B.E. MECHANICAL ENGINEERING FIRST YEAR FIRST SEMESTER SUPPLEMENTARY EXAM – 2024

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. The flanged steel cantilever beam with riveted bracket is subjected to the couple and two forces shown in **Fig. Q1a**, and their effect on the design of the attachment at '*A*' must be determined. Replace the two forces and couple by an equivalent couple *M* and resultant force **R** at '*A*'. **[10]**

Q1b. The turnbuckle in **Fig. Q1b** is tightened until the tension in cable *AB* is **1.2 kN**. Calculate the magnitude of the moment about point '*O*' of the force acting on point '*A*'. **[10]**

Q1c. If $F_1 = 450$ **N** and the magnitude of the moment of both forces about line *AB* is **30 N-m**, determine the magnitude of F_2 as shown in **Fig. Q1c**. Use the values $a = 200$ **mm**, $b = 400$ **mm**, and $c = 500$ **mm**. **[10]**

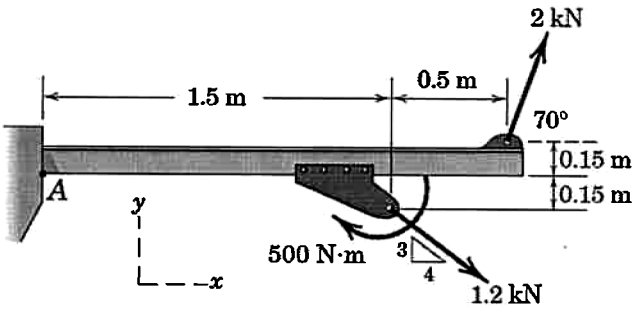


Fig. Q1a

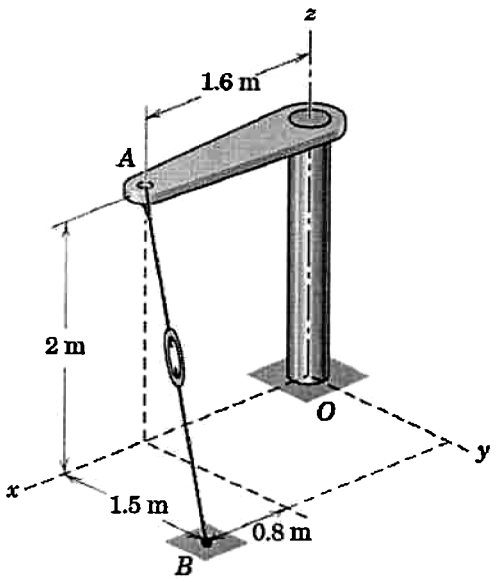
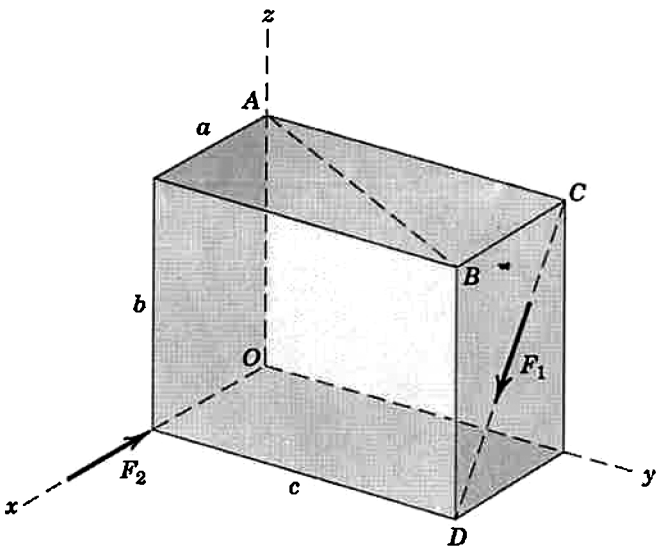


Fig. Q1b



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 *CH* and *GF*. **Draw the necessary free body diagram(s).** **[10]**

Q2b. Determine the magnitude of pin force at '*B*' for the frame loaded as shown in **Fig. Q2b. Draw the necessary free body diagram(s).** **[10]**

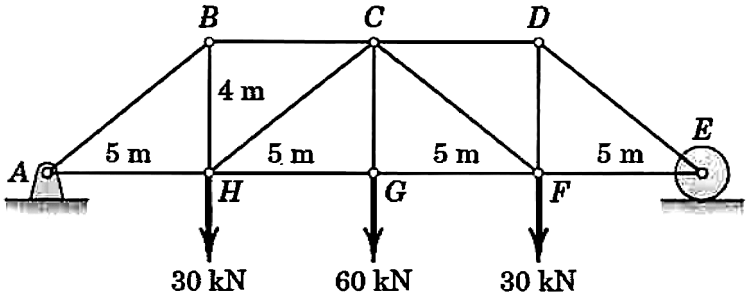


Fig. Q2a

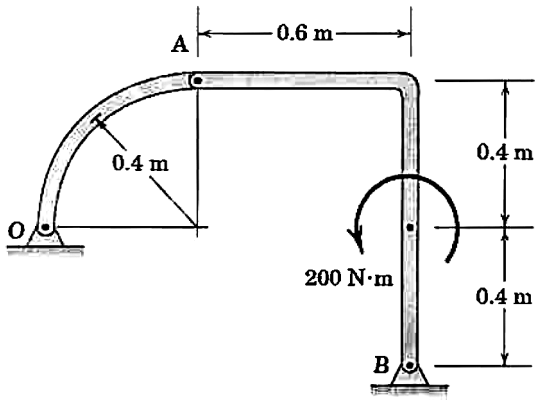


Fig. Q2b

Q2c. The light right-angle boom (as shown in **Fig. Q2c**) which supports the **400 kg** cylinder is supported by three cables and a ball-and-socket joint at '*O*' attached to the vertical *x-y* surface. Determine the cable tensions. **Draw the necessary free-body diagram(s).** **[10]**

Q2d. The light bracket *ABC* in **Fig. Q2d** is freely hinged at '*A*' and is constrained by the fixed pin in the smooth slot at '*B*'. Calculate the magnitude of the force supported by the pin at '*A*' under the action of the **80 N·m** applied couple. **Draw the necessary free body diagram(s).** **[10]**

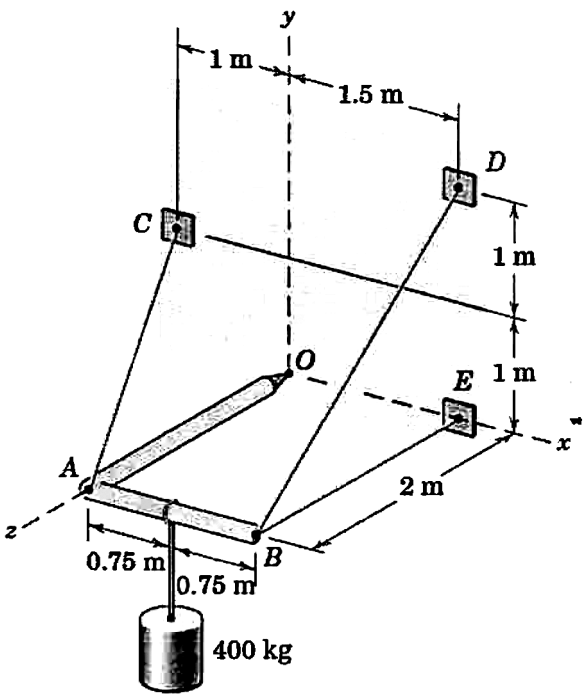


Fig. Q2c

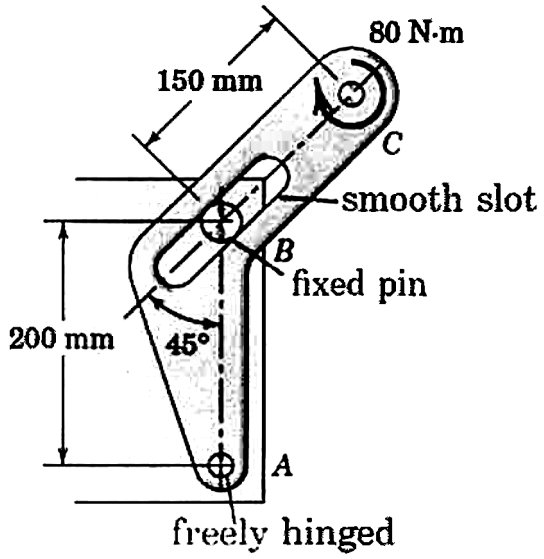


Fig. Q2d

Q2e. With necessary sketches and free body diagram(s), show that a flexible cable carrying uniformly distributed load of intensity w per unit horizontal distance in the vertical plane, forms a curve given by the equation $y = \frac{wx^2}{2T_0}$, where **x** and **y** are the coordinate of any point of the hanging cable and origin of the coordinate system is located at the lowest point of the cable. $\mathbf{T_0}$ is the tension of the cable at its lowest point. The self-weight of the cable is negligible. **[10]**

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

Q3a. The strut AB of negligible mass is hinged to the horizontal surface at 'A' and to the uniform **25 kg** wheel at 'B' as shown in **Fig. Q3a.** Determine the minimum couple M applied to the wheel which will cause it to slip if the coefficient of static friction between the wheel and the surface is $\mu_s = 0.40$. **Draw the necessary free body diagram(s).** **[10]**

Q3b. The **3 m** uniform beam is suspended by the flexible belt which passes over the large pulley as shown in **Fig. Q3b.** A locking pin 'A' prevents the rotation of the pulley. If the coefficient of friction between the belt and the pulley is **0.25,** determine the minimum value of x for which the belt will not slip on the pulley. **Draw the necessary free body diagram(s).** **[10]**

Q3c. With necessary sketches and free body diagram(s), show that in a square threaded screw jack, the expression of moment required to be applied about the axis of the screw, which is just enough to raise a load of W, will be $M = W r \tan(\alpha + \varphi)$, where r, α and φ are the mean radius of the screw, helix angle of the screw and the angle of static friction between the screw and nut surfaces, respectively. **[10]**

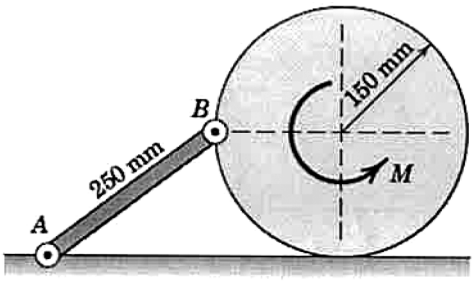


Fig. Q3a

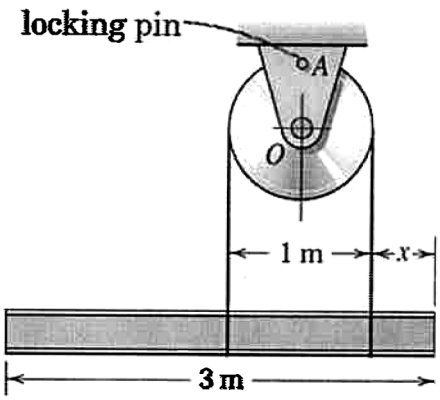


Fig. Q3b

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

Q4a. State and explain Pappus' Theorem with neat sketches. **[10]**

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

Q4c. Determine the moments of inertia of the **Z** section shown in **Fig. Q4c** about its centroidal x_0 and y_0 axes. **[10]**

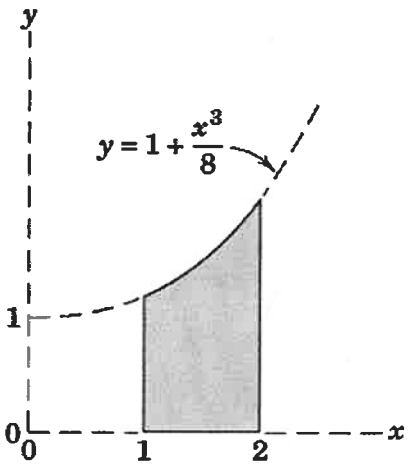


Fig. Q4b

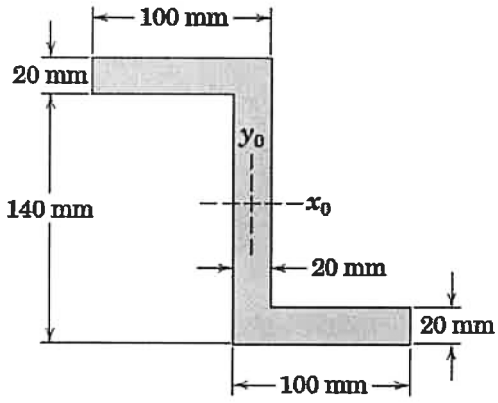


Fig. Q4c