B. E. MECHANICAL ENGINEERING (PART TIME) FIRST YEAR FIRST SEMESTER
SUPPLEMENTARY EXAM - 2023
Subject: ENGINEERING MECHANICS – III

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

Question No. 1 is compulsory. Answer any three (3) 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. Answer the following questions (**any 5**). **[05×5 = 25]**

(a) What is modulus of toughness and modulus of resilience? Derive the equation for strain energy in bending.

(b) In a rigid container, mass flows in a steady stream at a constant rate through two openings. Show that the resultant force on the steady flow system can be expressed as $\Sigma F = m'\Delta v$, where m' is the steady mass flow rate and Δv is the change in velocity vector.

(c) Define slenderness ratio. Discuss how Euler's column formula can be used for columns with different end conditions.

(d) Write a short note on singularity function and its application to represent the shear force and bending moment with single mathematical expressions.

(e) Derive the equations of angular momentum and its derivative with respect to time for a mass system about a point '*O*' fixed in the Newtonian reference system and about the mass centre '*G*'.

(f) Briefly discuss about Castigliano's theorem.

2. The compound beam shown in **Fig. Q2** has two segments connected by pin joint at *B*. (a) Draw the free body diagram and compute all reaction forces at *A*, *B*, *C* and *D*. (b) Draw the bending moment and shear force diagram for the beam. (c) What is the maximum bending stress generated in the beam if it has a rectangular cross section with 100mm height and 50mm width? **[10+10+05]**

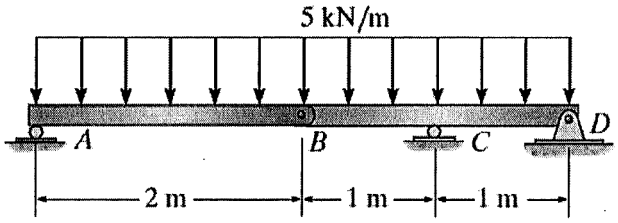

Fig. Q2

3. A simply supported beam is subjected to distributed load $w(x)$ as shown in **Fig. Q3**. The modulus of elasticity of the beam material is E and the area moment of inertia of the beam cross section is I.
(a) Starting from the fourth order governing differential equation for the beam, determine the equation of the elastic curve.
(b) Compute the slope at end *A*.
(c) Find the deflection at the midpoint of the span. **[15+05+05]**

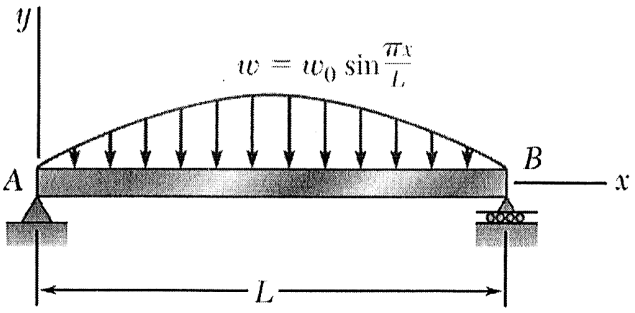

Fig. Q3

4. (a) A statically indeterminate beam of length L is loaded as shown in **Fig. Q4(a)**. Use singularity functions to determine all the support reactions at ends A and C. The modulus of elasticity of the beam material is E and the area moment of inertia of the beam cross section is I. **[15]**

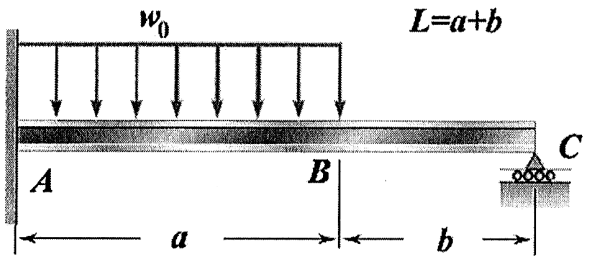

Fig. Q4(a)

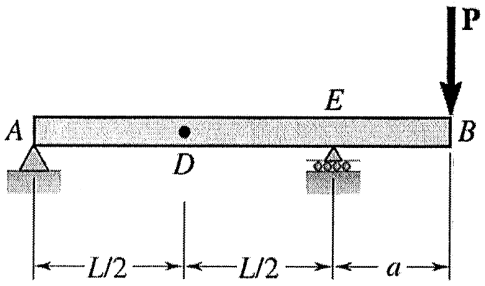

Fig. Q4(b)

(b) Use Castigliano's theorem to determine the deflection at D for the beam and loading shown in **Fig. Q4(b)**. The modulus of elasticity of the beam material is E and the area moment of inertia of the beam cross section is I. **[10]**

5. (a) The system of three particles in **Fig. Q5(a)** has the indicated particle masses, velocities, and external forces. Determine $\bar{r}$, $\dot{\bar{r}}$, $\ddot{\bar{r}}$, T, $\bar{H}_O$, $\dot{\bar{H}}_O$, $\bar{H}_G$ and $\dot{\bar{H}}_G$ for this three–dimensional system. All the symbols have their usual meaning. **[07]**

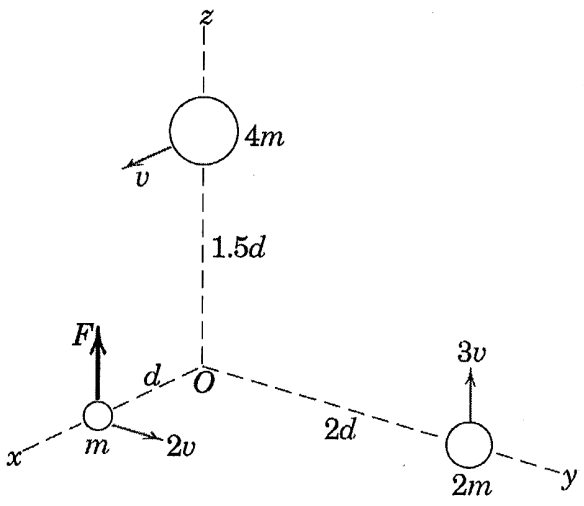

Fig. Q5(a)

(b) The three small spheres are welded to the light rigid frame as shown in **Fig. 5(b)**. It is rotating in a horizontal plane about a vertical axis through O with an angular velocity $\dot{\theta} = 20$ rad/s. If a couple $M_O = 30$ N-m is applied to the frame for 5 seconds, compute the new angular velocity. **[08]**

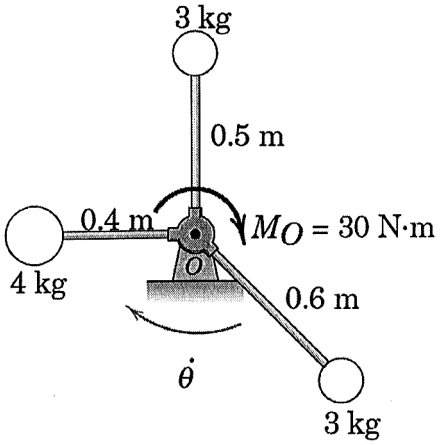

Fig. Q5(b)

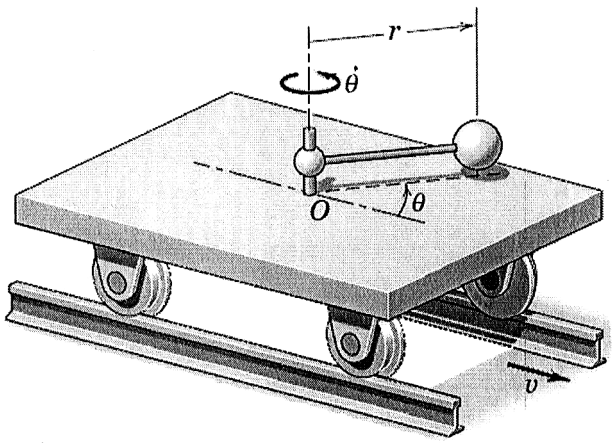

Fig. Q5(c)

(c) A small car is shown in **Fig. Q5(c)**. It has a mass of 25 kg, rolls freely on the horizontal track and carries the 4 kg sphere mounted on the light rotating rod with $r = 0.5$ m. A geared motor drive maintains a constant angular speed $\dot{\theta} = 5$ rad/s of the rod. If the car has a velocity $v = 0.6$ m/s when $\theta = 0^o$, calculate v when $\theta = 60^o$. Neglect the mass of the wheels and any friction. **[10]**