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UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination – May 2018

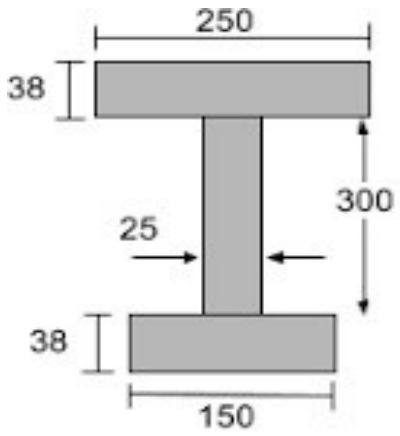
Program/course: B.Tech. ADE, Mechanical (PE, TE, MD, and MSNT)		**Semester**	**: IV**
Subject: Mechanics of Materials		**Max. Marks**	**: 100**
Code : GNEG 253	**No. of Pages: 03**	**Duration**	**: 3 Hrs**

NOTE: This question paper has 3 sections; Section A, section B and Section C. Make use sketches/plots to elaborate your answers. Assume any **MISSING** data appropriately. Brief and to the point answers are expected.

SECTION-A (4 X 5 = 20 MARKS)
Attempt all Questions

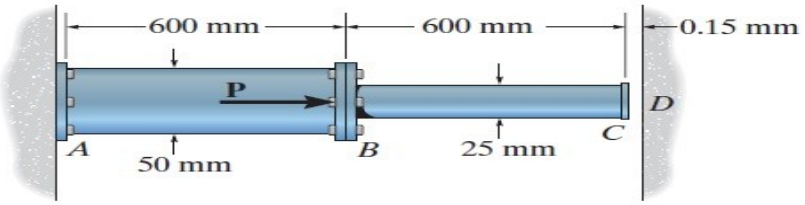
Q1. Define critical buckling load. Write down the expressions for Euler's critical load for different end conditions of a column. Enumerate the assumptions of Euler's theory of buckling. **(CO2)**

Q2. An I-beam with cross-section as shown in figure below is subjected to a bending moment of 5.0 kN-m. Determine the maximum bending stresses induced in the beam. **(CO2)**



Q3. A thin spherical shell has internal diameter of 1.25 m and a wall thickness of 10 mm. If the yield stress of the material is 240 MPa and factor of safety is 3, find out the safe pressure for the vessel. Also, calculate the change in diameter and volume. Poisson's ratio is 0.30 for the material and Young's modulus is 210 GPa. **(CO4)**

Q4. Two pipes of same material are connected as shown in figure below. If the gap between C and the rigid wall at D is initially 0.15 mm, determine the support reactions at A and D when a force P = 200 kN is applied and the temperature is raised by 10°C. Take E = 200 GPa and $\alpha = 12\times10^{-6}$/°C. **(CO1)**



SECTION-B (4 X 10 = 40 MARKS)
Attempt all Questions

Q5. A steel pipe 38 mm inside diameter, wall thickness 6.3 mm, and 1.22 m long, has its ends rigidly fixed as to prevent any expansion in length of the pipe. The pipe fixed in position under normal temperature condition is unstressed, but may be subjected to a temperature rise of 50°C. Calculate the temperature stress in the pipe and the factor of safety against failure as a strut. Use Rankine formula, σ_c = 320 MPa, Rankine's constant = 1/22500 for a strut with hinged ends. Take Coefficient of Linear Thermal Expansion $\alpha = 11.1\times10^{-6}$/°C and E = 206 GPa**.** **(CO1 & CO2)**

Q6. A thin steel cylinder of wall thickness 10 mm and external diameter of 220 mm is subjected to an internal pressure of 15 MPa. Determine how much axial compressive force can be applied to the cylinder if yielding occurs according to maximum strain energy per unit volume theory. The Poisson's ratio and yield stress of the material in tension are 0.3 and 240 MPa respectively. **(CO4)**

Q7. A solid alloy shaft of 50 mm diameter is coupled in series with a hollow steel shaft of same external diameter. Determine the internal diameter of the hollow steel shaft if the angle of twist per unit length in hollow shaft is 75% of that of the solid alloy shaft. Determine the speed at which the compound shaft must be driven to transmit 200 kW, if the limiting shear stresses are 55 MPa and 75 MPa in alloy and steel respectively. Take $G_{steel} = 2.2\ G_{alloy.}$ **(CO3)**

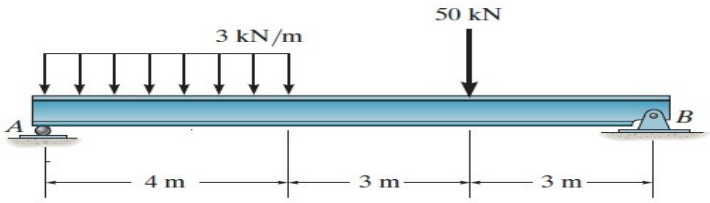
Q8. Two plates 25 mm thick are connected by a triple riveted butt joint with two cover straps. The pitch of the rivets in the outermost row is twice the pitch of those in other rows. Determine the pitch of the rivets in outer row. Also, determine the efficiency of the joint if the tensile strength of the plate material is 90 N/mm^2, bearing strength is 120 MPa and shear strength of the rivet material is 60 N/mm^2. **(CO1)**

OR

A tie bar consisting of a single angle 200 mm × 100 mm ×10 mm is to be welded to a steel plate by means of fillet welds. The angle is subjected to a static force of 150 kN and the permissible shear stress for the weld is 70 N/mm^2. Determine the length of the weld at top and bottom. **(CO1)**

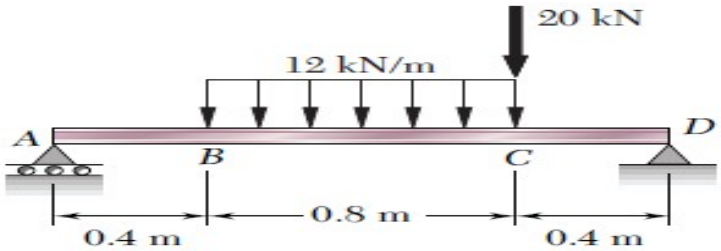
SECTION-C (2 X 20 = 40 MARKS)
Attempt all Questions

Q9. For the beam and loading shown, draw SFD and BMD. Also, derive the equation of the elastic curve and determine maximum deflection. Use E = 200 GPa and I= 70.0 X 10^6 mm^4. **(CO2)**



OR

For the beam and loading shown in figure below, draw SFD and BMD. Using Mohr's area moment method, determine the deflection of the point at a distance 0.5 m from point A for the loaded beam. Take EI = 8.3 x 10^5 Nm^2. **(CO2)**



Q10. (a) A 3.0 m long cylindrical bar has a diameter of 2.0 cm along 1.5 m of its length and 1.0 cm for the remaining 1.5 m length. The bar is hanging vertically from a fixed support and a collar (stopper) is attached at the free end. Determine the maximum stress and extension developed in this bar when a mass of 100 kg is dropped on the collar from a height of 4.0 cm. Take E = 205 GPa. **(CO4)**

(b) The state of stress for a steel component is shown in figure below. Determine analytically, the magnitude of principal stresses, maximum shear stress and position of principal planes. Also, determine the normal and shear stresses on an oblique plane 40° clockwise to the plane of 20 MPa stress. Draw Mohr's stress circle for this plane stress condition and confirm your answers. **(CO4)**