Solutions to Problems

1.1

Since 1 billion is equal to 1 000 000 000, or 10^9; $10\,\text{billion} = 10\,000\,000\,000 = 10 \times 10^9 = 10^{10}$.

1.3

Use the definitions of the various prefixes listed in Table 1.2.

(a) $10.0\,\text{ms} = (10.0\,\text{ms})(0.001\,\text{s/ms}) = 0.010\,\text{s}$.

(b) $1000\,\mu\text{s} = (1000\,\mu\text{s})(0.000\,001\,\text{s}/\mu\text{s}) = 0.001\,\text{s}$.

(c) $10.000\,\text{ks} = (10.000\,\text{ks})(1000\,\text{s/ks}) = 10\,000\,\text{s}$.

(d) $100\,\text{Ms} = (100\,\text{Ms})(1\,000\,000\,\text{s/Ms}) = 100\,000\,000\,\text{s}$.

(e) $1000\,\text{ns} = (1000\,\text{ns})(0.000\,000\,001\,\text{s/ns}) = 0.000\,001\,\text{s}$.

1.6

Since $1\,\text{mi} = 1.609\,\text{km}$,

$$1.0 \times 10^3\,\text{mi} = (1.0 \times 10^3\,\text{mi})(1.609\,\text{km/mi}) = 1.6 \times 10^3\,\text{km}\,.$$

1.10

Since $1\,\text{nm} = 10^{-9}\,\text{m}$ and $1\,\text{m} = 10^2\,\text{cm}$,

$$1\text{Å} = 0.1\,\text{nm} = (0.1\,\text{nm})(10^{-9}\,\text{m/nm})(10^2\,\text{cm/m}) = 10^{-8}\,\text{cm}\,.$$

1.13

According to the hint given in the problem statement the number of meters in a mile is given by $1\,\text{mi} = (1\,\text{mi})(5280\,\text{ft/mi})(12\,\text{in./ft})(2.54\,\text{cm/in.})(0.01\,\text{m/cm}) = 1609\,\text{m}$. Thus

$$1.00\,\text{ly} = 5.88 \times 10^{12}\,\text{mi} = (5.88 \times 10^{12}\,\text{mi})(1609\,\text{m/mi}) = 9.46 \times 10^{15}\,\text{m}\,.$$

1.19

Let the mass of each nickel be m and the number of nickels whose total mass is $M = 1\,\text{kg}$ be N. Then $M = Nm$. Since $m = 5\,\text{g} = (5\,\text{g})(10^{-3}\,\text{kg/g}) = 5 \times 10^{-3}\,\text{kg}$,

$$N = \frac{M}{m} = \frac{1\,\text{kg}}{5 \times 10^{-3}\,\text{kg}} = 2 \times 10^2\,.$$

1.23

The time in question is $t = (1/500)\,\text{s} = 2 \times 10^{-3}\,\text{s}$. Using $1\,\text{s} = 10^3\,\text{ms} = 10^6\,\mu\text{s} = 10^9\,\text{ns}$, this is

$$\begin{aligned} t &= (2 \times 10^{-3}\,\text{s})(10^3\,\text{ms/s}) = 2\,\text{ms} \\ &= (2 \times 10^{-3}\,\text{s})(10^6\,\mu\text{s/s}) = 2 \times 10^3\,\mu\text{s} \\ &= (2 \times 10^{-3}\,\text{s})(10^9\,\text{ns/s}) = 2 \times 10^6\,\text{ns}\,. \end{aligned}$$

1.24

Since $1\,\text{h} = (1\,\text{h})(60\,\text{min/h})(60\,\text{s/min}) = 3\,600\,\text{s}$, $\quad 24\,\text{h} = (24\,\text{h})(3\,600\,\text{s/h}) = 86\,400\,\text{s}$.

1.46

The diameter D of each hydrogen atom is twice its radius, at about $D = 2(5.291\,77 \times 10^{-11}\,\text{m}) = 1.058\,354 \times 10^{-10}\,\text{m}$. A total of N such atoms, lined up one "touching" the next, will have an end-to-end length of ND. If that length is 1.0 m, then

$$N = \frac{1.0\,\text{m}}{D} = \frac{1.0\,\text{m}}{1.058\,354 \times 10^{-10}\,\text{m}} = 9.4 \times 10^9 .$$

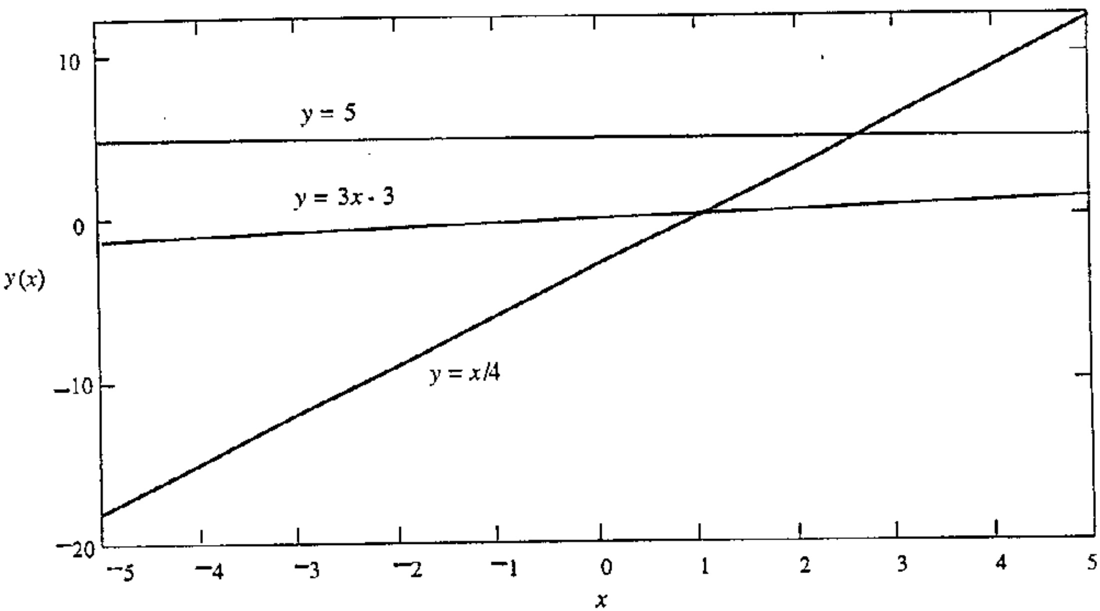
1.47

The volume V of a sphere of radius R is given by $V = \frac{4}{3}\pi R^3$. Thus for the Moon

$$V_{☾} = \frac{4\pi}{3} R_{☾}^3 = \frac{4\pi}{3} \left[(1.738 \times 10^3\,\text{km})(10^3\,\text{m/km})\right]^3 = 2.199 \times 10^{19}\,\text{m}^3 ,$$

where we used $1\,\text{km} = 10^3\,\text{m}$ to convert the result to m^3. To two significant figures, this is $2.2 \times 10^{19}\,\text{m}^3$.

1.59

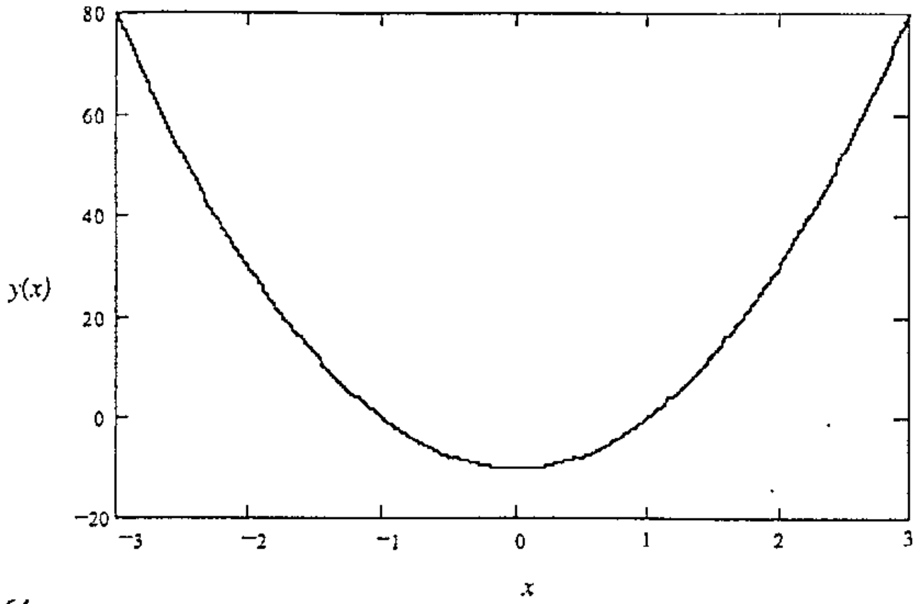


(d) Let the equation in question be $y = mx + b$. Since it represents a straight line parallel to the one described by $y = 3x - 3$ we have $m = 3$. Also, as it passes the point (0, 5) we have $5 = 3 \times 0 + b$, or $b = 5$. So the equation is $y = 3x + 5$.

1.61
The sketch is shown below. The minimum value of $y(x)$ occurs at the point where $dy/dx = 0$:

$$\frac{dy}{dx} = \frac{d}{dx}(10x^2 - 10) = 10(2x) = 20x = 0\,,$$

i.e., at $x = 0$. This is apparent since the only x-dependent term in $y(x)$ is $10x^2$, which cannot be negative and reaches its minimum value of zero at $x = 0$. The minimum value of y is $y_{\min} = 10(0)^2 - 10 = -10$.
To find the value of x at which $y(x) = 0$, let $y(x) = 10x^2 - 10 = 0$ and solve for x: $x^2 = 10/10 = 1$, $x = \pm 1$.



1.64
The plot is shown below. Note that the only x-dependent term in $y(x)$ is $-12(x-2)^2$, which cannot be positive and reaches its maximum value of zero at $x - 2 = 0$, or $x = 2$. Thus $y(x)$ has a maximum value of 24 when $x = 2$, as you can easily verify by setting $dy/dx = 0$.
To find the value of x when $y(x) = 0$, set

$$y(x) = -12(x-2)^2 + 24 = 0\,,$$

or $(x-2)^2 = 24/12 = 2$, $x - 2 = \pm\sqrt{2}$, i.e., $x = 2 \pm \sqrt{2} \approx 0.586$ or 3.414. Check these results with the plot below.