Problem 17.10 (Page 396)

The shape below made of concrete was formed by rotating the shaded area about the y-axis. Determine the moment of inertia about the y-axis, \( I_y \). The specific weight of the concrete is \( \gamma = 150 \text{ lb/ft}^3 \).

\[
dI_y = \frac{1}{2} dm \left( 10 \right)^2 - \frac{1}{2} dm \left( x^2 \right)
\]

\[
= \frac{1}{2} \left( \frac{dm}{\pi} \right) (10) dy \gamma (10)^2
\]

\[
- \frac{1}{2} \left( \frac{dm}{\pi} \right) y^2 \gamma x^2
\]

\[
dI_y = \frac{1}{2} \gamma \pi \left[ \int_0^8 y^2 dy - \int_0^8 \left( \frac{9}{2} \right) y^2 dy \right]
\]

\[
= \frac{1}{2} \times \frac{8}{9} \pi \frac{11}{12} \left[ 10 \left( 8 \right) - \left( \frac{9}{2} \right)^2 \frac{1}{3} \left( 8^3 \right) \right]
\]

\[
= 324.1 \text{ slug in}^2 = 2.25 \text{ slug ft}^2
\]
Problem 17.15 (Page 397 - 11th Ed)

The wheel below consists of a thin ring having a mass of 10 kg and four spokes made of slender rods, each having a mass of 2 kg. Determine the wheel's moment of inertia about an axis perpendicular to the page and passing through point A.

\[
I_A = I_o + md^2
\]

\[
m = 10 + 4(2) = 18 \text{ kg}
\]

\[
d^2 = (0.5 \text{ m})^2 = 0.25 \text{ m}^2
\]

\[
I_o = 4 \cdot \frac{1}{12} (2)(1)^2 + 10(0.5)^2 = 3.167 \text{ kg m}^2
\]

\[
I_A = 3.167 + 18(0.25) = 7.667 \text{ kg m}^2
\]
Problem 17.23 (Page 398)

The pendulum shown consists of two slender rods AB and OC, each with a mass per length of 3 kg/m. The thin circular plate, which has a small hole in the center, has a mass per area of 12 kg/m². Determine the location \( \bar{y} \) of the mass center G of the pendulum, then calculate the moment of inertia of the pendulum about an axis perpendicular to the screen and passing through G.

\[
\text{Location of the mass center}
\]

\[
\begin{align*}
M_{AB} &= 0.8 \times 3 = 2.4 \text{ kg} \\
M_{OC} &= 1.5 \times 3 = 4.5 \text{ kg} \\
M_{\text{plate w/o hole}} &= \pi \left( \frac{0.3}{2} \right)^2 \times 12 = 3.392 \text{ kg} \\
M_{\text{hole}} &= \pi \left( \frac{0.1}{2} \right)^2 \times 12 = 0.3768 \text{ kg} \\
M_{\text{plate}} &= 3.392 - 0.3768 = 3.015 \text{ kg} \\
\bar{y} \left[ 2.4 + 4.5 + 3.015 \right] &= 0.75(4.5) + 1.8(3.015) \\
\bar{y} &= 0.888 \text{ m}
\end{align*}
\]
Problem 17.23 (Page 398)

The pendulum shown consists of two slender rods AB and OC, each with a mass per length of 3 kg/m. The thin circular plate, which has a small hole in the center, has a mass per area of 12 kg/m². Determine the location \( \bar{y} \) of the mass center \( G \) of the pendulum, then calculate the moment of inertia of the pendulum about an axis perpendicular to the screen and passing through \( G \).

\[
I_o = I_{AB} + I_{OC} + I_{\text{plate}}
\]

\[
I_{AB} = \frac{1}{12} (2.4)(.8)^2 = 0.128 \text{ Kg m}^2
\]

\[
I_{OC} = \frac{1}{3} (4.5)(1.5)^2 = 3.375 \text{ Kg m}^2
\]

\[
I_{\text{plate}} = I_{G_{\text{plate}}} + md^2
\]

\[
I_{G_{\text{plate}}} = \frac{1}{2} (3.392)(.3)^2 - \frac{1}{2} (.3768)(.1)^2
\]

\[
= 0.151 \text{ Kg m}^2
\]

\[
I_{\text{plate}} = 0.151 + 3.015(1.8)^2 = 9.92 \text{ Kg m}^2
\]

\[
I_o = 0.128 + 3.375 + 9.92 = 13.423 \text{ Kg m}^2
\]

\[
I_o = I_G + I_{\text{total}} d^2
\]

\[
13.423 = I_G + 9.915(.888)^2
\]

\[
I_G = 5.604 \text{ Kg m}^2
\]
A jet aircraft with three engines has a total mass of 22 Mg and a center of mass at G. At take-off the engines provide a thrust of \(2T = 4\) kN and \(T' = 1.5\) kN. Determine the acceleration of the plane, plus the normal reactions on the nose wheel at A, and on each of the two wing wheels located at B. Neglect the mass of the wheels, and the lift caused by the wings.

\[\sum F_x = 1.5 + 4 = 22 a_c\]
\[a_c = 0.25 \text{ m/s}^2\]

\[\sum F_y = 2N_b + N_A - 22(9.81) = 0\]

\[\sum M_c = 6N_a - 3N_b - 4(1.1) - 1.5(1.3) = 0\]

\[N_A = 72.6 \text{ kN}\]
\[N_b = 71.6 \text{ kN}\]
Problem 17.54 (Page 422)
A 10-kg wheel has a radius of gyration about the center A of \( k_A = 200 \text{ mm} \). The wheel is at rest when it is subjected to a moment \( M = 5t \text{ (N·m)} \), where \( t \) is in seconds. Determine a) its angular velocity after \( t = 3 \) seconds and b) the reactions at A which is pinned and fixed.

\[
I_A = k_A^2 m = (2)^2 (10) = 4 \text{ m}^2 \text{ kg}
\]

\[
\sum \tau_A = 5t = 4\alpha
\]

\[
\alpha = \frac{d\omega}{dt} = 12.5t
\]

\[
\int_0^3 \omega \, dt = \int_0^3 12.5t \, dt
\]

\[
\omega = 12.5 \cdot \frac{3^2}{2} = 56.25 \text{ rad/sec}
\]

\[
\sum F_x = A_x = 0
\]

\[
\sum F_y = A_y - 98.1 = 0
\]

This assumes that the pin at A is the only support.