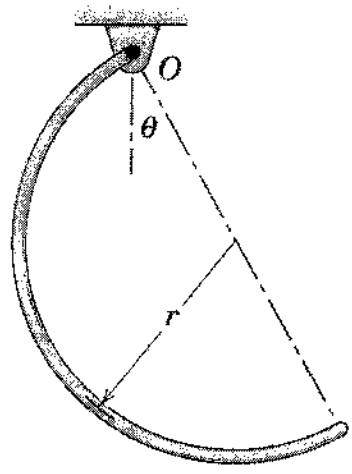
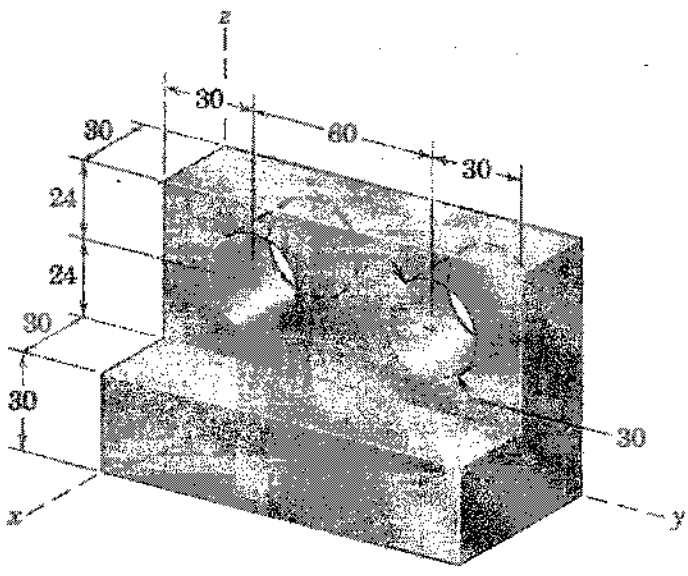
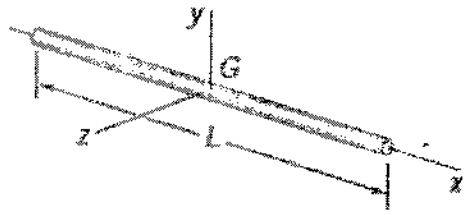
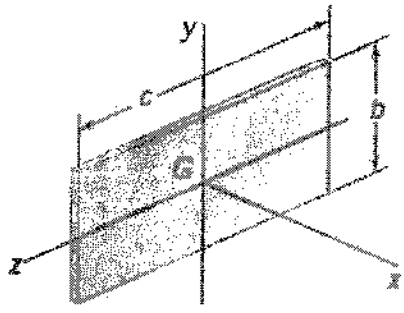
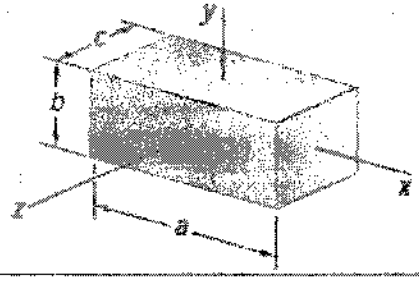
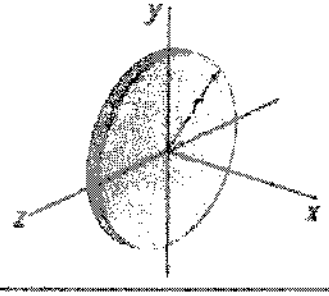
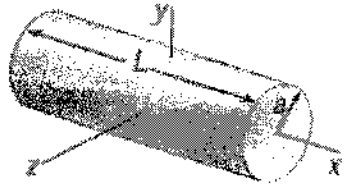
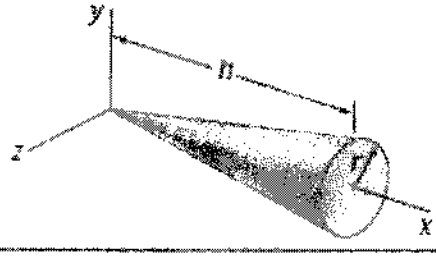
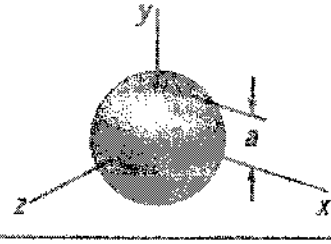
1. **(a) (6 Marks)** (ILO a1.1) A uniform semicircular rod of radius r is supported in a bearing at its upper end and is free to swing in the vertical plane. Calculate the angle θ made by the diameter with the vertical for the equilibrium position.



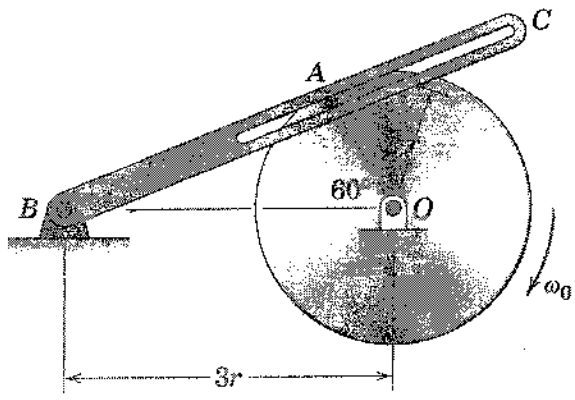
1. **(b) (10 Marks)** (ILO b2.1) Determine the mass and the centroid location of the cast-aluminum body. The density $\rho = 2690$ kg/m^3.



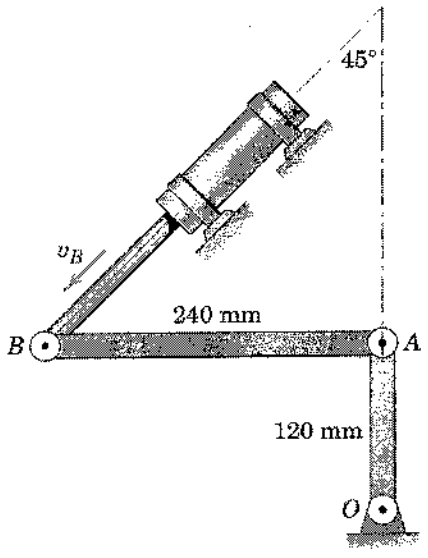
Dimensions in millimeters

Slender rod		$I_y = I_z = \frac{1}{12} mL^2$
Thin rectangular plate		$I_x = \frac{1}{12} m(b^2 + c^2)$ $I_y = \frac{1}{12} mc^2$ $I_z = \frac{1}{12} mb^2$
Rectangular prism		$I_x = \frac{1}{12} m(b^2 + c^2)$ $I_y = \frac{1}{12} m(c^2 + a^2)$ $I_z = \frac{1}{12} m(a^2 + b^2)$
Thin disk		$I_x = \frac{1}{2} mr^2$ $I_y = I_z = \frac{1}{4} mr^2$
Circular cylinder		$I_x = \frac{1}{2} ma^2$ $I_y = I_z = \frac{1}{12} m(3a^2 + L^2)$
Circular cone		$I_x = \frac{3}{10} ma^2$ $I_y = I_z = \frac{3}{5} m(\frac{1}{4} a^2 + h^2)$
Sphere		$I_x = I_y = I_z = \frac{2}{5} ma^2$

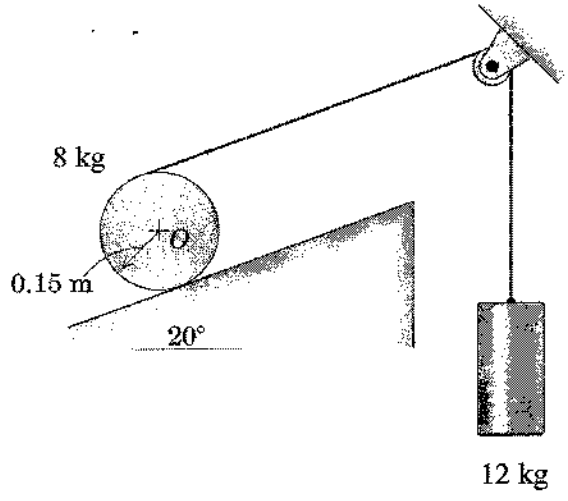
7. **(10 Marks)** The disk rotates about a fixed axis through point O with a clockwise angular velocity $\omega_0 = 10$ rad/s and a counter-clockwise angular acceleration $\alpha_0 = 4$ rad/s^2. at the instant under consideration. The value of r is 250 mm. Pin A is fixed to the disk but slides freely within the slotted member BC. Determine the velocity and acceleration of A relative to slotted member BC and the angular velocity and angular acceleration of BC.



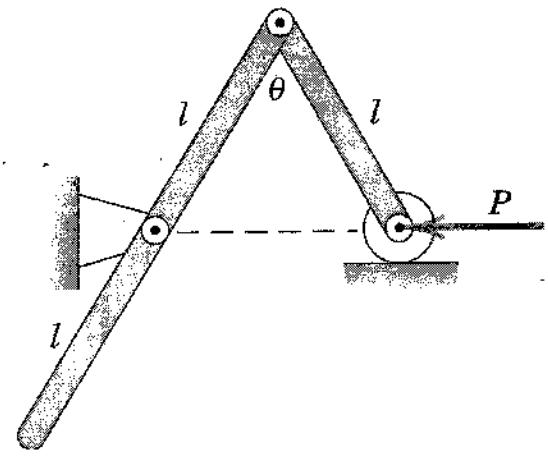
5. **(10 Marks)** (ILO b2.3) The hydraulic cylinder imparts motion to point B which causes link OA to rotate. For the instant shown where OA is vertical and AB is horizontal, the velocity v_B of pin B is 5 m/s and is increasing at the rate of 16 m/s^2. For this position determine the angular velocity of OA.



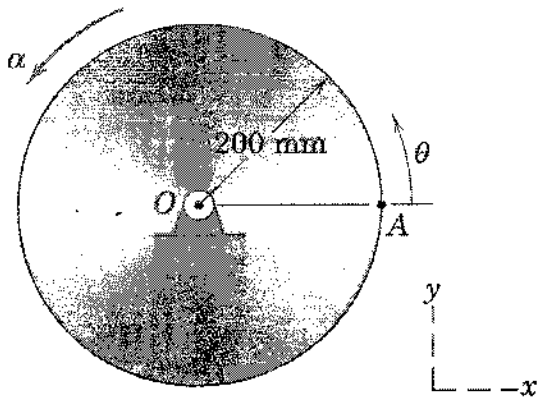
6. **(10 Marks)** (ILO a1.2, a1.3) The system is released from rest with the cable taut, and the homogeneous cylinder does not slip on the rough incline. Determine the angular acceleration of the cylinder and the minimum coefficient of friction for which the cylinder will not slip.



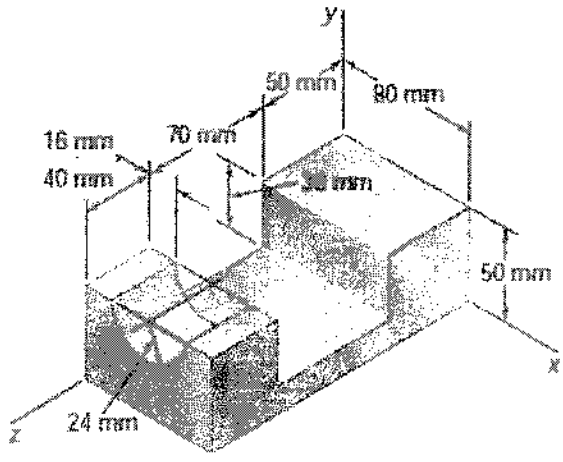
3. **(8 Marks)** The mass of the uniform bar of length l is m while that of the uniform bar of length $2l$ is $2m$. For a given force P, determine the angle θ for equilibrium using the method of virtual work.



4. **(10 Marks)** (ILO b2.3) Point A of the circular disk is at the angular position $\theta = 0$ at time $t = 0$. The disk has angular velocity $\omega_0 = 0.2$ rad/s at $t = 0$ and subsequently experiences a constant angular acceleration $\alpha = 4$ rad/s^2. Determine the velocity and acceleration of point A in terms of fixed **i** and **j** unit vectors at time $t = 2$ s.



2. (a) (10 Marks) (ILO b2.2) Determine the mass moment of inertia of the steel fixture shown with respect to the y-axis. (The density of steel is 7850 kg/m^3.)



2. **(b) (6 Marks)** (ILO b2.2) Calculate the moment of inertia of the shaded area about the y-axis. Dimensions are in mm.