Problem Set #1 Solutions

1.

a) $32000.0 = 3.20 \times 10^4$

b) $0.000451 = 4.51 \times 10^{-4}$

c) $17.862 = 1.7862 \times 10^1$

d) $437.2 \times 10^6 = 4.372 \times 10^8$. (Even though the original expression used a power of ten, we prefer to have the "number" factor between 1 and 10.)

2.

a)

$$(1.7 \times 10^6) \times (1.38 \times 10^{-16}) = 2.35 \times 10^{-10}$$

b)

$$\frac{28.0}{6.02 \times 10^{23}} = 4.65 \times 10^{-23}$$

c)

$$(3.4 \times 10^{-15})^3 = 3.93 \times 10^{-44}$$

d)

$$4\pi(6.36 \times 10^6)^2 = 5.08 \times 10^{14}$$

e)

$$\frac{(6.67 \times 10^{-11})(0.5)(0.3)}{(3.0 \times 10^{-2})^2} = 1.11 \times 10^{-8}$$

3. Unit conversion. Express:

a) A furlong (220 yards) in meters

$$1 \text{ fur} = (1 \text{ fur}) \left(\frac{220 \text{ yd}}{1 \text{ fur}}\right) \left(\frac{36 \text{ in}}{1 \text{ yd}}\right) \left(\frac{1 \text{ m}}{39.37 \text{ in}}\right) = 201.2 \text{ m}$$

b) A fortnight (2 weeks) in seconds

$$1 \text{ fortnight} = (1 \text{ fn}) \left(\frac{2 \text{ week}}{1 \text{ fn}}\right) \left(\frac{7 \text{ day}}{1 \text{ week}}\right) \left(\frac{24 \text{ hr}}{1 \text{ day}}\right) \left(\frac{3600 \text{ s}}{1 \text{ hr}}\right) = 1.21 \times 10^6 \text{ s}$$

c) $65 \ \frac{\text{mi}}{\text{hr}}$ in $\frac{\text{km}}{\text{hr}}$

$$65 \tfrac{\text{mi}}{\text{hr}} = \left(65 \tfrac{\text{mi}}{\text{hr}}\right) \left(\frac{1.609 \text{ km}}{1 \text{ mi}}\right) = 104.6 \tfrac{\text{km}}{\text{hr}}$$

d) 65 $\frac{\text{mi}}{\text{hr}}$ in $\frac{\text{m}}{\text{s}}$

$$65\,\tfrac{\text{mi}}{\text{hr}} = (65\,\tfrac{\text{mi}}{\text{hr}})\left(\frac{1.609\ \text{km}}{1\ \text{mi}}\right)\left(\frac{10^3\ \text{m}}{1\ \text{km}}\right)\left(\frac{1\ \text{hr}}{3600\ \text{s}}\right) = 29.05\,\tfrac{\text{m}}{\text{s}}$$

4.

a)

$$4.3 \times 10^{12}\ \text{m} = (4.3 \times 10^{12}\ \text{m})\left(\frac{1\ \text{km}}{10^3\ \text{m}}\right)\left(\frac{1\ \text{mi}}{1.609\ \text{km}}\right) = 2.67 \times 10^9\ \text{mi}$$

b) How long did it take for its signals to reach us? (These signals travel at the speed of light, $2.998 \times 10^8 \frac{\text{m}}{\text{s}}$.)

Use $t = \frac{d}{v}$:

$$t = \frac{4.3 \times 10^{12}\ \text{m}}{2.998 \times 10^8\ \frac{\text{m}}{\text{s}}} = 1.43 \times 10^4\ \text{s}$$

It is more informative to convert this to minutes or hours:

$$(1.43 \times 10^4\ \text{s})\left(\frac{1\ \text{min}}{60\ \text{s}}\right) = 238\ \text{min} = 3.97\ \text{hr}$$

5.

First, convert some units. The mass and radius are:

$$M = 5.69 \times 10^{26}\ \text{kg} = 5.69 \times 10^{29}\ \text{g} \qquad \text{and} \qquad R = 5.8 \times 10^9\ \text{cm}$$

Using the formula for the volume of a sphere, the volume of Saturn is

$$\begin{aligned} V &= \tfrac{4}{3}\pi R^3 \\ &= \tfrac{4}{3}\pi(5.8 \times 10^9\ \text{cm})^3 \\ &= 8.17 \times 10^{29}\ \text{cm}^3 \end{aligned}$$

Then the (average) density of Saturn is:

$$D = \frac{M}{V} = \frac{5.69 \times 10^{29}\ \text{g}}{8.17 \times 10^{29}\ \text{cm}^3} = 0.696\,\tfrac{\text{g}}{\text{cm}^3}$$

This is significantly less than the density of water.

$1\ \text{mi} = 1.609\ \text{km} \qquad 1\ \text{kg} = 10^3\ \text{g} \qquad 1\ \text{km} = 10^3\ \text{m} \qquad 1\ \text{m} = 10^2\ \text{cm}$