B.E. MECHANICAL ENGINEERING (EVENING) FIRST YEAR SECOND SEMESTER - 2024
ENGINEERING MECHANICS – IV

Time: 3 Hours **Full Marks: 100**

Question No. 1 is compulsory. Answer any four (4) from the rest.
All the parts of a question should be answered together.
Missing data (if any) should be assumed reasonably with suitable justification.

1. Write short notes (any 4): **[05×4 = 20]**

(a) Static and dynamic balancing
(b) Shear centre and shear flow
(c) Mass moment of inertia and radius of gyration
(d) 3D Stress Components and symmetry of stress matrix
(e) Coefficient of restitution
(f) Stress invariants

2. (a) The cross section of a curved beam is shown in **Fig. Q2(a)**. Find the expression for the radius of the neutral surface from the centre of curvature. **[08]**

(b) A curved beam with 'T' cross section is loaded as shown in **Fig. Q2(b)**. (i) Calculate the distance of neutral surface from the centre of the undeformed beam. (ii) Find the distance between centroid and the neutral axis of the cross section. (iii) Determine the maximum value of compressive stress if $P = 10$kN. **[12]**

3. (a) The state of stress of a point in an elastic body is given by

$$\left[\sigma_{ij}\right] = \begin{bmatrix} 80 & 45 & 0 \\ 45 & -35 & 0 \\ 0 & 0 & -50 \end{bmatrix} \text{MPa.}$$

Calculate the stress invariants, principal stresses, maximum shear stress and the octahedral shear stress. **[08]**

(b) The couple M = 120 N-m acts in a vertical plane of a beam cross section oriented as shown in **Fig. Q3(b)**. For the cross section, area moment of inertia are given as $I_{y'}$ = 14.77×10^3 mm^4 and $I_{z'}$ = 53.60×10^3 mm^4. Determine (i) the angle that the neutral axis forms with the horizontal, (ii) the stresses at point A and point E in the beam. **[12]**

4. (a) Plot the region of safety for Maximum Shear Stress Theory and Distortion Energy Theory under bi-axial stresses. Explain which one is more conservative. **[08]**

(b) Find the distance e of the shear center O of a thin-walled beam of uniform thickness having the cross section shown in **Fig. Q4(b)**. Also, draw the shear flow diagram for the cross section. **[12]**

5. Derive Lame's equations for calculating stresses developed in thick cylinder pressure vessels. Deduce the expressions for radial, tangential and longitudinal stresses for a thick cylinder subjected to external pressure only. Also plot the radial and tangential stress distribution across the cross section of the thick cylinder. **[20]**

6. (a) Determine the moment of inertia about the y axis for the paraboloid of revolution shown in **Fig. Q6(a)**. The mass of the homogenous body is m. You may consider the equation of parabola as $y^2 = kz$. **[10]**

[Turn over

(b) The two identical frictionless balls moving with initial velocities $v_A = 3$ m/s and $v_B = 4$ m/s collide as shown in **Fig. Q6(b)**. The mass of each ball is m. The coefficient of restitution is $e = 0.9$. Determine the magnitude and direction of velocity of each ball just after impact and find the percentage loss of kinetic energy of the system. **[10]**

7. A shaft carries four masses A, B, C and D of magnitude 3kg, 5kg, 6kg and 4kg respectively and revolving at radii 60mm, 50mm, 40mm and 60mm in planes measured from A at 300mm, 500mm and 700mm. The angles between the cranks measured anticlockwise are A to B 45°, B to C 75° and C to D 120°. The balancing masses are to be placed in planes P and Q. The distance between the planes A and P is 100mm, between P and Q is 500mm and between Q and D is 100mm. If the balancing masses revolve at a radius of 100 mm, find their magnitudes and angular positions. **[20]**

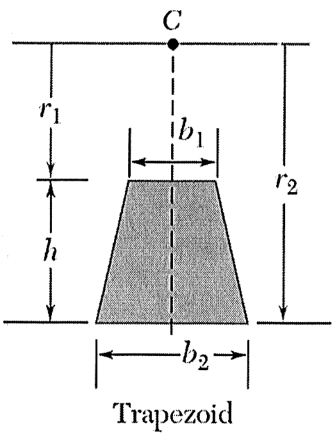

Fig. Q2(a)

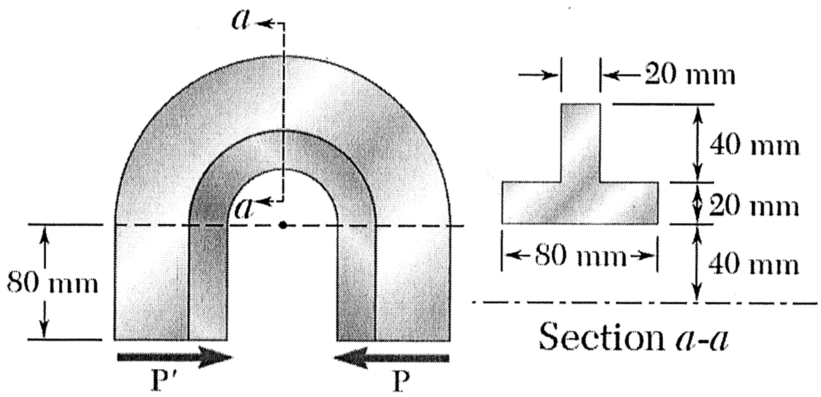

Fig. Q2(b)

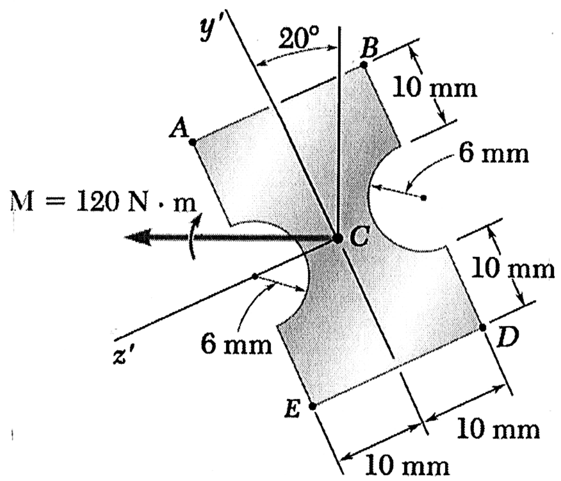

Fig. Q3(b)

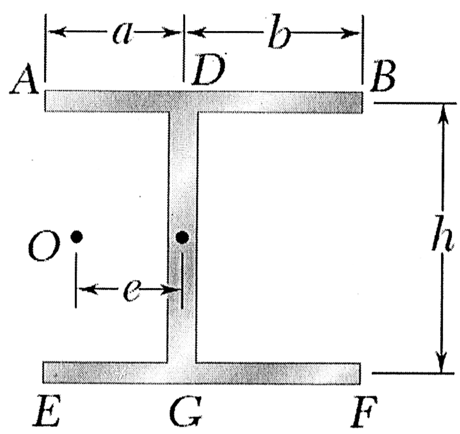

Fig. Q4(b)

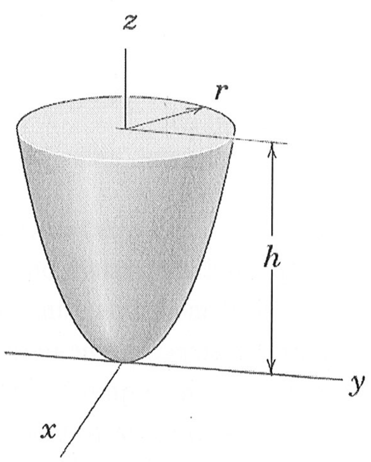

Fig. Q6(a)

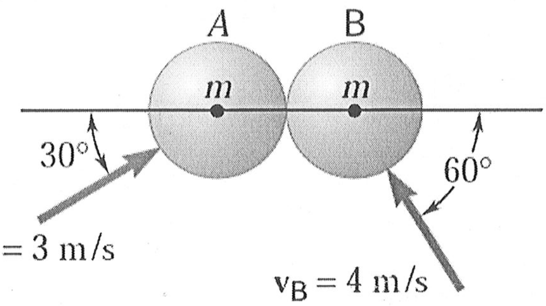

Fig. Q6(b)