Physics 11 Homework I Solutions

Ch. 1 - Problems 3, 14, 16, 27, 30, 39, 46, 53.

Problem 3

We are given that the period of a simple pendulum of length l near the surface of the earth is given by

$$T = 2\pi\sqrt{\frac{l}{g}}.$$

Recall, the period is defined as the time necessary for one complete oscillation. In order to show the dimensional consistency of this equation, recall that length is measured in units of meters and acceleration in units meters per second squared. Thus, with period in seconds, we find,

$$[s] = \sqrt{\frac{[m]}{[\frac{m}{s^2}]}} = \sqrt{[s^2]} = [s],$$

as expected. The above demonstration relied on SI units as discussed in class. However, the formula is true generally. With period measured in units of time and acceleration in units length per time squared, we again find

$$time = \sqrt{\frac{length}{\frac{length}{time^2}}} = \sqrt{time^2} = time.$$

Problem 14

This question asks us to apply the rules for arithmetic operations with scientific notation. Recall from our text, on page 8, that **in multiplying or dividing two or more quantities, the number of significant figures in the final product or quotient is the same as the number of significant figures in the least accurate of the factors being combined, where least accurate means having the lowest number of significant figures.** Thus, in part (a) the denominator has the fewest significant figures, three, and thus our final answer should be

$$\frac{(2.437 * 10^4)(6.5211 * 10^9)}{5.37 * 10^4} = 2.96 * 10^9.$$

Similiarly, the result in part (b) should clearly have four significant digits. Thus,

$$\frac{(3.14159 * 10^2)(27.01 * 10^4)}{(1234 * 10^6)} = 6.876 * 10^{-2}.$$

Problem 16

(a)

$$\begin{aligned} 348miles &= (348miles)(1.609\frac{km}{mile}) = 560km, \\ &= (560km)(1000\frac{m}{km}) = 5.60 * 10^5 m, \\ &= (5.60 * 10^5 m)(100\frac{cm}{m}) = 5.60 * 10^7 cm. \end{aligned}$$

(b)

$$\begin{aligned} 1612feet &= (1612feet)(30.48\frac{cm}{foot}) = 4.913 * 10^4 cm, \\ &= (4.913 * 10^4 cm)(10^{-2}\frac{m}{cm}) = 491.3m, \\ &= (491.3m)(10^{-3}\frac{km}{m}) = .4913km. \end{aligned}$$

(c)

$$\begin{aligned} 20320feet &= (20320feet)(30.48\frac{cm}{foot}) = 6.194 * 10^5 cm, \\ &= (6.194 * 10^5 cm)(10^{-2}\frac{m}{cm}) = 6194m, \\ &= (6194m)(10^{-3}\frac{km}{m}) = 6.194km. \end{aligned}$$

(d)

$$\begin{aligned} 8200feet &= (8200feet)(30.48\frac{cm}{foot}) = 2.5 * 10^5 cm, \\ &= (2.5 * 10^5 cm)(10^{-2}\frac{m}{cm}) = 2500m, \\ &= (2500m)(10^{-3}\frac{km}{m}) = 2.5km. \end{aligned}$$

Problem 27

So we start with the given information that one cubic centimeter of water has a mass of 1 g.

(a) One cubic meter of water.

$$volume = (1.0m^3)(10^2\frac{cm}{m})^3 = 10^6cm^3,$$

$$\begin{aligned} mass &= density * volume \\ &= (1\frac{g}{cm^3})(10^6cm^3) \\ &= (10^6g)(10^{-3}\frac{kg}{g}) \\ &= 1000kg. \end{aligned}$$

(b) Cell of diameter one micron, 98% water.

Well, let's assume that a cell is a sphere of diameter one micron. Then, its volume is given by

$$volume = \frac{4}{3}\pi(\frac{1}{2}\mu m)^3 = (0.52\mu m^3)(10^{-4}\frac{cm}{\mu m})^3 = 5.2 * 10^{-13}cm^3.$$

Now, the mass of the cell is only 98% water, so let's define an effective volume as

$$effectivevolume = 0.98 * volume = 5.1 * 10^{-13}cm^3$$

so then the cell mass is approximately

$$mass = density{*}effectivevolume = (10^{-3}\frac{kg}{cm^3})(5.1{*}10^{-13}cm^3) = 5.1{*}10^{-16}kg.$$

(c) Kidney of radius 4 cm, 98% water.

Well, let's assume that a kidney is a sphere of radius 4 cm. Then, its volume is given by

$$volume = \frac{4}{3}\pi(4cm)^3 = 268cm^3.$$

Now, the mass of the kidney is only 98% water, so let's define an effective volume as

$$effectivevolume = 0.98 * volume = 263cm^3$$

so then the kidney mass is approximately

$$mass = density * effectivevolume = (1\frac{g}{cm^3})(263cm^3) = 260g.$$

(d) Fly of length 4 mm and diameter 2 mm, 98% water.

Well, let's assume that a fly is a cylinder of diameter 2 mm and length 4 mm. Then, its volume is given by

$$volume = \pi * (4mm)(1mm)^2 = (13mm^3)(10^{-1}\frac{cm}{mm})^3 = 1.3 * 10^{-2}cm^3.$$

Now, the mass of the fly is only 98

$$effectivevolume = 0.98 * volume = 1.2 * 10^{-2}cm^3$$

so then the fly mass is approximately

$$\begin{aligned} mass &= density * effectivevolume \\ &= (1\frac{g}{cm^3})(1.2 * 10^{-2}cm^3) = 1.2 * 10^{-2}g \\ &= (1.2 * 10^{-2}g)(10^3\frac{mg}{g}) = 12mg. \end{aligned}$$

Problem 30

Let's suppose that an average hamburger is a quarter pound before hitting the grill. Then, if 50 billion hamburgers have been sold, this corresponds to 12.5 billion pounds of meat (just divide 50 by 4 and retain the exponent). Now, if you do a quick google search, you can find that the quantity of edible meat derived from a typical cow is in the neighborhood of 300 lbs. Dividing 12.5 billions lbs. by 300 lbs. per cow yields an estimate of 42 million heads of cattle. Holy cow, no wonder they're mad.

Problem 39

This problem asks us to apply some basic knowledge of geometry and trigonometry. To determine the unknown side, simply use the Pythagorean theorem to get

$$length = \sqrt{9^2 - 6^2} = \sqrt{45} = 3\sqrt{5}m \approx 6.71m.$$

The angles are simply given by

$$\theta = \arcsin(\frac{6}{9}) \approx 41.8 degrees \approx 0.73 rad,$$
$$\phi = \arcsin(\frac{3\sqrt{5}}{9}) \approx 48.2 degrees \approx 0.84 rad.$$

Problem 46

Well, this is just a continuation of the thought process from the previous problem. Here we have a right triangle and are given an angle and the adjacent side. Thus, the opposite side is just given by

$$riverwidth = 100 * \tan(35) \approx 70m.$$

Problem 53

Well, suppose there are roughly 10 million people living New York City and the immediate surrounding area. An estimate of one piano per 10 thousand individuals seems reasonable. Now, in order to have a healthy market, there cannot be more than one piano tuner for every 100 pianos nor less than one tuner for every 1000. Thus, we are looking at

$$\begin{aligned} numberofpianotuners &= (10^7 people)\frac{1piano}{10^3 people} = (10^4 pianos)\frac{1tuner}{10^2 pianos} = 100tuners, \\ &= (10^7 people)\frac{1piano}{10^3 people} = (10^4 pianos)\frac{1tuner}{10^3 pianos} = 10tuners. \end{aligned} \quad (1)$$

A more reasonable estimate yet places a guess somewhere between these two bounds, in the neighborhood of 50. And indeed, one quick search of internet yellow pages for the city of New York lists 52 entries for piano repairmen. Not too bad.