National Exams December 2016

07-Mec-A6-2 Advanced Strength of Materials

3 Hours Duration

NOTES:

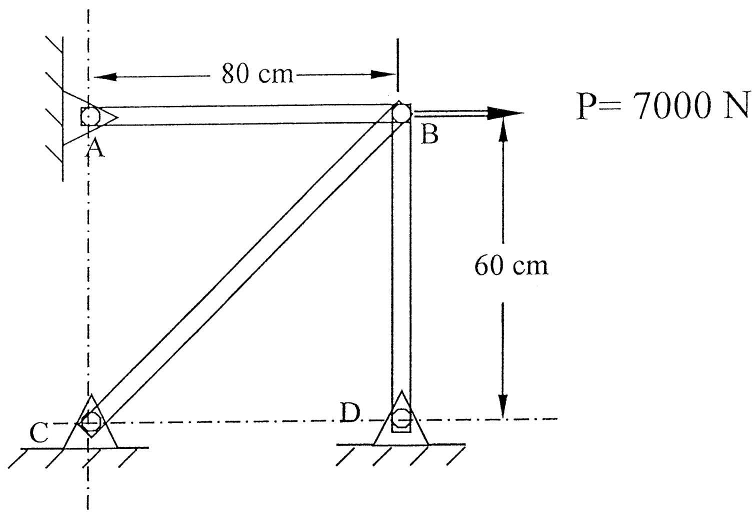
1. If doubts exist as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

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

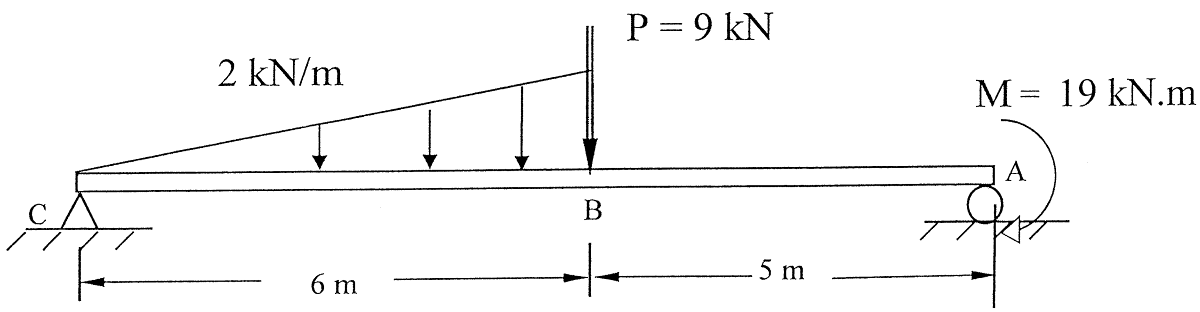
3. Any five of the eight problems constitute a complete paper. If you choose to attempt more than five problems, only the first five problems as they appear in your answer book will be marked.

4. All problems are of equal value.

1- A 7800 N force is applied horizontally at joint B of the three-element, pin-joined truss shown below. Cross section area for all members is 8.8 cm^2 and modulus is E = 88 GPa. Determine the horizontal displacement u and the vertical displacement v at joint B



2- Using Castigliano's theorem, determine the displacement of point B of the beam shown below. Take E = 205 GPa, I = 165×10^6 mm^4.



3- A thick-walled cylinder with 0.11 m internal diameter and 0.16 m external diameter is fabricated of a material whose yield strength is 300 MPa and Poisson's ratio $\nu = 0.29$. 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 criterion
b) the Von-Mises criterion

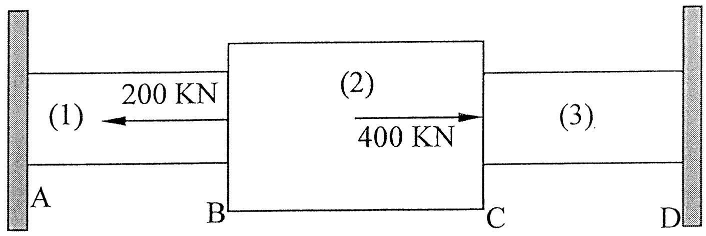
4- A two-dimensional strain field is given by

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

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 (5,2) if they're both 0 at point (0,0)

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, $L_1 = L_3 = 0.5$ m and $L_2 = 1$ m. Rods 1 and 3 are made from a material with E = 180 GPa. Rod 2 is made from a material with E = 120 GPa. The cross sections are given by: $A_1 = A_3 = 0.008\ m^2$ and $A_2 = 0.015\ m^2$. Determine the displacements of joints B and C.



6- A thin isotropic square plate of 1.5 m by 1.5 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 0.8 mm in the x direction and by 0.25 mm in the y direction. If it is known that the material's Young's modulus E is equal to 120 GPa and its Poisson's ratio v is equal to 0.28 and that all deformations are in the linear-elastic range, determine:

a) the stresses σ_x and σ_y that have caused the above deformations, and
b) the factor of safety against yielding according to the maximum shear stress theory

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7- A bar of solid circular cross-section of 60 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: $\varepsilon_0 = 240\times10^{-6}$, $\varepsilon_{45} = -50\times10^{-6}$ and $\varepsilon_{90} = -140\times10^{-6}$ with the 0 degree strain gauge being aligned with the axial direction of the bar. If Young's modulus, E, for the bar is 60 GPa and Poisson's ratio, v, is 0.3, calculate the magnitude of T and P.

8- Calculate the forces in the members FG, GD and CD of the truss shown in the figure below using an energy method of your choice. All horizontal and vertical members are 1m long.