

National Exams December 2017

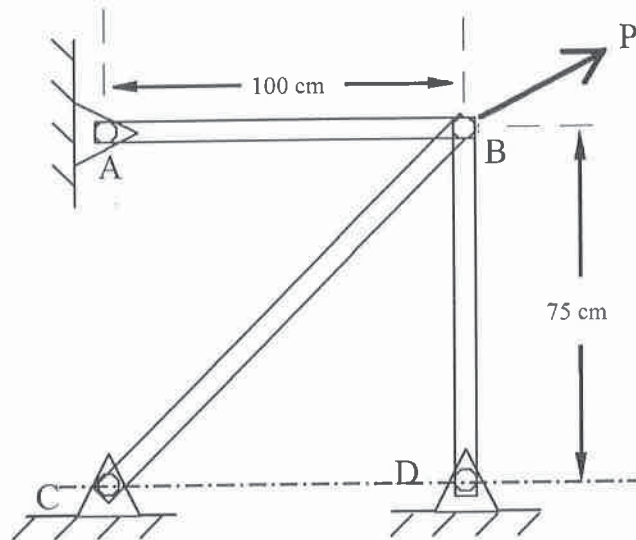
16-Mec-A7 Advanced Strength of Materials

3 Hours Duration

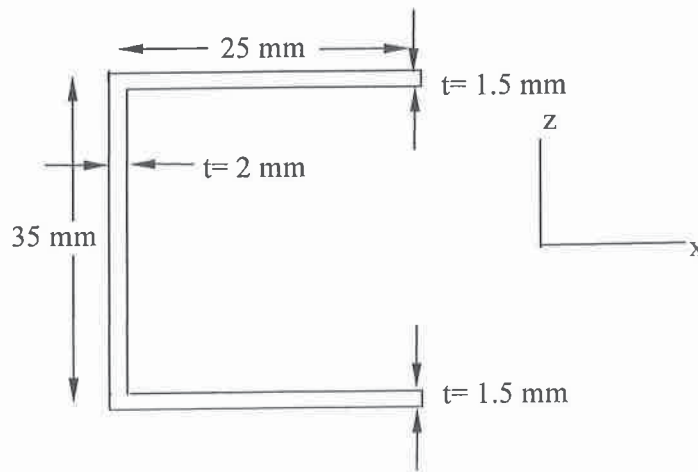
NOTES:

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.

- 2- A 10,000 N force is applied at 30 degrees from the horizontal at joint B of the three-element, pin-jointed truss shown below. Cross section area for all members is 5.0 cm^2 and modulus is $E = 70 \text{ GPa}$. Using an energy method of your choice:
- Determine the horizontal displacement u at joint B.
 - Determine the vertical displacement v at joint B.



- 2- The beam cross section shown below has a variable wall thickness as shown and is subjected to a constant vertical upward shear force of 1500 N acting at the shear centre.
- Determine and plot the flexural shear flow in the two flanges and the web.
 - Locate the shear centre of the beam.
 - Determine the location and magnitude of the maximum shear stress in the cross section.



3- The figure below shows a uniform cross section semicircular curved beam of 500 mm mean radius, a moment of inertia I equal $810 \times 10^6 \text{ mm}^4$, and a modulus of elasticity E equal to 200 GPa. Using Castigliano's theorem, determine:

- the allowable magnitude of the force P if the beam is not to deflect (extend) by more than 0.1 mm horizontally at the point where the force is applied (point A).
- the magnitude and direction of the corresponding vertical deflection.



4- A thick-walled cylinder with 0.9 m internal diameter and 0.15 m external diameter is fabricated of a material whose elastic limit is 330 MPa and Poisson's ratio $\nu = 0.28$. The cylinder is subjected to an internal pressure five times greater than the external pressure. Calculate the allowable internal pressure according to:

- the maximum shear stress yielding criterion
- the Von-Mises yielding criterion

5- A two-dimensional strain field is given by

$$\epsilon_x = c(-1.5x^2 + 3.5y^2) \quad \epsilon_y = c(0.5x^2 - 2.5y^2) \quad \gamma_{xy} = 0.5bxy$$

where b and c are nonzero constants.

- What is the relationship between b and c for this field to satisfy the strain compatibility conditions?
- Determine the displacements $u(x,y)$ and $v(x,y)$ corresponding to this field of strain at point (3,5) if they are zero at point (0,0).

6- A thin square plate of 1 m by 1 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 0.53 mm in the x direction and by 0.66 mm in the y direction. If it is known that σ_x is equal to 160 MPa and E is equal to 200 GPa and that all deformations are in the linear-elastic range, determine:

- σ_y and the Poisson's ratio ν for the material from which the square is made, and
- the strain in the thickness direction (z -direction).

- 7- A bar of solid circular cross-section of 50 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: $\epsilon_0 = 250 \times 10^{-6}$, $\epsilon_{45} = -50 \times 10^{-6}$ and $\epsilon_{90} = -150 \times 10^{-6}$ 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 .

- 8- Using Castigliano's theorem, determine the magnitude and direction of the allowable force P if the displacement of point B of the beam shown below is not to exceed 1 mm. Take $E = 195 \text{ GPa}$, $I = 975 \times 10^6 \text{ mm}^4$.

