Name:

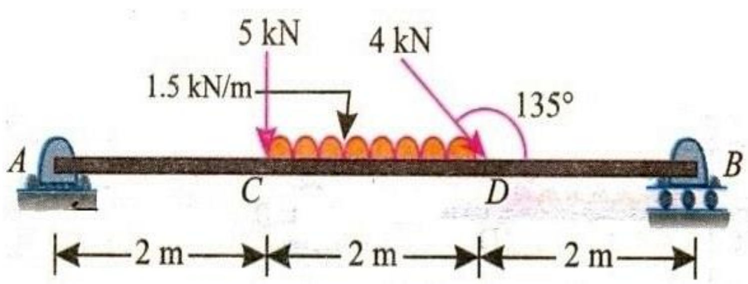
Enrolment No:

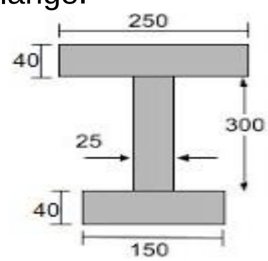
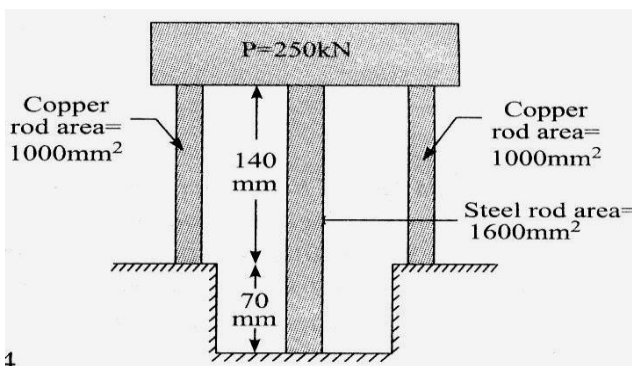
UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, May 2021

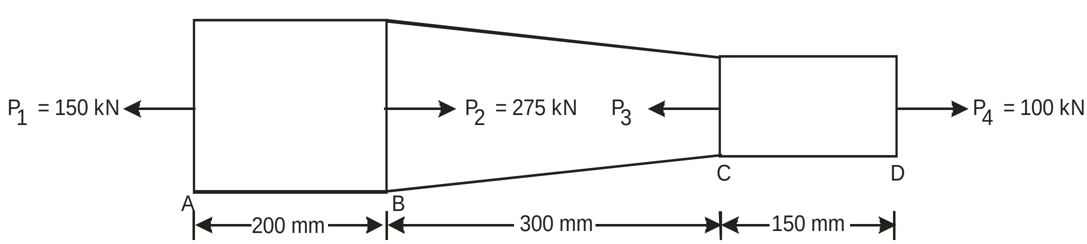
Course: Strength of Materials | **Semester: IV**
Program: B. Tech. Mechatronics | **Time: 3 Hours**
Corse Code: MECH 2012 | **Max. Marks: 100**

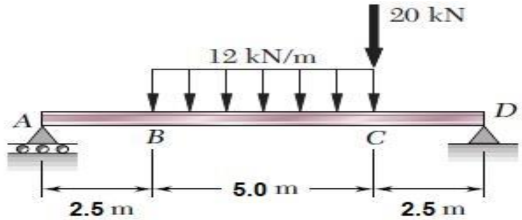
SECTION A

1. **Attempt all questions. Each question will carry 5 marks.**
2. **Instruction: For Q-1 to Q-6, Type the final answer only.**

S. No.		**Marks**	**CO**
Q-1	A steel rod 30 mm diameter and 300 mm long is subjected to a tensile force P acting axially. The temperature of the rod is then raised through 80ºC and the total extension measured as 0.35mm. Calculate the value of P. Take E_s = 200 GN/m^2 and α_s =12 x 10^{-6} per ºC.	**5**	**CO1**
Q-2	A cantilever 6 m long carries a uniformly distributed load of 30 kN/m throughout the length. It is supported by an upward force 'P' at the free end so that the mid-point becomes point of contra-flexure. Determine the magnitude of force 'P'.	**5**	**CO1**
Q-3	Determine the support reactions A_x, A_y and B_y for the beam shown in the figure below.  	**5**	**CO1**
Q-4	A material has modulus of elasticity E = 200 GPa. If the bulk modulus of the material K = 160 GPa, determine the Poisson's ratio and shear modulus of the material.	**5**	**CO1**
Q-5	A cylindrical boiler shell is to be made of 20 mm thick plate having a limiting tensile stress of 160 MPa. If the efficiencies of the longitudinal and circumferential joints are 80 % and 35 % respectively, determine the maximum permissible diameter of the shell for an internal pressure of 5.0 MPa.	**5**	**CO4**
Q-6	A thin spherical shell of 1.2 m diameter is to be subjected to an internal pressure of 1.5 MPa. Determine the change in volume of the sphere due to internal pressure. Take Elastic Modulus E = 180 GPa & Poisson's ratio v = 0.3.	**5**	**CO4**

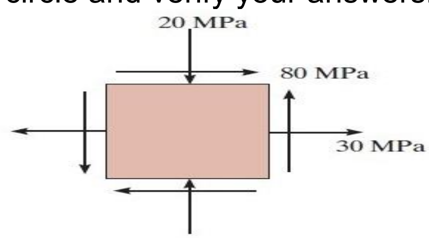
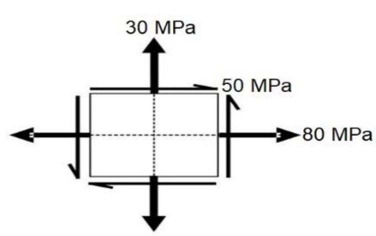
<table>
<tr><td colspan="4">SECTION B
1. Attempt all questions. Each question will carry 10 marks.
2. Instruction: For Q-1 to Q-5, Scan and Upload the answer.</td></tr>
<tr><td>Q-1</td><td>An unequal I-beam with cross-section as shown in figure below is subjected to a maximum bending moment of +25 kN-m. The shear force at this cross-section is 40 kN. Determine the maximum tensile and compressive bending stresses induced in the beam. Also, determine the shear stress developed at the mid surface of the upper flange.

</td><td>10</td><td>CO2</td></tr>
<tr><td>Q-2</td><td>Two copper rods and one steel rod together support a load 250 kN as shown in figure. Determine the stresses developed in the copper and steel rods. Take E_{steel} = 200 GPa and E_{copper} = 100 GPa.


OR
A machine component is subjected to point loads as shown in the figure below. The segments AB and CD have a uniform diameter of 60 mm and 30 mm respectively. Determine load P_3 for equilibrium and net change in the length of the component. Take modulus of elasticity of the material as E = 200 GPa.

</td><td>10</td><td>CO3</td></tr>
<tr><td>Q-3</td><td>A hollow steel shaft transmits 200 kW power at 150 rpm. The total angle of twist in a length of 5.0 m of the shaft is 3º. Find the inner and outer diameters of the shaft if the permissible shear stress is 60 MPa. Also, determine the strain energy stored in the shaft. Take modulus of rigidity G = 80 GPa.</td><td>10</td><td>CO2</td></tr>
</table>

Q-4	For the beam and loading shown in figure below, determine the deflection of the mid-point of the loaded beam. Take EI = 5.3×10^5 Nm^2.  	**10**	**CO3**
Q-5	A column has a rectangular cross-section of base 50 mm and height 150 mm. It is hinged at both the ends and has a length just sufficient for the validity of Euler's formula. Determine the Rankine's crippling load for a factor of safety 2, if Rankine's constant α = 1/1600. For the material of the column, take E = 200 GPa and σ_y = 250 MPa.	**10**	**CO4**

SECTION C

1. **Attempt all questions. Each question will carry 20 marks.**
2. **Instruction: For Q-1, Scan and Upload the answer.**

Q-1	The state of stress for a steel component is shown in figure below. Determine the magnitudes of principal stresses, maximum shear stress and position of principal planes. Draw the Mohr's stress circle and verify your answers.  If the yield strength of the material is found to be 350 MPa, determine the factor of safety with respect to yielding according to maximum distortion energy criterion. **OR** The state of stress for a steel component is shown in figure below. Determine the magnitudes of principal stresses, maximum shear stress and position of principal planes. Draw the Mohr's stress circle and verify your answers.  If the yield strength of the material is found to be 300 MPa, determine the factor of safety with respect to yielding according to maximum strain energy per unit volume criterion. Take Poisson's ratio v = 0.3.	**20**	**CO2** **CO4**