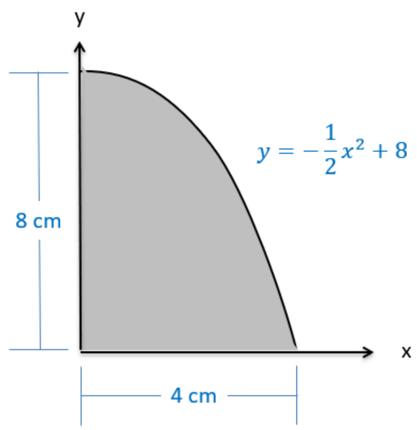
Appendix 2 Homework Problems

Problem A2.1

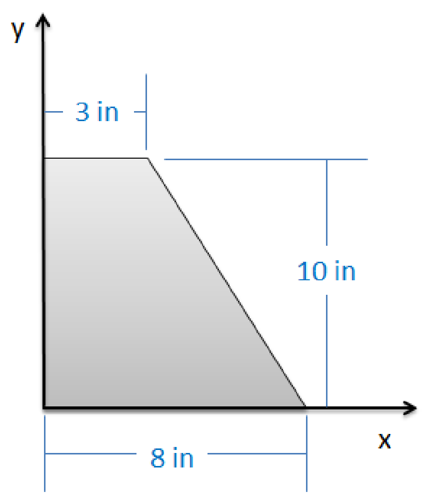
A shape is bounded on the left by the y axis, on the bottom by the x axis, and along its remaining side by the function $y = -1/2\, x^2 + 8$. Determine the x and y coordinates of the centroid of this shape via integration. (Hint: for y bar, work from the top down to make the math easier)



Solution: $\bar{x}$ = 1.5 cm, $\bar{y}$ = 3.2 cm

Problem A2.2

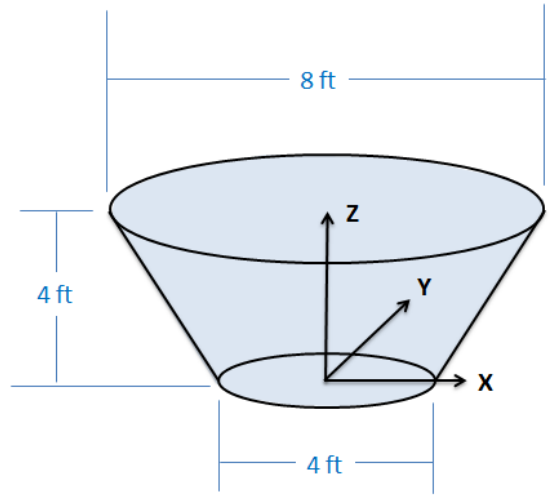
Determine the x and y coordinates of the centroid of the shape shown below via integration.



Solution: X_C = 2.94 in, Y_C = 4.24 in

Problem A2.3

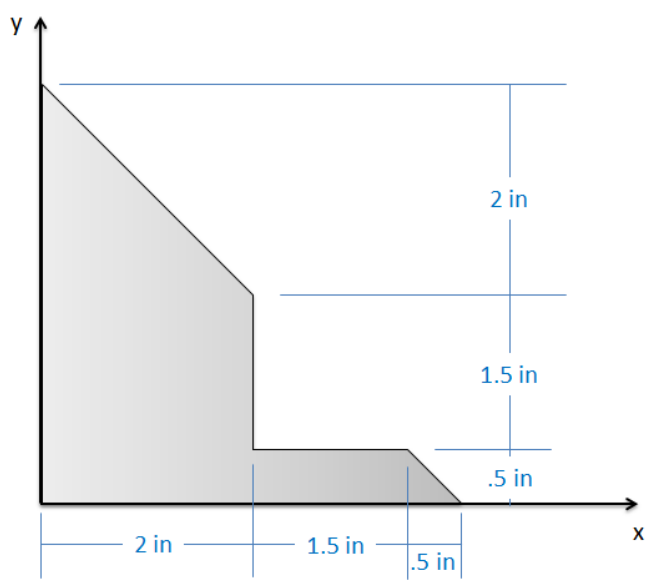
A water tank as shown below takes the form of an inverted, truncated cone. The diameter of the base is 4 ft, the diameter of the top is 8 ft, and the height of the tank is 4 ft. Using integration, determine the height of the center of mass of the filled tank. (Assume the tank is filled with water and the walls have negligible mass)



Solution: Z_C = 2.43 ft

Problem A2.4

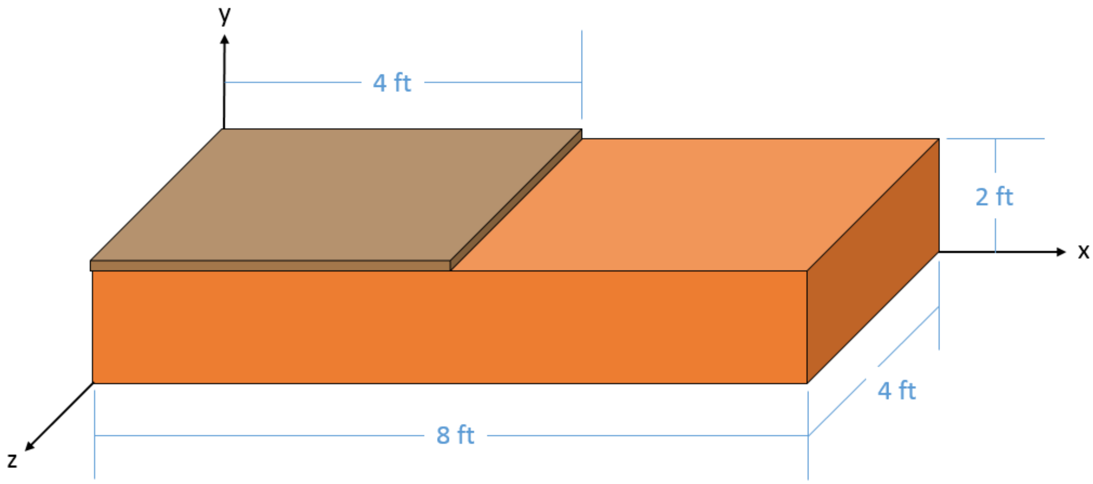
Use the method of composite parts to determine the centroid of the shape shown below.



Solution: X_C = 1.14 in, Y_C = 1.39 in

Problem A2.5

A floating platform consists of a square piece of plywood weighing 50 lbs with a negligible thickness on top of a rectangular prism of a foam material weighing 100 lbs as shown below. Based on this information, what is the location of the center of mass for the floating platform?

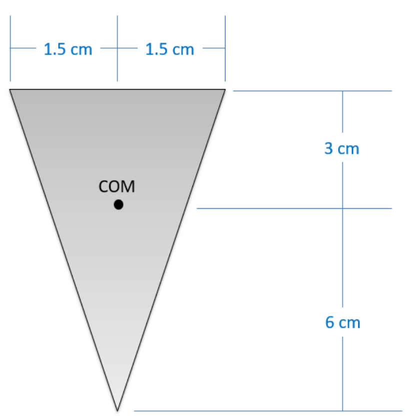


Solution: $X_C = 3.33$ ft, $Y_C = 1.33$ ft, $Z_C = 2$ ft

Problem A2.6

Use the integration method to find the moments of inertia for the shape shown below…

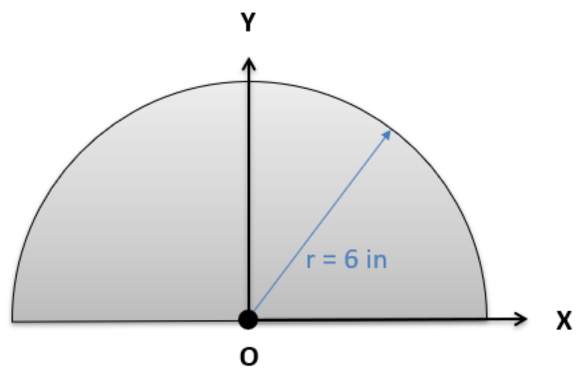
i) About the x axis through the centroid.
ii) About the y axis through the centroid.



Solution: $I_{xx} = 6.075*10^{-7}$ m^4, $I_{yy} = 5.0625*10^{-8}$ m^4

A2.7

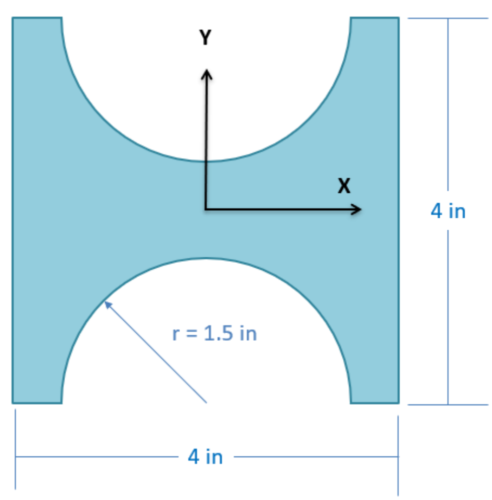
Use the integration method to find the polar moment of inertia for the semicircle shown below about point O.



Solution: J_{zz} = 1017.9 in^4

Problem A2.8

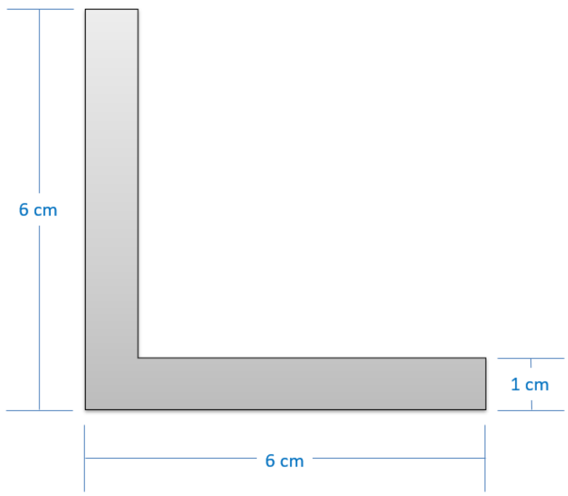
A plastic beam has of a four-inch square cross section with semi-circular cutouts on the top and bottom as shown below. What is the area moment of inertia of the beam's cross section about x and y axes through the center point?



Solution: I_{xx} = 7.08 in^4, I_{yy} = 17.36 in^4

Problem A2.9

A piece of angled steel has a cross section that is 1 cm thick and has a length of 6 cm on each side as shown below. What are the x and y area moments of inertia through the centroid of the cross section?



Solution: $I_{xx} = I_{yy} = 35.462\ cm^4 = 3.546 * 10^{-7}\ m^4$

Problem A2.10

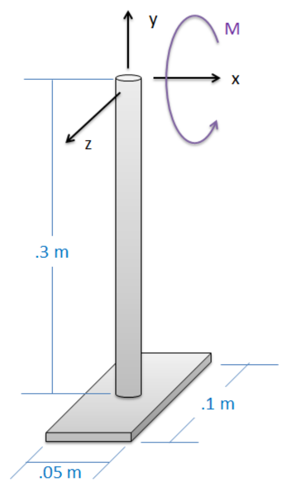
The pendulum in an antique clock consists of a 6 cm brass disc with a mass of .25 kg at the end of a slender wooden rod with a mass of .1 kg. Determine the mass moment of inertia of the pendulum about the top of the rod.

(Solution: $I_{zz} = .02026\ kg\ m^2$)

Problem A2.11

A robotic leg (from the knee down) can be approximated as a slender rod with a mass of 1kg and a length of .3 meters attached to the center of a flat plate with a mass of .75 kg measuring .1 x .05 m.

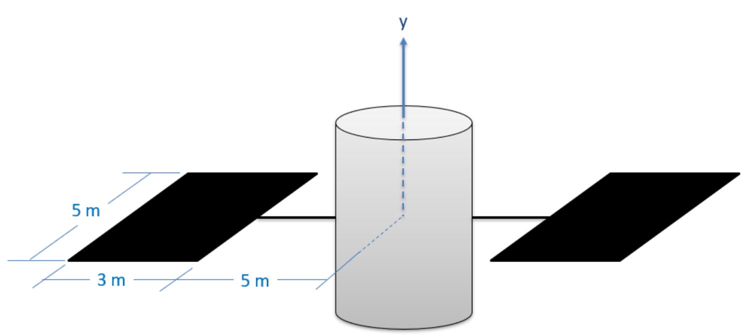
a. What is the moment of inertia of the leg about the x axis at the knee joint at the top?
b. What is the moment at the knee joint required to achieve an angular acceleration of 3 rad/s^2 for this leg about the x axis?



(Solution: I_{xx} = .098125 kg m^2, M = .2944 Nm)

Problem A2.12

A space telescope can be approximated as a 600 kg cylinder with a 4-meter diameter and 4-meter height attached to two 100 kg solar panels as shown below. What is the approximate mass moment of inertia for the space telescope about the y axis shown?

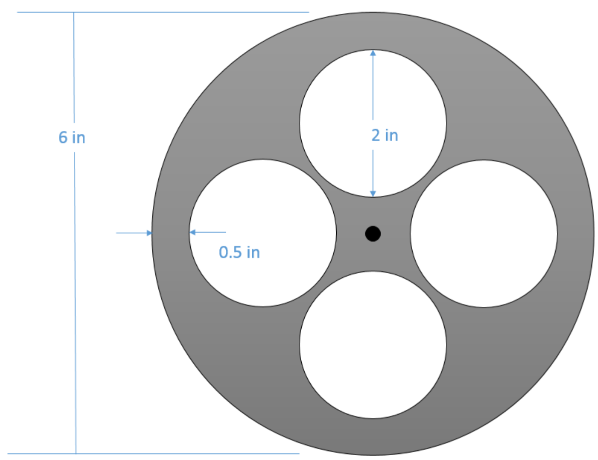


(Solution: $I_{yy} = 10{,}216.7\ kg\ m^2$)

Problem A2.13

A flywheel has an original weight of 15 pounds and a diameter of 6 inches. To reduce the weight, four two-inch diameter holes are drilled into the flywheel, each leaving half an inch to the outside edge as shown below.

- What was the original mass moment of inertia about the center point (without holes)?
- Assuming a uniform thickness, what is the new mass moment of inertia after drilling in the holes? (Hint: holes count as negative mass in the mass moment calculations)



(Solution: $J_{\text{without holes}}$ = .01456 slug ft^2, $J_{\text{with holes}}$ = .01060 slug ft^2)