion bar with major diameter D = 65 mm and minor diameter d = 40 mm is subjected to a torque T = 100 N.m.

a) Determine the maximum shear stress in the shaft for the following size fillets: r = 5mm and r = 10 mm.

b) Compare the shear stress results you obtained in part (a) with the maximum shear stress the shaft would experience if it were of uniform diameter D = d = 40 mm.

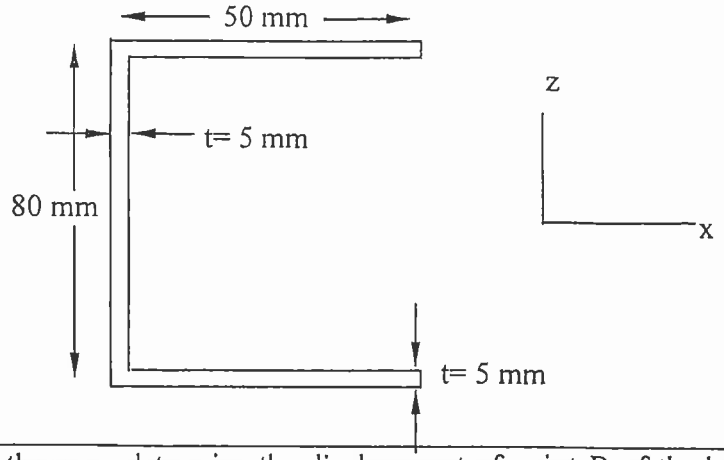


5- A 6500 N force is applied horizontally at joint B of the three-element, pin-joined truss shown below. Cross section area for all members is 5.0 cm^2 and modulus is E = 75 GPa. Determine the horizontal displacement u and the vertical displacement v at joint B

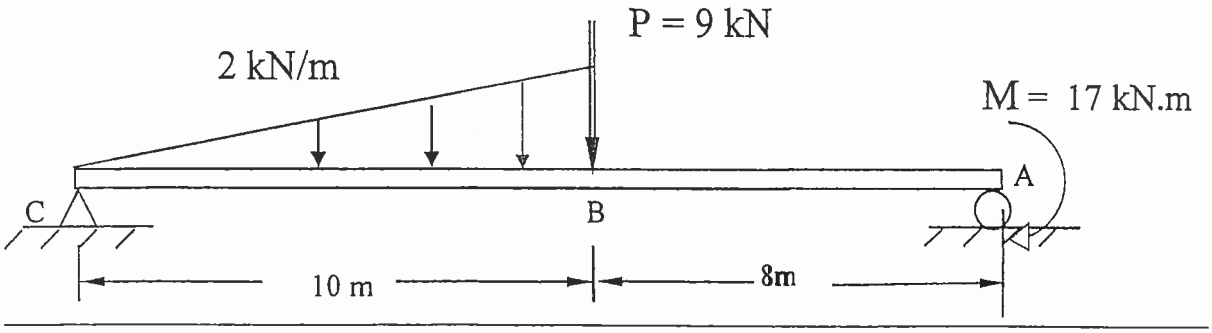


6- The beam cross section shown below has a variable wall thickness as shown and is subjected to a constant vertical shear force of 2200 N and a torque of 500 N.m.

a) Determine and plot the flexural shear flow in the two flanges and the web.
b) Locate the shear centre of the beam.



7- Using Castigliano's theorem, determine the displacement of point B of the beam shown below. Take E = 205 GPa, I = 195×10^6 mm^4 .



8- A three element rosette is mounted on a thin steel specimen with a Young's modulus of 180 GPa and a Poisson's ratio of 0.32. The rosette provides the following readings along the 0, 45 and 90 degree directions respectively:

$$\varepsilon_0 = 400\ \mu \qquad \varepsilon_{45} = 1000\ \mu \qquad \varepsilon_{90} = 500\ \mu$$

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) Using the generalized Hooke's law, calculate σ_x , σ_y and τ_{xy} .