B.E. MECHANICAL ENGINEERING FIRST YEAR FIRST SEMESTER SUPPLEMENTARY EXAM – 2023

Subject: ENGINEERING MECHANICS: STATICS **Time: Three Hours** **Full Marks: 100**

The value of the acceleration due to gravity (g) can be taken as 10 m/s^2, if it is not specified. Any missing information may be suitably assumed with appropriate justification.

Group A *(Answer any two questions from this group)*

Q1a. Replace the two forces acting on the bent pipe as show in **Fig. Q1a** by an equivalent force-couple system at the point *A*. Find the distance from the point *A* to the point on *y*-axis through which a single resultant force equivalent to the given force system (with zero moment) will pass. **[10]**

Q1b. The access door in **Fig. Q1b** is held in the **30°** open position by the chain *AB*. The tension in the chain is known to be **100 N**. Express this tension as a vector with respect to the given *x-y-z* coordinate system. Find the component of this force along the direction parallel to the line *CD*. **[10]**

Q1c. Determine the moment of the **800 N** force about the point *B* and the line *BC* as shown in **Fig. Q1c**. Express the results in vector form. **[10]**

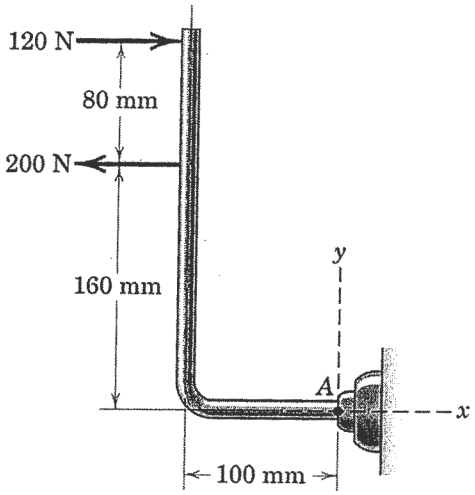

Fig. Q1a

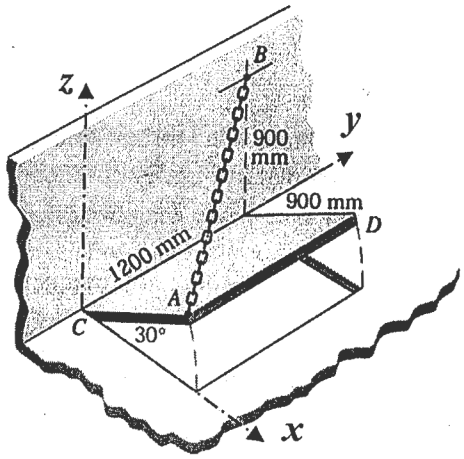

Fig. Q1b

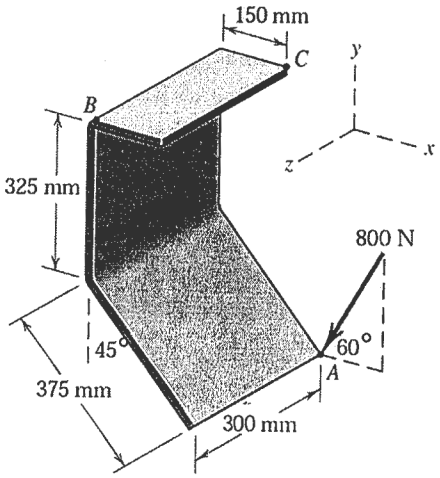

Fig. Q1c

Group B (*Answer any four questions from this group*)

Q2a. For the truss loaded as shown in **Fig. Q2a**, determine the forces in the members ***AB***, ***BE*** and ***BD***. **Draw the necessary free body diagram(s).** **[10]**

Q2b. Determine the reaction at the roller ***F*** and force carried by the member ***BD*** for the frame loaded as shown in **Fig. Q2b**. **Draw the necessary free body diagram(s).** **[10]**

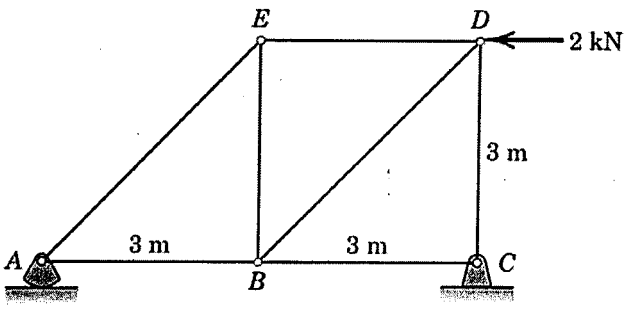

Fig. Q2a

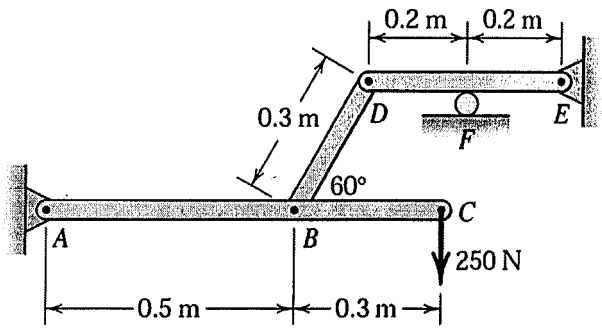

Fig. Q2b

Q2c. Determine the tensions in the three cables which support the uniform **80-kg** plate ***ABC*** whose shape is that of an equilateral triangle (as shown in **Fig. Q2c**). The mass centre ***G*** of the plate is located one-third of the distance ***MC*** from ***M***. **Draw the necessary free-body diagram(s).** **[10]**

Q2d. Determine the magnitudes of resultant reaction force ***R*** and the reaction couple ***M*** exerted by the nut and bolt on the loaded bracket at ***O*** (as shown in **Fig. Q2d**) to maintain the equilibrium. **Draw the necessary free-body diagram(s).** **[10]**

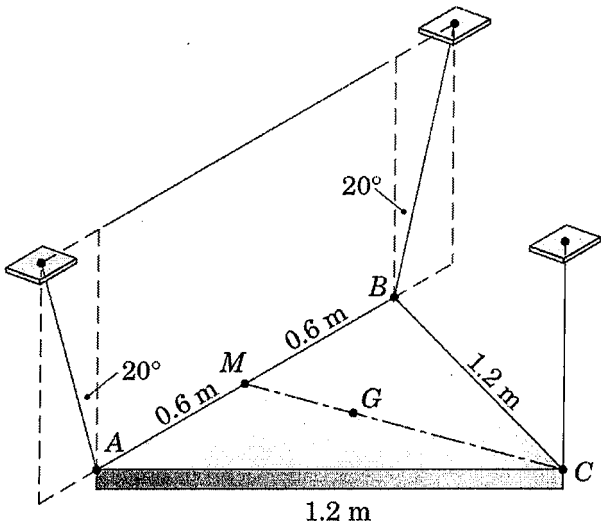

Fig. Q2c

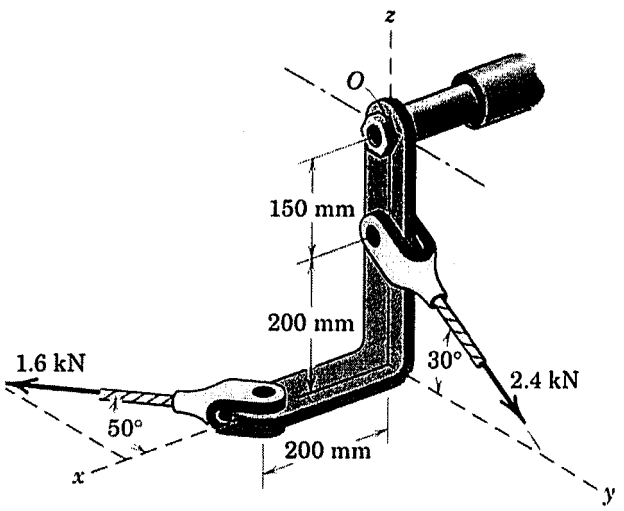

Fig. Q2d

Q2e. The light member ***ABC*** is freely hinged at ***B*** and rests against a smooth support at ***A*** as shown in **Fig. Q2e**. Determine the horizontal and vertical components of reaction at the pin ***B*** under the action of the triangular distributed load with maximum magnitude of **80-N/m** and **90-N·m** couple. **Draw the necessary free body diagram(s).** **[10]**

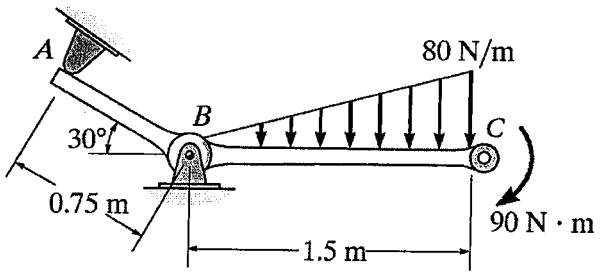

Fig. Q2e

Group C (*Answer any two questions from this group*)

Q3a. The uniform slender bar has an ideal roller at its upper end ***A*** as shown in **Fig. Q3a**. If the coefficient of static friction at ***B*** is $\mu_S = 0.25$, determine the minimum angle θ for which equilibrium is possible. **Draw the necessary free body diagram(s).** **[10]**

Q3b. Determine the range of cylinder mass ***m*** for which the system, shown in **Fig. Q3b**, is in equilibrium. The coefficient of friction between the **50-kg** block and the incline is **0.15** and that between the cord and cylindrical support is **0.25**. **Draw the necessary free body diagram(s).** **[10]**

Q3c. Block ***A*** supports a pipe column and rests on wedge ***B*** as shown in **Fig. Q3c**. If the coefficient of static friction at all surfaces of contact is $\mu_S = 0.25$ and $\theta = 45°$, determine the smallest force ***P*** required to raise block ***A***. **Draw the necessary free body diagram(s).** **[10]**

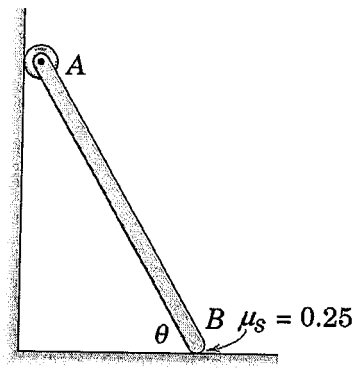

Fig. Q3a

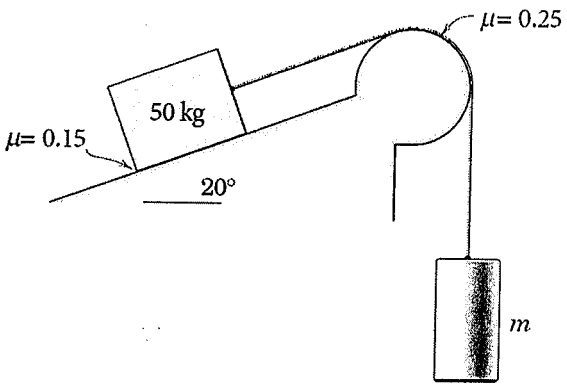

Fig. Q3b

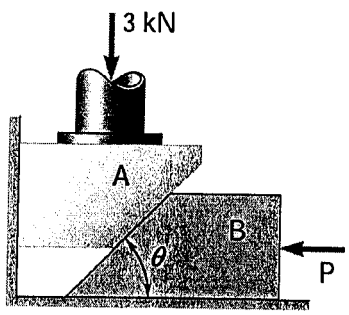

Fig. Q3c

Group D (*Answer any two questions from this group*)

Q4a. Using Pappus' Theorem determine the surface area of revolution of the conical shell shown in **Fig. Q4a.** **[10]**

Q4b. Determine the coordinates of the centroid of the shaded area as shown in the **Fig. Q4b.** **[10]**

Q4c. For the sector of the circle shown in **Fig. Q4c**, find second moment of the area about the horizontal axis passing through *C*. **(Centroid)** **[10]**

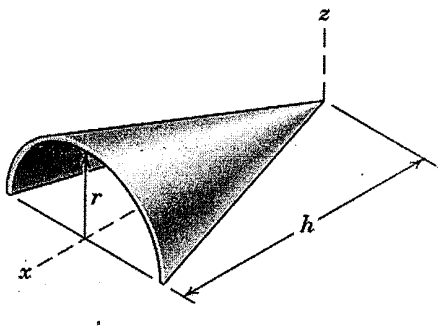

Fig. Q4a

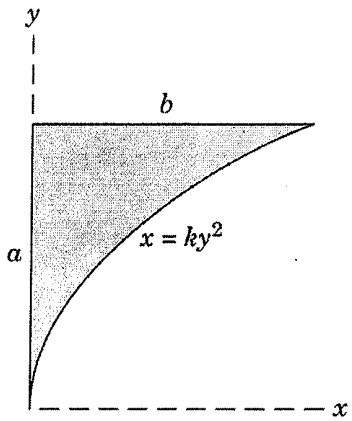

Fig. Q4b

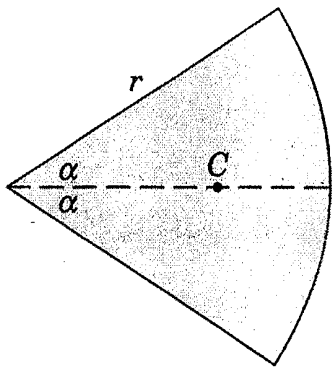

Fig. Q4c