National Exams May 2019

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.

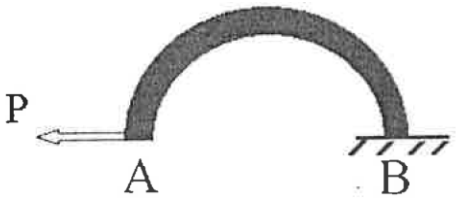
3. Any five problems constitute a complete paper. If you choose to attempt more than five problems, only the first five problems as they appear in your answer book will be marked.

4. All problems are of equal value.

1- The figure below shows a uniform cross section semicircular curved beam with a mean radius R = 510 mm, a moment of inertia I equal 815×10^6 mm^4, about an axis out of the page directed through the centroid of an area section, and a modulus of elasticity E = 205 GPa. Using Castigliano's second theorem, determine:

a) 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).

b) the magnitude and direction of the corresponding vertical deflection



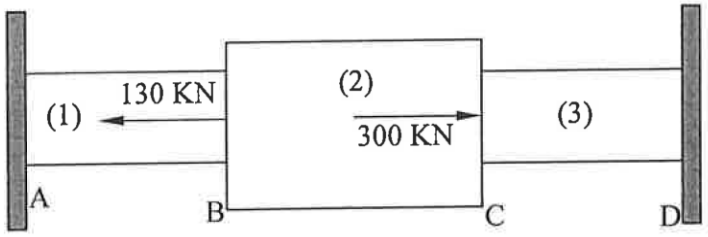
2- A two-dimensional strain field is given by:

$$x = c(-x^2 + \frac{7}{3}y^2) \qquad y = c(\frac{1}{3}x^3 - \frac{5}{3}y^2) \qquad xy = \frac{1}{3}bxy$$ (b and c are nonzero constants)

a) What is the relationship between b and c if this field satisfies the strain compatibility conditions?

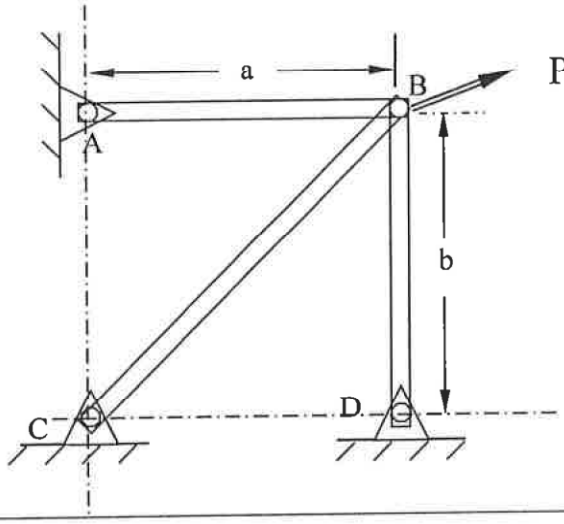
b) Determine the displacements u and v corresponding to this field of strain at point (5,2) if they are zero at point (0,0). Use as a value of 4 for c.

3- 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, $L_1 = L_3 = 1.2$ m and $L_2 = 1.5$ 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: $A_1 = A_3 = 0.01$ m^2 and $A_2 = 0.025$ m^2. Determine the displacements of joints B and C.

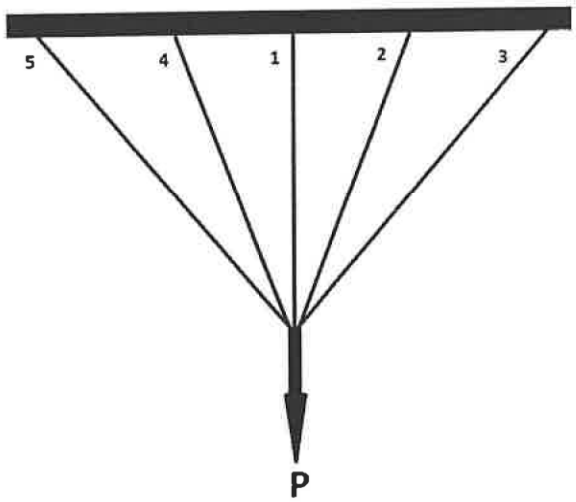


4- A cantilevered aluminum alloy bar of solid square cross-section (**a** by **a**) is subjected to a compressive axial force of magnitude P = 177 KN acting at the centroid of the section and a torque T = 23 KN.m. This member is to be designed in accordance with the maximum-shear-stress criterion of failure, with a safety factor of 2. What is the minimum allowable cross-sectional dimension **a** if $\sigma_{yielding} = 350$ Mpa?

5- A 16500 N force is applied 25° from the horizontal at joint B of the three-element, pin-joined truss shown below. Cross section areas for all members are 3 cm^2, a = 85 cm, b = 100 cm, and E = 210 GPa. Determine the horizontal displacement u and the vertical displacement v at joint B



6- The structure shown below has five simply supported cables pinned to a rigid ceiling and laid symmetrically with respect to the middle cable (cable 1). The angle between cables 2, 4 and the ceiling is 70 degrees and between cables 3, 5 and the ceiling is 50 degrees. Using Castigliano's first theorem, determine the forces in the 5 cables due to a force P of 10 KN applied at the common joint of all five cables as shown. Assume all cables have the same cross sectional area A = 200 mm^2 and E = 200 GPa. Also take the length of cable 1, L_1 = 2000 mm.



7- A three element rosette is mounted on a thin elastic plate with a Young's modulus of 70 GPa and a Poisson's ratio of 0.31. The rosette provides the following readings along the 0, 45 and 90 degree directions respectively:

$$\varepsilon_0 = 600\ \mu \qquad \varepsilon_{45} = 400\ \mu \qquad \varepsilon_{90} = 500\ \mu$$

a) Determine the principal strains ε_1 and ε_2 and the principal directions.
b) Determine σ_x , σ_y and τ_{xy} if the x axis is aligned with the 0 degree direction.

8- A thick-walled cylinder with 0.11 m internal diameter and 0.175 m external diameter is fabricated of a material whose yield strength is 289 MPa and Poisson's ratio $\nu = 0.29$. The cylinder is subjected to an internal pressure 8 times greater than the external pressure. Calculate the allowable internal pressure according to:

a) the maximum shear stress yield criterion
b) the Von-Mises yield criterion
