B.E. MECHANICAL ENGINEERING (EVENING) FIRST YEAR SECOND SEMESTER - 2023
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) Stress invariants
(b) Shear centre and shear flow
(c) Symmetry of stress matrix
(d) Mass moment of inertia and radius of gyration
(e) Coefficient of restitution
(f) Static and dynamic balancing

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 trapezoidal 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 stresses at point *A* and point *B*. [12]

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

$$\left[\sigma_{ij}\right]=\begin{bmatrix}150 & -45 & 0\\ -45 & 70 & 0\\ 0 & 0 & -80\end{bmatrix}\text{ MPa.}$$

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

(b) The couple M = 25 kN-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 $I_y = 7.27\times10^6$ mm^4 and $I_z = 85.10\times10^6$ 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) Show that 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)** is $e = 1.25a$. Also, draw the shear flow diagram for the cross section. [12]

5. (i) A thin solid disc is rotating about its axis at an angular velocity ω. Derive the governing differential equation and find the expressions for radial and tangential stresses for the disc. Assume the density and Poisson's ratio of the disc material as ρ and ν, respectively. (ii) Find the expressions for the radial and tangential stresses of a circular disc of radius R_o with a central hole of radius R_i. What will be the maximum values of the stresses for this disc with a hole? [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 $y^2 = az$. [10]

[Turn over

(b) The two identical steel balls moving with initial velocities $v_A = 6$ m/s and $v_B = 8$ m/s collide as shown in **Fig. Q6(b)**. The mass of each ball is m and they collide in such a way that the line joining their centres is in the direction of v_B. The coefficient of restitution is $e = 0.7$. Determine the velocity of each ball just after impact and find the percentage loss of kinetic energy of the system. [10]

7. (a) Define body cone and space cone with the help of an example and sketches. [05]

(b) A 700 mm long rotating shaft carries four unbalanced masses of $A = 25$ kg, $B = 20$ kg, $C = 35$ kg and $D = 15$ kg at radial distances of 70 mm, 75 mm, 60 mm and 80 mm and at the angular positions of 0°, 45°, 135° and 210°, respectively. The angular positions are measured counter-clockwise from x axis as shown in **Fig. Q7(b)**. Masses A and D are located at the two ends of the shaft. Masses B and C are in the planes at 300 mm and 400 mm from the plane of mass A. Two countermasses rotating at radius of 90 mm are to be placed in planes C_1 and C_2. Plane of C_1 is located between masses A and B at 100 mm from mass A and plane of C_2 is located between masses C and D at 200 mm from mass D. Consider the reference plane at C_1 and determine the magnitudes and angular positions of the countermasses from x axis. [15]

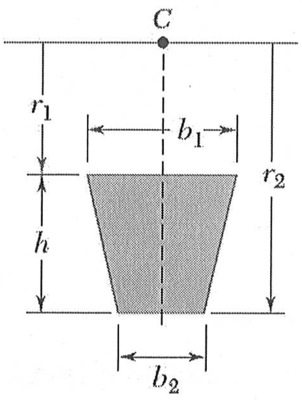

Fig. Q2(a)

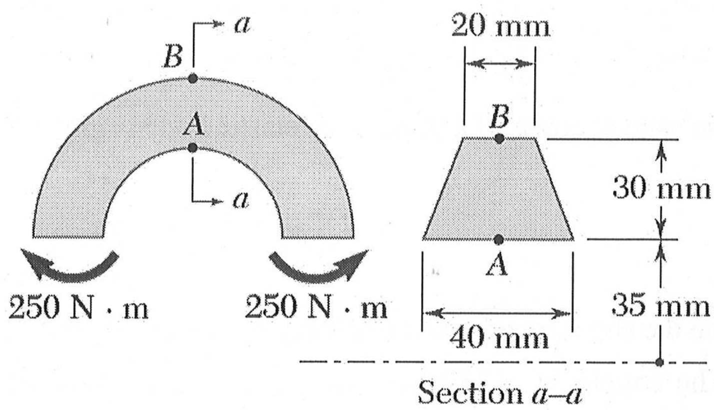

Fig. Q2(b)

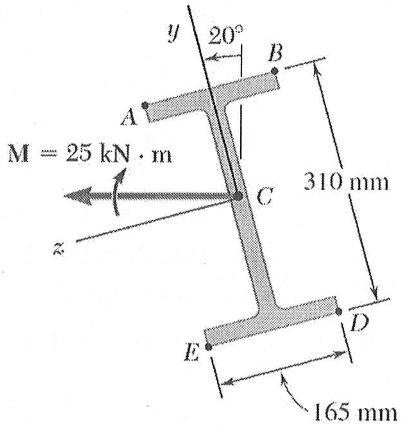

Fig. Q3(b)

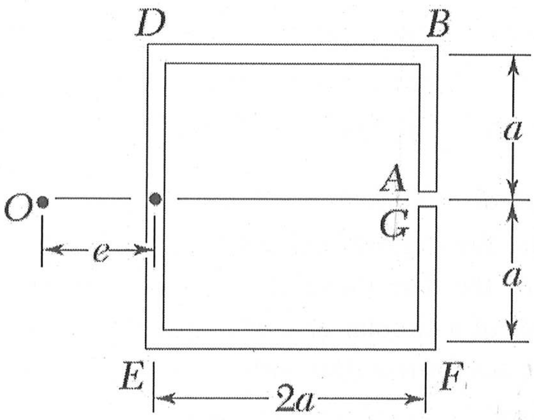

Fig. Q4(b)

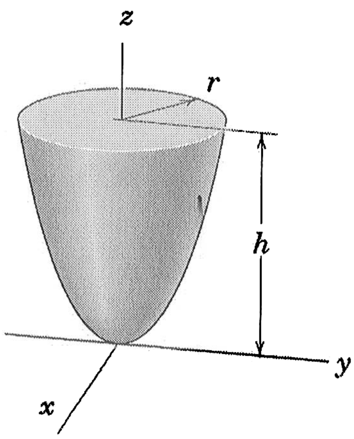

Fig. Q6(a)

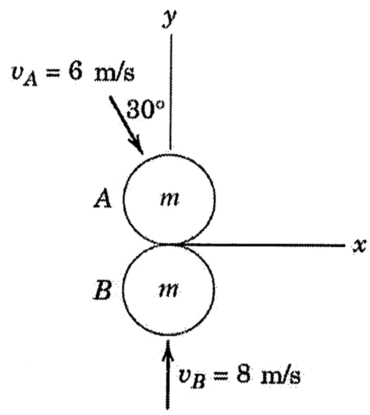

Fig. Q6(b)

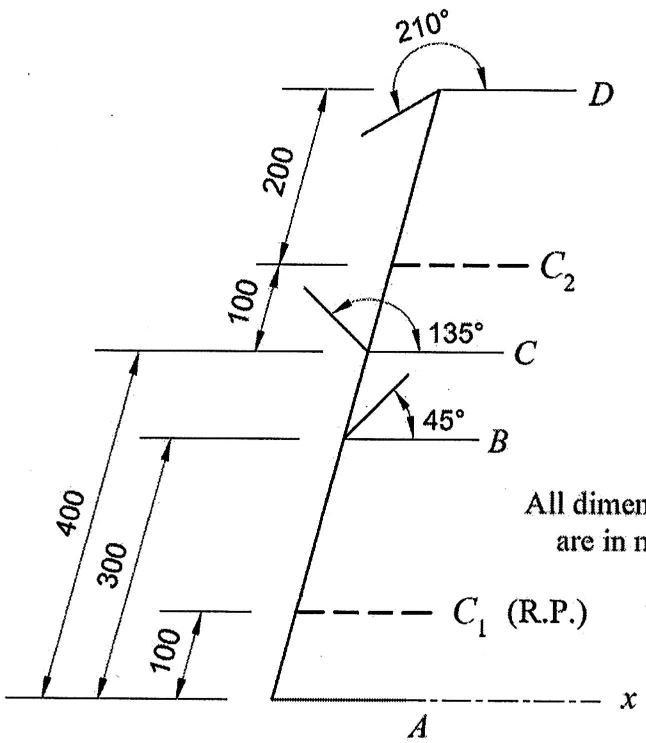

Fig. Q7(b)