Name : Enrolment No :	UPES

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

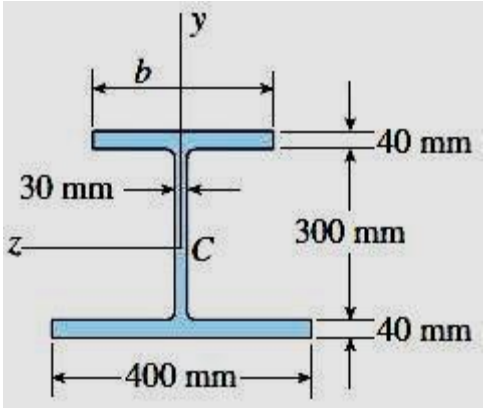
End Semester Examination, December 2019

Program Name	**: M. Tech. Automation and Robotics Engineering**	**Semester**	**: I**
Course Name	**: Mechanics and Mechanism**	**Time**	**: 03 Hrs**
Course Code	**: MECH 7002** **Nos. of pages : 04**	**Max. Marks**	**: 100**

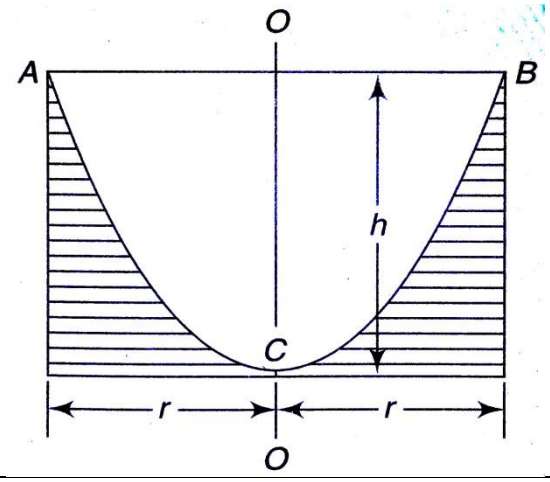
Instructions:	**This question paper has 3 sections; Section A, Section B and Section C. Make use of sketches/plots to elaborate your answers. Assume any** MISSING **data appropriately. Brief and to the point answers are expected.**

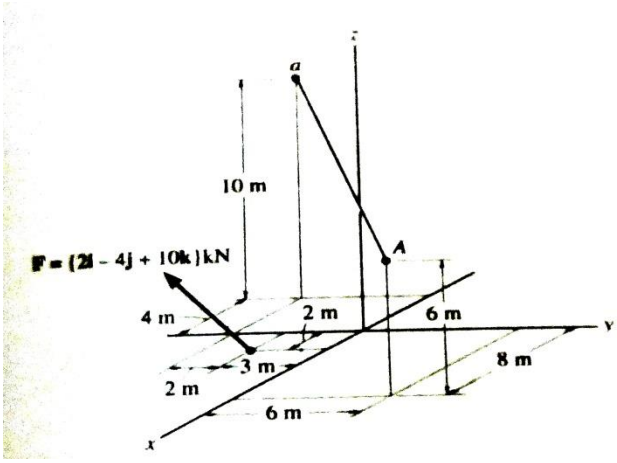
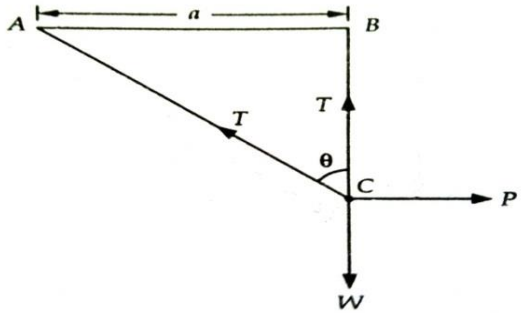
SECTION A (5 x 4 = 20 Marks)

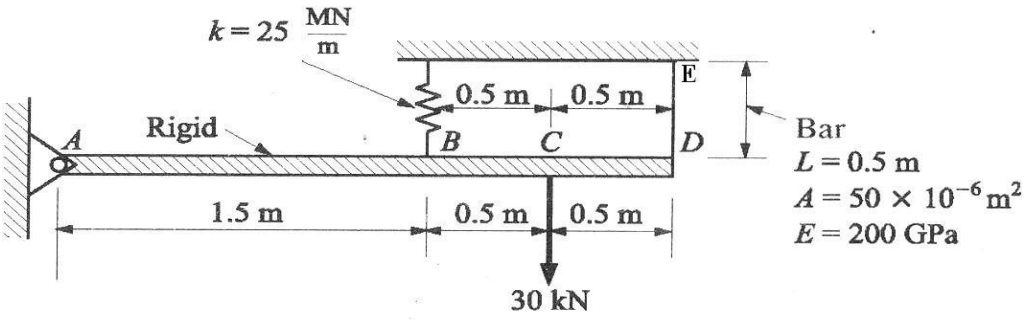
Q 1 A beam having a cross section in the form of an unsymmetrical wide-flange shape as shown in figure below is subjected to a negative bending moment acting about the z-axis. Determine the width of the top flange in order that the stresses at the top and bottom of the beam will be in the ratio 4:3, respectively.



Q 2 A right circular cylindrical tank containing water spins about its vertical geometric axis OO at such speed that the free water surface is a parabaloid ACB as shown in figure below. Using theorem of Pappus and Guldinus, determine the depth of water in the tank when it comes to rest.

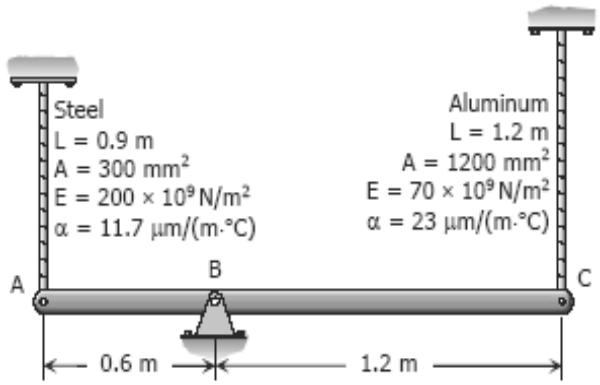


Q 3	Determine the moment of the force F about the Aa axis. Express the result as a Cartesian vector. 
Q 4	A string of length 'L' is fastened to two points A and B at the same horizontal level at a distance 'a' apart. A ring of weight 'W' can slide on the string and a horizontal force 'P' is applied to it such that system is in equilibrium with ring vertically below point B as shown in figure below. Determine force 'P' and the tension 'T' in the string in terms of W, L and a. 
SECTION B (10 x 4 = 40 Marks)	
Q 5	A shaft of unknown material is subjected to a tensile stress of 100 MPa on one plane and tensile stress of 48 MPa on another plane perpendicular to first plane, together with clock-wise shear stress of 65 MPa on the plane of 48 MPa. Determine: a) The magnitude of principle stress. b) Magnitude of greatest shear stress. c) The direction of principle plane. d) The normal and tangential stresses on a plane at 20^o anticlockwise to the plane of 100 MPa. If Poisson's ratio for the shaft material is 0.3 and failure of the shaft is according to Maximum Strain Energy per unit volume theory, determine the yield strength of the material for a factor of safety 3.0.
Q 6	A gun metal sleeve is fitted tightly over a solid steel shaft to make a composite shaft. The compound shaft carries a torque. Determine (a) the ratio of outer diameter of the sleeve to the diameter of the solid shaft if the torque carried by the sleeve is three times to the torque carried by the shaft, (b) the torque transmitted by the compound shaft when steel shaft diameter is 60 mm. The allowable shear stresses in gun metal and steel are 45 and 80 MPa respectively. The corresponding Modulus of Rigidity for gun metal and steel are 30 and 80 GPa respectively.
Q 7	The rigid bar AD as shown in figure is pinned at A and supported by a steel rod at D, together with a linear spring at B. The bar carries a vertical load of 30 kN applied at C. Determine the vertical displacement of point D and the stress induced in rod DE.

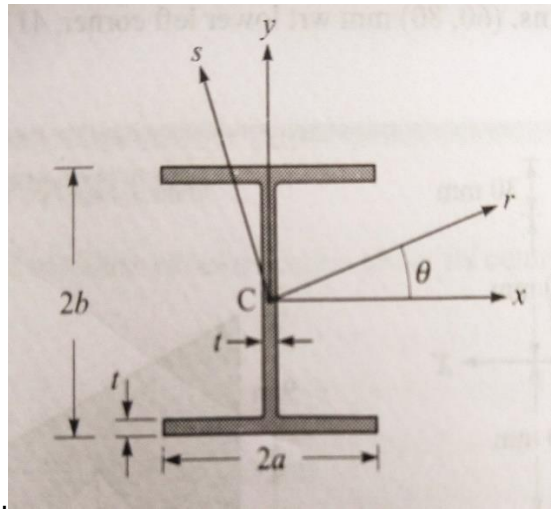


OR

The rigid bar ABC shown below is pinned at B and attached to the two vertical rods. Initially, the bar is horizontal and the vertical rods are stress-free. Determine the stress in the aluminum rod if the temperature of the steel rod is decreased by 40°C. Neglect the weight of bar ABC.

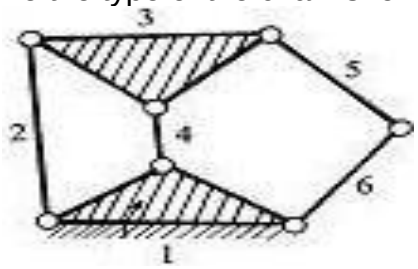
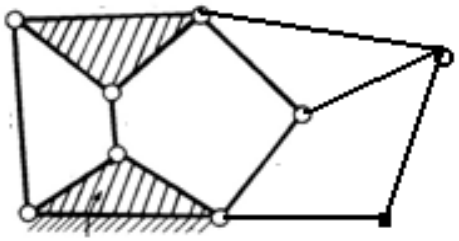


Q 8 Determine the moments of inertia of the I-section shown below about centroidal x and y-axes. Also, determine the product moment of inertia of the I-section about r and s-axes. Given that a = 100 mm, b = 150 mm, t = 15 mm and θ = 15°.



SECTION-C (20 x 2 = 40 Marks)

Q 9 A double overhanging beam ABCDE has equal overhung AB and DE, each of 2 m on both sides. It is simply supported at B and D such that span BD is 6m and the total length of beam is 10 m. It carries two equal point loads each of 75 kN at the ends A and E together with third point load of 100kN at the mid-point C. In addition, it also carries a uniformly distributed load of 50 kN/m between the supports. Sketch the Shear Force and Bending Moment diagrams for this beam. Determine the location of point of contra-flexure, if any and the value of deflection at the mid-

	point of the beam either by Macaulay's method or by Area Moment method. Given E = 200 GPa and I = 72 x 10^{-6} m^4. **OR** A simply supported AB beam of length 6.0 m carries two point loads each of 60 kN at a distance of 1.5 m and 4.5 m from end A. It also carries a third point load of 110 kN at the mid-point and a uniformly distributed load of intensity 40 kN/m between the point loads of 60 kN. Draw the shear force and bending moment diagram for the loaded beam. Using Macaulay's or Mohr's area-moment method, determine the deflection at a cross-section 2.5 m from end A. Take E = 200 GPa and I = 72 x 10^{-4} m^4.
Q 10	(a) What is a kinematic chain? Differentiate between locked chain, constrained chain and unconstrained chain. Determine the type of the chain shown in figure below.  (b) What is degree of freedom? Explain the Grubler's criteria to obtain the degree of freedom of any planer mechanism. How can you decide whether given kinematic chain is either structure or mechanism? Support your answer with suitable examples. Determine the degree of freedom for following mechanism.  (c) Differentiate between mechanism and machine. What do you mean by inversion? Explain briefly any three inversion of Four Bar Chain.