Chapter 1  Physics and Measurement

P1.3  Let $V$ represent the volume of the model, the same in $\rho = \frac{m}{V}$ for both. Then

$\rho_{\text{iron}} = 9.35 \text{ kg/}V$ and $\rho_{\text{gold}} = \frac{m_{\text{gold}}}{V}$. Next,

$\frac{\rho_{\text{gold}}}{\rho_{\text{iron}}} = \frac{m_{\text{gold}}}{9.35 \text{ kg}} \left( \frac{19.3 \times 10^3 \text{ kg/m}^3}{7.86 \times 10^3 \text{ kg/m}^3} \right) = 23.0 \text{ kg}.$

P1.5  For either sphere the volume is $V = \frac{4}{3} \pi r^3$ and the mass is $m = \rho V = \frac{4}{3} \pi r^3$. We divide this equation for the larger sphere by the same equation for the smaller:

$$\frac{m_l}{m_s} = \frac{\rho_4 \pi r_l^3}{\rho_4 \pi r_s^3} = \frac{r_l^3}{r_s^3} = 5.$$  

Then $r_l = r_s \sqrt[3]{5} = 4.50 \text{ cm} \left( 1.71 \right) = 7.69 \text{ cm}.$

P1.9  Inserting the proper units for everything except $G$,

$$\left[ \frac{\text{kg} \cdot \text{m}}{\text{s}^2} \right] = \frac{G}{\left[ \text{m} \right]}.$$  

Multiply both sides by $\left[ \text{m} \right]$ and divide by $\left[ \text{kg} \right]$; the units of $G$ are $\left[ \text{m}^3 \right] \text{kg} \cdot \text{s}^2$.

P1.10  Apply the following conversion factors:

$1 \text{ in} = 2.54 \text{ cm}$, $1 \text{ d} = 86400 \text{ s}$, $100 \text{ cm} = 1 \text{ m}$, and $10^9 \text{ nm} = 1 \text{ m}$

$$\left( \frac{1}{32} \text{ in/day} \right) \left( \frac{2.54 \text{ cm/in}}{10^{-2} \text{ m/cm}} \right) \left( 10^6 \text{ nm/m} \right) = 9.19 \text{ nm/s}.$$  

This means the proteins are assembled at a rate of many layers of atoms each second!

P1.12  (a) $V = (40.0 \text{ m}) (20.0 \text{ m}) (12.0 \text{ m}) = 9.60 \times 10^3 \text{ m}^3$

$V = 9.60 \times 10^3 \text{ m}^3 \left( 3.28 \text{ ft/}1 \text{ m} \right)^3 = 3.39 \times 10^5 \text{ ft}^3$

(b) The mass of the air is

$$m = \rho_{\text{air}} V = (1.20 \text{ kg/m}^3) (9.60 \times 10^3 \text{ m}^3) = 1.15 \times 10^4 \text{ kg}.$$  

The student must look up weight in the index to find

$$F_g = mg = (1.15 \times 10^4 \text{ kg}) (9.80 \text{ m/s}^2) = 1.13 \times 10^5 \text{ N}.$$  

Converting to pounds, $F_g = \left( 1.13 \times 10^5 \text{ N} \right) \left( 1 \text{ lb/4.45 N} \right) = 2.54 \times 10^4 \text{ lb}.$
The area of the four walls is \((3.6 + 3.8 + 3.6 + 3.8) \text{ m} \times 2.5 \text{ m}) = 37 \text{ m}^2\). Each sheet in the book has area \((0.21 \text{ m}) \times (0.28 \text{ m}) = 0.059 \text{ m}^2\). The number of sheets required for wallpaper is \(37 \text{ m}^2 / 0.059 \text{ m}^2 = 629 \text{ sheets}\). Thus, the 629 sheets (2 pages/sheet) = 1260 pages.

The pages from volume one are inadequate, but the full version has enough pages.

\[ \left( \frac{8 \times 10^{12} \$}{1000 \text{ $/s}} \right) \left( \frac{1 \text{ h}}{3600 \text{ s}} \right) \left( \frac{1 \text{ day}}{24 \text{ h}} \right) \left( \frac{1 \text{ yr}}{365 \text{ days}} \right) = 250 \text{ years} \]

(b) The circumference of the Earth at the equator is \(2\pi \left( 6.378 \times 10^3 \text{ m} \right) = 4.01 \times 10^7 \text{ m}\). The length of one dollar bill is 0.155 m so that the length of 8 trillion bills is \(1.24 \times 10^{12} \text{ m}\). Thus, the 8 trillion dollars would encircle the Earth \(3.09 \times 10^4 \text{ times}\).

\[ F_g = \left( 2.50 \text{ tons/block} \right) \left( 2.00 \times 10^6 \text{ blocks} \right) \left( 2000 \text{ lb/ton} \right) = 1.00 \times 10^{10} \text{ lbs} \]

A reasonable guess for the diameter of a tire might be 2.5 ft, with a circumference of about 8 ft. Thus, the tire would make \(50000 \text{ mi} \times (5280 \text{ ft/mi}) \times \left( \frac{1 \text{ rev}}{8 \text{ ft}} \right) = 3 \times 10^7 \text{ rev} \approx 3 \times 10^7 \text{ rev} \).

METHOD ONE

We treat the best value with its uncertainty as a binomial \((21.3 \pm 0.2) \text{ cm} \times (9.8 \pm 0.1) \text{ cm}\),

\[ A = \left[ 21.3(9.8) \pm 21.3(0.1) \pm 0.2(9.8) \pm (0.2)(0.1) \right] \text{ cm}^2 \].

The first term gives the best value of the area. The cross terms add together to give the uncertainty and the fourth term is negligible.

\[ A = 209 \text{ cm}^2 \pm 4 \text{ cm}^2 \].

METHOD TWO

We add the fractional uncertainties in the data.

\[ A = (21.3 \text{ cm})(9.8 \text{ cm}) \pm \left( \frac{0.2}{21.3} + \frac{0.1}{9.8} \right) = 209 \text{ cm}^2 \pm 2\% = 209 \text{ cm}^2 \pm 4 \text{ cm}^2 \]

(a) \( 756.?? \)

(b) \( 0.0032(2 \text{ s.f.}) \times 356.3(4 \text{ s.f.}) = 1.14016(2 \text{ s.f.}) \)

(c) \( 5.620(4 \text{ s.f.}) \times \pi(>4 \text{ s.f.}) = 17.656(4 \text{ s.f.}) \)

\[ 796.5/3 = 797 \]

\[ 1.1 \]

\[ 17.66 \]
The rate of volume increase is

\[
\frac{dV}{dt} = \frac{d}{dt} \frac{4}{3} \pi r^3 = \frac{4}{3} \pi 3r^2 \frac{dr}{dt} = 4 \pi r^2 \frac{dr}{dt}.
\]

(a) \( \frac{dV}{dt} = 4 \pi (6.5 \text{ cm})^2 (0.9 \text{ cm/s}) = 478 \text{ cm}^3/\text{s} \)

(b) \( \frac{dr}{dt} = \frac{dV / dt}{4 \pi r^2} = \frac{478 \text{ cm}^3/\text{s}}{4 \pi (13 \text{ cm})^2} = 0.225 \text{ cm}^3/\text{s} \)

(c) When the balloon radius is twice as large, its surface area is four times larger. The new volume added in one second in the inflation process is equal to this larger area times an extra radial thickness that is one-fourth as large as it was when the balloon was smaller.

P1.53

\[ 2 \pi r = 15.0 \text{ m} \]
\[ r = 2.39 \text{ m} \]
\[ h = \tan 55.0^\circ \]
\[ h = \frac{2.39 \text{ m}}{\tan (55.0^\circ)} = 3.41 \text{ m} \]

P1.55

The actual number of seconds in a year is

\[ (86 400 \text{ s/day})(365.25 \text{ day/yr}) = 31 557 600 \text{ s/yr}. \]

The percent error in the approximation is

\[
\left( \frac{\pi \times 10^7 \text{ s/yr}}{31 557 600 \text{ s/yr}} \right) \left( \frac{31 557 600 \text{ s/yr}}{31 557 600 \text{ s/yr}} \right) \times 100\% = 0.449\%.
\]

P1.57

(a) The speed of rise may be found from

\[
v = \left( \text{Vol rate of flow} \right) \left( \frac{\text{Area: } \pi D^2}{4} \right) = \frac{16.5 \text{ cm}^3/\text{s}}{\pi (6.30 \text{ cm})^2 / 4} = 0.529 \text{ cm/s}.
\]

(b) Likewise, at a 1.35 cm diameter,

\[
v = \frac{16.5 \text{ cm}^3/\text{s}}{\pi (1.35 \text{ cm})^2 / 4} = 11.5 \text{ cm/s}.
\]