PROBLEM 1-8

Statement: Prepare an interactive computer program (using, for example, Excell, Mathcad, or TKSolver) from which the mass properties for the solids shown in the page opposite the inside front cover can be calculated. Arrange the program to deal with both *ips* and *SI* unit systems and convert the results between those systems.

Units: $blob := \dfrac{lbf \cdot sec^2}{in}$

Solution: See the page opposite the inside front cover and Mathcad file P0108.

1. Rectangular prism, let: $a := 2 \cdot in$ $b := 3 \cdot in$ $c := 4 \cdot in$ $\gamma := 0.28 \cdot lbf \cdot in^{-3}$

Volume	$V := a \cdot b \cdot c$	$V = 24.000 \cdot in^3$
		$V = 393290 \cdot mm^3$
Mass	$M := \dfrac{V \cdot \gamma}{g}$	$M = 0.017 \cdot blob$
		$M = 3.048 \cdot kg$
Moment about *x*-axis	$I_x := \dfrac{M \cdot \left(a^2 + b^2\right)}{12}$	$I_x = 0.019 \cdot blob \cdot in^2$
		$I_x = 2130.4 \cdot kg \cdot mm^2$
Moment about *y*-axis	$I_y := \dfrac{M \cdot \left(a^2 + c^2\right)}{12}$	$I_y = 0.029 \cdot blob \cdot in^2$
		$I_y = 3277.6 \cdot kg \cdot mm^2$
Moment about *z*-axis	$I_z := \dfrac{M \cdot \left(b^2 + c^2\right)}{12}$	$I_z = 0.036 \cdot blob \cdot in^2$
		$I_z = 4097.0 \cdot kg \cdot mm^2$
Radius of gyration about *x*-axis	$k_x := \sqrt{\dfrac{I_x}{M}}$	$k_x = 1.041 \cdot in$
		$k_x = 26.437 \cdot mm$
Radius of gyration about *y*-axis	$k_y := \sqrt{\dfrac{I_y}{M}}$	$k_y = 1.291 \cdot in$
		$k_y = 32.791 \cdot mm$
Radius of gyration about *z*-axis	$k_z := \sqrt{\dfrac{I_z}{M}}$	$k_z = 1.443 \cdot in$
		$k_z = 36.662 \cdot mm$

2. Cylinder, let: $r := 2 \cdot in$ $L := 3 \cdot in$ $\gamma := 0.30 \cdot lbf \cdot in^{-3}$

Volume	$V := \pi \cdot r^2 \cdot L$	$V = 37.699 \cdot in^3$
		$V = 617778 \cdot mm^3$
Mass	$M := \dfrac{V \cdot \gamma}{g}$	$M = 0.029 \cdot blob$
		$M = 5.13 \cdot kg$

Moment about x-axis $I_x := \frac{M \cdot r^2}{2}$ $I_x = 0.059 \cdot blob \cdot in^2$

$I_x = 6619.4 \cdot kg \cdot mm^2$

Moment about y-axis $I_y := \frac{M \cdot \left(3 \cdot r^2 + L^2\right)}{12}$ $I_y = 0.051 \cdot blob \cdot in^2$

$I_y = 5791.9 \cdot kg \cdot mm^2$

Moment about z-axis $I_z := \frac{M \cdot \left(3 \cdot r^2 + L^2\right)}{12}$ $I_z = 0.051 \cdot blob \cdot in^2$

$I_z = 5791.9 \cdot kg \cdot mm^2$

Radius of gyration about x-axis $k_x := \sqrt{\frac{I_x}{M}}$ $k_x = 1.414 \cdot in$

$k_x = 35.921 \cdot mm$

Radius of gyration about y-axis $k_y := \sqrt{\frac{I_y}{M}}$ $k_y = 1.323 \cdot in$

$k_y = 33.601 \cdot mm$

Radius of gyration about z-axis $k_z := \sqrt{\frac{I_z}{M}}$ $k_z = 1.323 \cdot in$

$k_z = 33.601 \cdot mm$

3. Hollow cylinder, let:

$a := 2 \cdot in$ $b := 3 \cdot in$ $L := 4 \cdot in$ $\gamma := 0.28 \cdot lbf \cdot in^{-3}$

Volume $V := \pi \cdot \left(b^2 - a^2\right) \cdot L$ $V = 62.832 \cdot in^3$

$V = 1029630 \cdot mm^3$

Mass $M := \frac{V \cdot \gamma}{g}$ $M = 0.046 \cdot blob$

$M = 7.98 \cdot kg$

Moment about x-axis $I_x := \frac{M}{2} \cdot \left(a^2 + b^2\right)$ $I_x = 0.296 \cdot blob \cdot in^2$

$I_x = 3.3 \times 10^4 \cdot kg \cdot mm^2$

Moment about y-axis $I_y := \frac{M}{12} \cdot \left(3 \cdot a^2 + 3 \cdot b^2 + L^2\right)$ $I_v = 0.209 \cdot blob \cdot in^2$

$I_y = 2.4 \times 10^4 \cdot kg \cdot mm^2$

Moment about z-axis $I_z := \frac{M}{12} \cdot \left(3 \cdot a^2 + 3 \cdot b^2 + L^2\right)$ $I_z = 0.209 \cdot blob \cdot in^2$

$I_z = 2.4 \times 10^4 \cdot kg \cdot mm^2$

Radius of gyration about x-axis $k_x := \sqrt{\frac{I_x}{M}}$ $k_x = 2.550 \cdot in$

$k_x = 64.758 \cdot mm$

Radius of gyration about y-axis $k_y := \sqrt{\frac{I_y}{M}}$ $k_y = 2.141 \cdot in$ $k_y = 54.378 \cdot mm$

Radius of gyration about z-axis $k_z := \sqrt{\frac{I_z}{M}}$ $k_z = 2.141 \cdot in$ $k_z = 54.378 \cdot mm$

4. Right circular cone, let:

$r := 2 \cdot in$ $h := 5 \cdot in$ $\gamma := 0.28 \cdot lbf \cdot in^{-3}$

Volume $V := \frac{\pi \cdot r^2 \cdot h}{3}$ $V = 20.944 \cdot in^3$ $V = 343210 \cdot mm^3$

Mass $M := \frac{V \cdot \gamma}{g}$ $M = 0.015 \cdot blob$ $M = 2.66 \cdot kg$

Moment about x-axis $I_x := \frac{3}{10} \cdot M \cdot r^2$ $I_x = 0.018 \cdot blob \cdot in^2$ $I_x = 2059.4 \cdot kg \cdot mm^2$

Moment about y-axis $I_y := M \cdot \frac{\left(12 \cdot r^2 + 3 \cdot h^2\right)}{80}$ $I_y = 0.023 \cdot blob \cdot in^2$ $I_y = 2638.5 \cdot kg \cdot mm^2$

Moment about z-axis $I_z := M \cdot \frac{\left(12 \cdot r^2 + 3 \cdot h^2\right)}{80}$ $I_z = 0.023 \cdot blob \cdot in^2$ $I_z = 2638.5 \cdot kg \cdot mm^2$

Radius of gyration about x-axis $k_x := \sqrt{\frac{I_x}{M}}$ $k_x = 1.095 \cdot in$ $k_x = 27.824 \cdot mm$

Radius of gyration about y-axis $k_y := \sqrt{\frac{I_y}{M}}$ $k_y = 1.240 \cdot in$ $k_y = 31.495 \cdot mm$

Radius of gyration about z-axis $k_z := \sqrt{\frac{I_z}{M}}$ $k_z = 1.240 \cdot in$ $k_z = 31.495 \cdot mm$

5. Sphere, let:

$r := 3 \cdot in$

Volume $V := \frac{4}{3} \cdot \pi \cdot r^3$ $V = 113.097 \cdot in^3$ $V = 1853333 \cdot mm^3$

Mass $M := \frac{V \cdot \gamma}{g}$ $M = 0.082 \cdot blob$ $M = 14.364 \cdot kg$

Moment about *x*-axis $I_x := \frac{2}{5} \cdot M \cdot r^2$

$I_x = 0.295 \cdot blob \cdot in^2$

$I_x = 33362 \cdot kg \cdot mm^2$

Moment about *y*-axis $I_y := \frac{2}{5} \cdot M \cdot r^2$

$I_y = 0.295 \cdot blob \cdot in^2$

$I_y = 33362 \cdot kg \cdot mm^2$

Moment about *z*-axis $I_z := \frac{2}{5} \cdot M \cdot r^2$

$I_z = 0.295 \cdot blob \cdot in^2$

$I_z = 33362 \cdot kg \cdot mm^2$

Radius of gyration about *x*-axis $k_x := \sqrt{\frac{I_x}{M}}$

$k_x = 1.897 \cdot in$

$k_x = 48.193 \cdot mm$

Radius of gyration about *y*-axis $k_y := \sqrt{\frac{I_y}{M}}$

$k_y = 1.897 \cdot in$

$k_y = 48.193 \cdot mm$

Radius of gyration about *z*-axis $k_z := \sqrt{\frac{I_z}{M}}$

$k_z = 1.897 \cdot in$

$k_z = 48.193 \cdot mm$