B.Sc.Engg. (M)/1st Sem. 05 December 2023 (Afternoon)

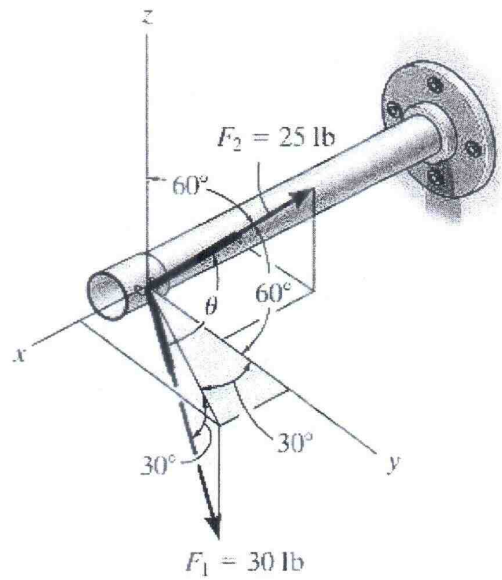
ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING

Semester Final Examination
Course No. ME 4103
Course Title: Statics

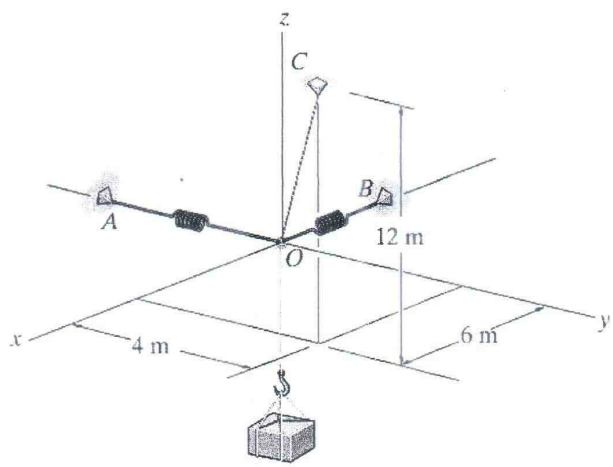
Winter Semester: A.Y. 2022-2023
TIME : 3 hours
Full Marks : 150

Each question carries equal marks. Symbols have their usual meanings. Draw the free body diagram if required. The right column also indicates the course objective (CO) and Program Outcomes (PO) addressed by each question. Assume reasonable values for missing data.

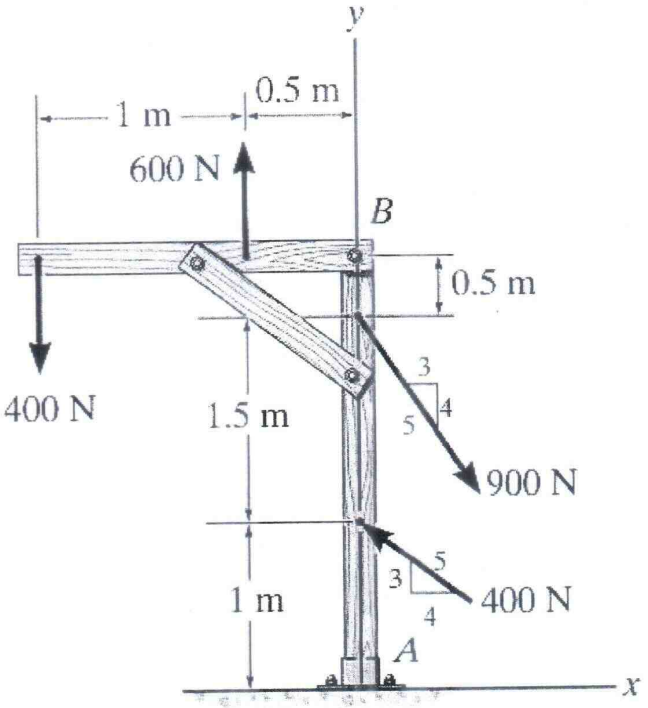
Q-01(a). Two cables exert forces on the pipe. Determine the magnitude of the projected component of F_1 along the line of action of F_2 **12.5 (CO1) (PO2)**



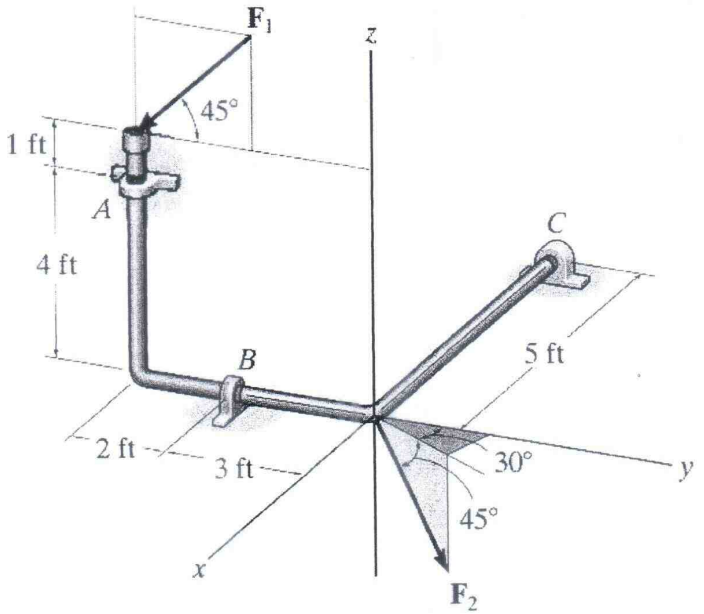
Q-01(b). Determine the stretch in each of two springs required to hold the ***20 kg*** crate in equilibrium position. Each spring has an unstretched length of ***2 m*** and a stiffness of ***k = 360 N/m*** **12.5 (CO1) (PO3)**



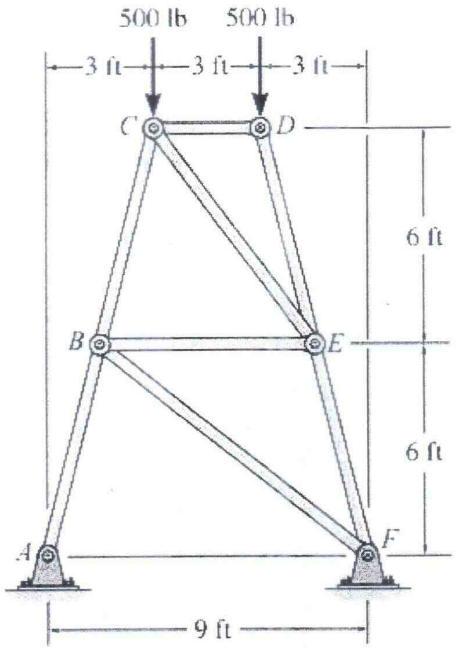
Q-02(a). Replace the loading on the frame by a single resultant force. Specify where its line of action intersects a horizontal line along member ***CB***, measured from end ***C***. **12.5 (CO2) (PO2)**



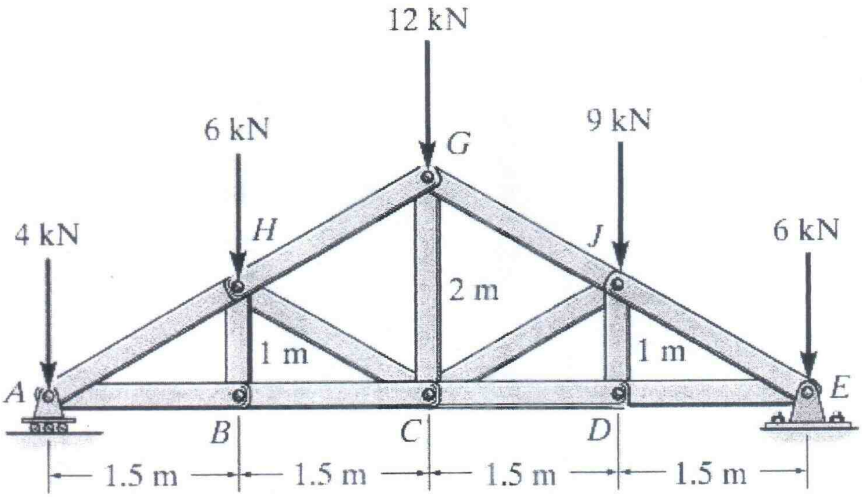
Q-02(b). The bent rod is supported at ***A, B***, and ***C*** by smooth journal bearings. Determine the magnitude of F_2 which will cause the reaction at the bearing C_y to be equal to zero. The bearings are in proper alignment and exert only force reactions on the rod. Set $F_1 = 300$ *lb*. **12.5 (CO2) (PO2)**



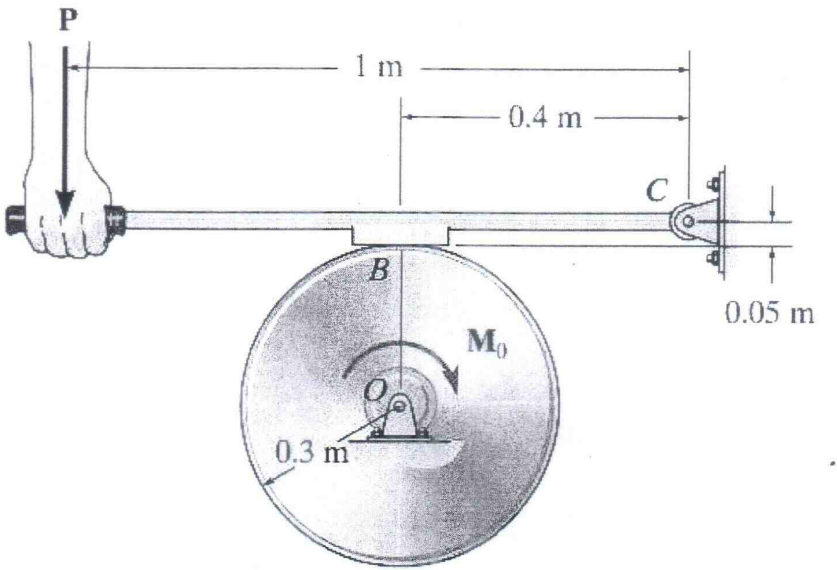
Q-03(a). Determine the force in each member of the truss and state if the members are in tension or compression. **12.5 (CO3) (PO3)**



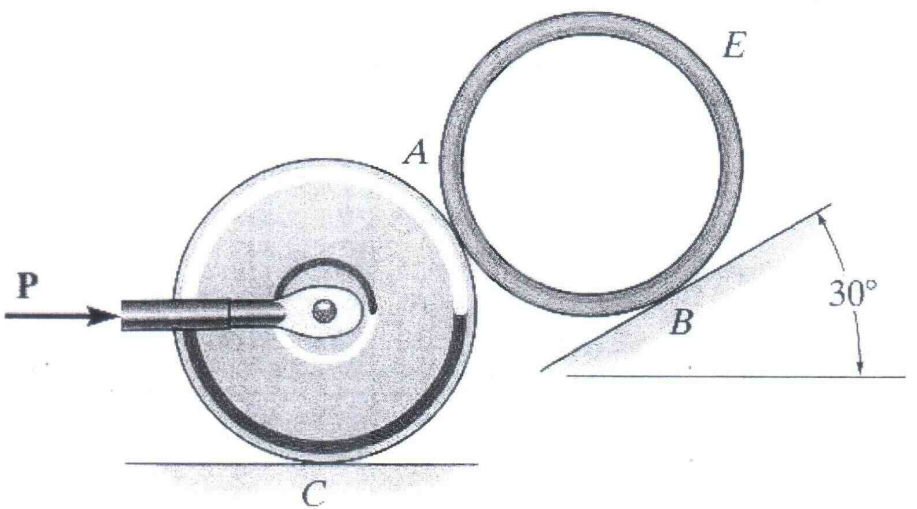
Q-03(b). Determine the force in members ***BC***, ***HC***, and ***HG***. State if these members are in tension or compression. **12.5 (CO3) (PO2)**



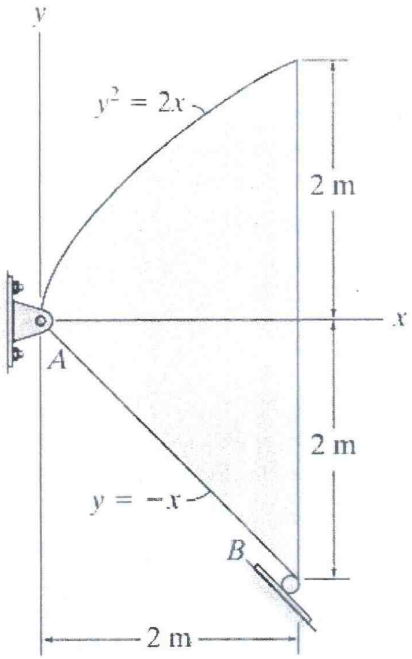
Q-04(a). The block brake is used to stop the wheel from rotating when the wheel is subjected to a couple moment $M_o = 360\ Nm$. If the coefficient of static friction between the wheel and the block is $\mu_S = 0.6$, determine the smallest force P that should be applied. **12.5 (CO3) (PO2)**



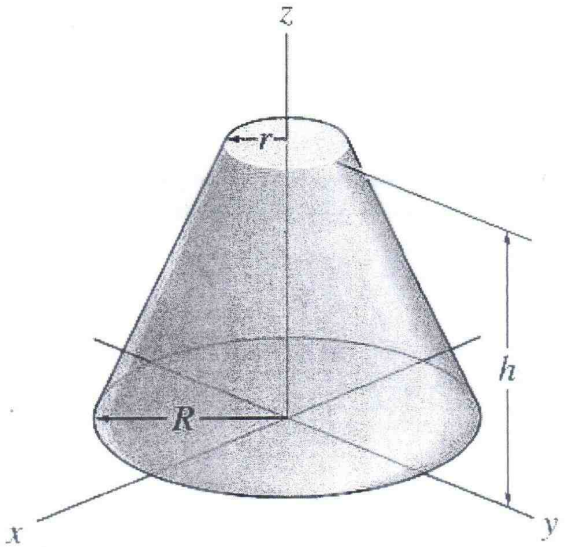
Q-04(b). Determine the minimum force P needed to push the tube E up the incline. The force acts parallel to the plane, and the coefficients of static friction at the contacting surfaces are $\mu_A = 0.2$, $\mu_B = 0.3$, and $\mu_C = 0.4$. The *100 kg* roller and *40-kg* tube each have a radius of *150 mm*. **12.5 (CO3) (PO2)**



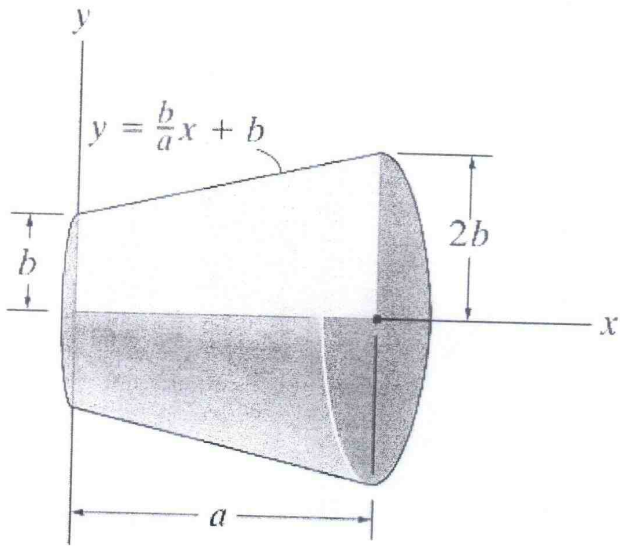
Q-05(a). The steel plate is ***0.3 m*** thick and has a density of ***7850 kg/m³***. Determine the location of its center of mass. Also compute the reactions at the pin and roller support. **12.5 (CO4) (PO2)**



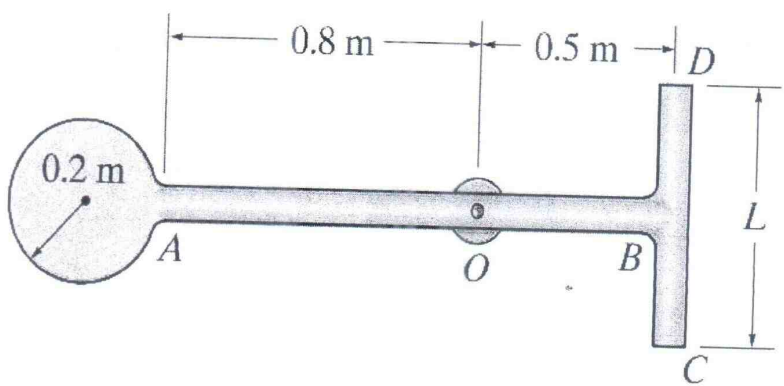
Q-05(b). Locate the centroid $\bar{z}$ of the frustum of the right-circular cone. **12.5 (CO4) (PO2)**



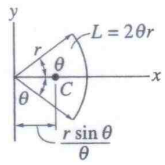
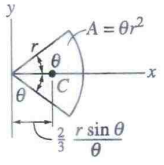
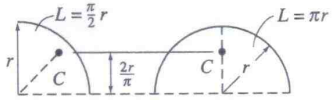
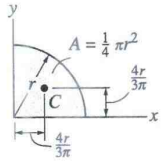
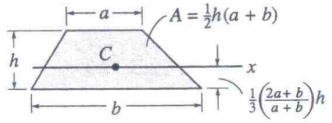
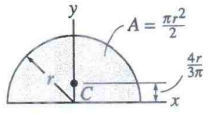
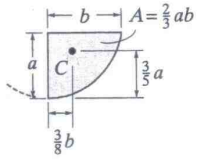
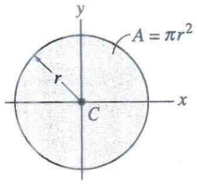
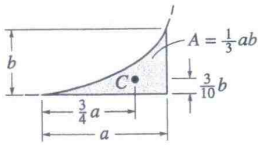
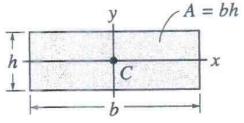
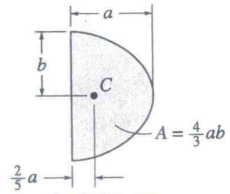
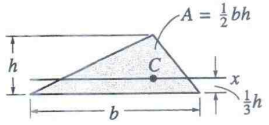
Q-06(a). The frustum is formed by rotating the shaded area around the x axis. Determine the moment of inertia I_x and express the result in terms of the total mass m of the frustum. The material has a constant density ρ. **12.5 (CO4) (PO1)**



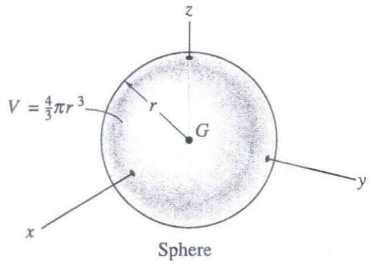
Q-06(b). The pendulum consists of a disk having a mass of ***6 kg*** and slender rods ***AB*** and ***DC*** which have a mass per unit length of ***2 kg/m***. Determine the length L of ***DC*** so that the center of mass is at the bearing ***O***. What is the moment of inertia of the assembly about an axis perpendicular to the page and passing through point ***O***? **12.5 (CO4) (PO2)**



Geometric Properties of Line and Area Elements

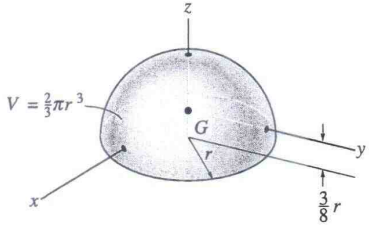
Centroid Location	Centroid Location	Area Moment of Inertia
 Circular arc segment	 Circular sector area	$I_x = \frac{1}{4}r^4(\theta - \frac{1}{2}\sin 2)\theta$ $I_y = \frac{1}{4}r^4(\theta + \frac{1}{2}\sin 2)\theta$
 Quarter and semicircle arcs	 Quarter circle area	$I_x = \frac{1}{16}\pi r^4$ $I_y = \frac{1}{16}\pi r^4$
 Trapezoidal area	 Semicircular area	$I_x = \frac{1}{8}\pi r^4$ $I_y = \frac{1}{8}\pi r^4$
 Semiparabolic area	 Circular area	$I_x = \frac{1}{4}\pi r^4$ $I_y = \frac{1}{4}\pi r^4$
 Exparabolic area	 Rectangular area	$I_x = \frac{1}{12}bh^3$ $I_y = \frac{1}{12}hb^3$
 Parabolic area	 Triangular area	$I_x = \frac{1}{36}bh^3$

Center of Gravity and Mass Moment of Inertia of Homogeneous Solids



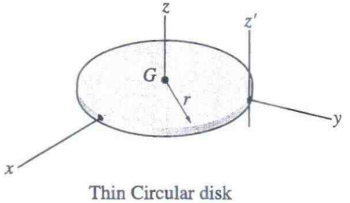
Sphere

$I_{xx} = I_{yy} = I_{zz} = \frac{2}{5} mr^2$



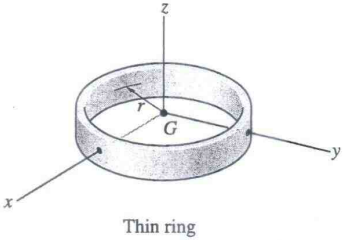
Hemisphere

$I_{xx} = I_{yy} = 0.259mr^2 \quad I_{zz} = \frac{2}{5} mr^2$



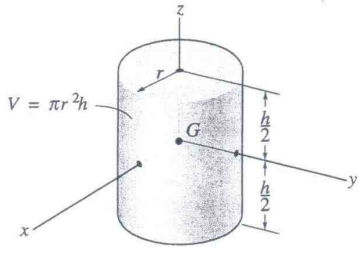
Thin Circular disk

$I_{xx} = I_{yy} = \frac{1}{4} mr^2 \quad I_{zz} = \frac{1}{2} mr^2 \quad I_{z'z'} = \frac{3}{2} mr^2$



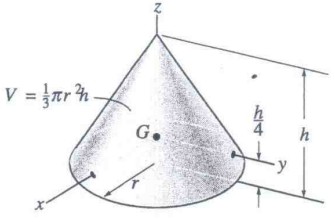
Thin ring

$I_{xx} = I_{yy} = \frac{1}{2} mr^2 \quad I_{zz} = mr^2$



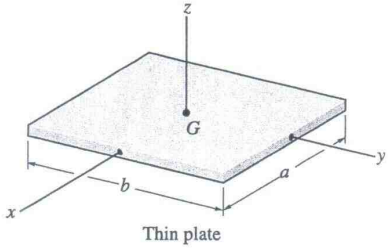
Cylinder

$I_{xx} = I_{yy} = \frac{1}{12} m(3r^2 + h^2) \quad I_{zz} = \frac{1}{2} mr^2$



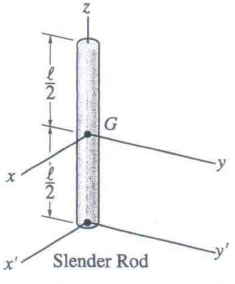
Cone

$I_{xx} = I_{yy} = \frac{3}{80} m(4r^2 + h^2) \quad I_{zz} = \frac{3}{10} mr^2$



Thin plate

$I_{xx} = \frac{1}{12} mb^2 \quad I_{yy} = \frac{1}{12} ma^2 \quad I_{zz} = \frac{1}{12} m(a^2 + b^2)$



Slender Rod

$I_{xx} = I_{yy} = \frac{1}{12} m\ell^2 \quad I_{x'x'} = I_{y'y'} = \frac{1}{3} m\ell^2 \quad I_{z'z'} = 0$