Chapter 1

INTRODUCTION

Conceptual Questions

1. Knowledge of physics is important for a full understanding of many scientific disciplines, such as chemistry, biology, and geology. Furthermore, much of our current technology can only be understood with knowledge of the underlying laws of physics. In the search for more efficient and environmentally safe sources of energy, for example, physics is essential. Also, many study physics for the sense of fulfillment that comes with learning about the world we inhabit.

2. Without precise definitions of words for scientific use, unambiguous communication of findings and ideas would be impossible.

3. Even when simplified models do not exactly match real conditions, they can still provide insight into the features of a physical system. Often a problem would become too complicated if one attempted to match the real conditions exactly, and an approximation can yield a result that is close enough to the exact one to still be useful.

4. **(a)** 3 **(b)** 9

5. Scientific notation eliminates the need to write many zeros in very large or small numbers. Also, the appropriate number of significant digits is unambiguous when written this way.

6. In scientific notation the decimal point is placed after the first (leftmost) numeral. The number of digits written equals the number of significant figures.

7. Not all of the significant digits are precisely known. The least significant digit (rightmost) is an estimate and is less precisely known than the others.

8. It is important to list the correct number of significant figures so that we can indicate how precisely a quantity is known and not mislead the reader by writing digits that are not at all known to be correct.

9. The kilogram, meter, and second are three of the base units used in the SI system.

10. The SI system uses a well-defined set of internationally agreed upon standard units and makes measurements in terms of these units and their powers of ten. The U.S. Customary system contains units that are primarily of historical origin and are not based upon powers of ten. As a result of this international acceptance and the ease of manipulation that comes from dealing with powers of ten, scientists around the world prefer to use the SI system.

11. Fathoms, kilometers, miles, and inches are units with dimensions of length. Grams and kilograms are units with dimensions of mass. Years, months, and seconds are units with dimensions of time.

12. The first step toward successfully solving almost any physics problem is to thoroughly read the question and obtain a precise understanding of the scenario. The second step is to visualize the problem, often making a quick sketch to outline the details of the situation and the known parameters.

13. Trends in a set of data are often the most interesting aspect of the outcome of an experiment. Such trends are more apparent when data is plotted graphically rather than listed in numerical tables.

14. The statement gives a numerical value for the speed of sound in air, but fails to indicate the units used for the measurement. Without units, the reader cannot relate the speed to one given in familiar units such as km/s.

15. After solving a problem, it is a good idea to check that the solution is reasonable and makes intuitive sense. It may also be useful to explore other possible methods of solution as a check on the validity of the first.

Multiple-Choice Questions

1. (b) **2.** (b) **3.** (a) **4.** (c) **5.** (d) **6.** (d) **7.** (b) **8.** (d) **9.** (b) **10.** (c)

Problems

1. **Strategy** The new fence will be $100\% + 37\% = 137\%$ of the height of the old fence.

   Solution Find the height of the new fence.
   $1.37 \times 1.8\text{ m} = \boxed{2.5\text{ m}}$

2. **Strategy** There are $\frac{60\text{ s}}{1\text{ min}} \times \frac{60\text{ min}}{1\text{ h}} \times \frac{24\text{ h}}{1\text{ d}} = 86,400$ seconds in one day and 24 hours in one day.

   Solution Find the ratio of the number of seconds in a day to the number of hours in a day.
   $$\frac{86,400}{24} = \frac{24 \times 3600}{24} = \boxed{3600/1}$$

3. **Strategy** Relate the surface area S to the radius r using $S = 4\pi r^2$.

   Solution Find the ratio of the new radius to the old.
   $S_1 = 4\pi r_1^2$ and $S_2 = 4\pi r_2^2 = 1.160 S_1 = 1.160(4\pi r_1^2)$.
   $$4\pi r_2^2 = 1.160(4\pi r_1^2)$$
   $$r_2^2 = 1.160 r_1^2$$
   $$\left(\frac{r_2}{r_1}\right)^2 = 1.160$$
   $$\frac{r_2}{r_1} = \sqrt{1.160} = 1.077$$
   The radius of the balloon increases by $\boxed{7.7\%}$.

4. **Strategy** Relate the surface area S to the radius r using $S = 4\pi r^2$.

   Solution Find the ratio of the new radius to the old.
   $S_1 = 4\pi r_1^2$ and $S_2 = 4\pi r_2^2 = 2.0 S_1 = 2.0(4\pi r_1^2)$.
   $$4\pi r_2^2 = 2.0(4\pi r_1^2)$$
   $$r_2^2 = 2.0 r_1^2$$
   $$\left(\frac{r_2}{r_1}\right)^2 = 2.0$$
   $$\frac{r_2}{r_1} = \sqrt{2.0} = 1.4$$
   The radius of the balloon increases by a factor of $\boxed{1.4}$.

5. **Strategy** To find the factor by which the metabolic rate of a 70 kg human exceeds that of a 5.0 kg cat use a ratio.

   Solution Find the factor.
   $$\left(\frac{m_h}{m_c}\right)^{3/4} = \left(\frac{70}{5.0}\right)^{3/4} = \boxed{7.2}$$

6. Strategy To find the factor Samantha's height increased, divide her new height by her old height. Subtract 1 from this value and multiply by 100 to find the percent increase.

Solution Find the factor.

$$\frac{1.65\text{ m}}{1.50\text{ m}} = \boxed{1.10}$$

Find the percentage.

$1.10 - 1 = 0.10$, so the percent increase is $\boxed{10\ \%}$.

7. Strategy Recall that area has dimensions of length squared.

Solution Find the ratio of the area of the park as represented on the map to the area of the actual park.

$$\frac{\text{map length}}{\text{actual length}} = \frac{1}{10,000} = 10^{-4}, \text{ so } \frac{\text{map area}}{\text{actual area}} = (10^{-4})^2 = \boxed{10^{-8}}.$$

8. Strategy Let X be the original value of the index.

Solution Find the net percentage change in the index for the two days.

$$(\text{first day change})\times(\text{second day change}) = [X\times(1+0.0500)]\times(1-0.0500) = 0.9975X$$

The net percentage change is $(0.9975-1)\times 100\% = -0.25\%$, or $\boxed{\text{down } 0.25\%}$.

9. Strategy Use a proportion.

Solution Find Jupiter's orbital period.

$$T^2 \propto R^3, \text{ so } \frac{T_\text{J}^2}{T_\text{E}^2} = \frac{R_\text{J}^3}{R_\text{E}^3} = 5.19^3. \text{ Thus, } T_\text{J} = 5.19^{3/2}T_\text{E} = \boxed{11.8\text{ yr}}.$$

10. Strategy The area of the circular garden is given by $A = \pi r^2$. Let the original and final areas be $A_1 = \pi r_1^2$ and $A_2 = \pi r_2^2$, respectively.

Solution Calculate the percentage increase of the area of the garden plot.

$$\frac{\Delta A}{A}\times 100\% = \frac{\pi r_2^2 - \pi r_1^2}{\pi r_1^2}\times 100\% = \frac{r_2^2 - r_1^2}{r_1^2}\times 100\% = \frac{1.25^2 r_1^2 - r_1^2}{r_1^2}\times 100\% = \frac{1.25^2 - 1}{1}\times 100\% = \boxed{56\%}$$

11. Strategy The area of the poster is given by $A = \ell w$. Let the original and final areas be $A_1 = \ell_1 w_1$ and $A_2 = \ell_2 w_2$, respectively.

Solution Calculate the percentage reduction of the area.

$$A_2 = \ell_2 w_2 = (0.800\ell_1)(0.800w_1) = 0.640\ell_1 w_1 = 0.640A_1$$

$$\frac{A_1 - A_2}{A_1}\times 100\% = \frac{A_1 - 0.640A_1}{A_1}\times 100\% = \boxed{36.0\%}$$

12. Strategy The volume of the rectangular room is given by $V = \ell wh$. Let the original and final volumes be $V_1 = \ell_1 w_1 h_1$ and $V_2 = \ell_2 w_2 h_2$, respectively.

Solution Find the factor by which the volume of the room increased.

$$\frac{V_2}{V_1} = \frac{\ell_2 w_2 h_2}{\ell_1 w_1 h_1} = \frac{(1.50\ell_1)(2.00w_1)(1.20h_1)}{\ell_1 w_1 h_1} = \boxed{3.60}$$

13. Strategy Assuming that the cross section of the artery is a circle, we use the area of a circle, $A = \pi r^2$.

Solution
$A_1 = \pi r_1^2$ and $A_2 = \pi r_2^2 = \pi(2.0r_1)^2 = 4.0\pi r_1^2$.
Form a proportion.

$$\frac{A_2}{A_1} = \frac{4.0\pi r_1^2}{\pi r_1^2} = 4.0$$

The cross-sectional area of the artery increases by a factor of $\boxed{4.0}$.

14. (a) Strategy The diameter of the xylem vessel is one six-hundredth of the magnified image.

Solution Find the diameter of the vessel.

$$d_{\text{actual}} = \frac{d_{\text{magnified}}}{600} = \frac{3.0\text{ cm}}{600} = \boxed{5.0\times10^{-3}\text{ cm}}$$

(b) Strategy The area of the cross section is given by $A = \pi r^2 = \pi(d/2)^2 = (1/4)\pi d^2$.

Solution Find by what factor the cross-sectional area has been increased in the micrograph.

$$\frac{A_{\text{magnified}}}{A_{\text{actual}}} = \frac{\frac{1}{4}\pi d_{\text{magnified}}{}^2}{\frac{1}{4}\pi d_{\text{actual}}{}^2} = \left(\frac{3.0\text{ cm}}{5.0\times10^{-3}\text{ cm}}\right)^2 = \boxed{360{,}000}.$$

15. Strategy Use the fact that $R_B = 1.42R_A$.

Solution Calculate the ratio of P_B to P_A.

$$\frac{P_B}{P_A} = \frac{\frac{V^2}{R_B}}{\frac{V^2}{R_A}} = \frac{R_A}{R_B} = \frac{R_A}{1.42R_A} = \frac{1}{1.42} = \boxed{0.704}$$

16. Strategy Recall that each digit to the right of the decimal point is significant.

Solution Comparing the significant figures of each value, we have (a) 5, (b) 4, (c) 2, (d) 2, and (e) 3. From fewest to greatest we have $\boxed{\text{c = d, e, b, a}}$.

17. (a) Strategy Rewrite the numbers so that the power of 10 is the same for each. Then add and give the answer with the number of significant figures determined by the less precise of the two numbers.

Solution Perform the operation with the appropriate number of significant figures.

$$3.783\times10^6\text{ kg} + 1.25\times10^8\text{ kg} = 0.03783\times10^8\text{ kg} + 1.25\times10^8\text{ kg} = \boxed{1.29\times10^8\text{ kg}}$$

(b) Strategy Find the quotient and give the answer with the number of significant figures determined by the number with the fewest significant figures.

Solution Perform the operation with the appropriate number of significant figures.

$$(3.783\times10^6\text{ m}) \div (3.0\times10^{-2}\text{ s}) = \boxed{1.3\times10^8\text{ m/s}}$$

18. (a) Strategy Move the decimal point eight places to the left and multiply by 10^8.

Solution Write the number in scientific notation.

$310{,}000{,}000 \text{ people} = \boxed{3.1\times10^8 \text{ people}}$

(b) Strategy Move the decimal point 15 places to the right and multiply by 10^{-15}.

Solution Write the number in scientific notation.

$0.000\,000\,000\,000\,003\,8 \text{ m} = \boxed{3.8\times10^{-15} \text{m}}$

19. (a) Strategy Rewrite the numbers so that the power of 10 is the same for each. Then subtract and give the answer with the number of significant figures determined by the less precise of the two numbers.

Solution Perform the calculation using an appropriate number of significant figures.

$3.68\times10^7 \text{ g} - 4.759\times10^5 \text{ g} = 3.68\times10^7 \text{ g} - 0.04759\times10^7 \text{ g} = \boxed{3.63\times10^7 \text{ g}}$

(b) Strategy Find the quotient and give the answer with the number of significant figures determined by the number with the fewest significant figures.

Solution Perform the calculation using an appropriate number of significant figures.

$$\frac{6.497\times10^4 \text{ m}^2}{5.1037\times10^2 \text{ m}} = \boxed{1.273\times10^2 \text{ m}}$$

20. (a) Strategy Rewrite the numbers so that the power of 10 is the same for each. Then add and give the answer with the number of significant figures determined by the less precise of the two numbers.

Solution Write your answer using the appropriate number of significant figures.

$6.85\times10^{-5} \text{ m} + 2.7\times10^{-7} \text{ m} = 6.85\times10^{-5} \text{ m} + 0.027\times10^{-5} \text{ m} = \boxed{6.88\times10^{-5} \text{ m}}$

(b) Strategy Add and give the answer with the number of significant figures determined by the less precise of the two numbers.

Solution Write your answer using the appropriate number of significant figures.

$702.35 \text{ km} + 1897.648 \text{ km} = \boxed{2600.00 \text{ km}}$

(c) Strategy Multiply and give the answer with the number of significant figures determined by the number with the fewest significant figures.

Solution Write your answer using the appropriate number of significant figures.

$5.0 \text{ m}\times4.3 \text{ m} = \boxed{22 \text{ m}^2}$

(d) Strategy Find the quotient and give the answer with the number of significant figures determined by the number with the fewest significant figures.

Solution Write your answer using the appropriate number of significant figures.

$(0.04/\pi) \text{ cm} = \boxed{0.01 \text{ cm}}$

(e) **Strategy** Find the quotient and give the answer with the number of significant figures determined by the number with the fewest significant figures.

Solution Write your answer using the appropriate number of significant figures.

$(0.040/\pi)\text{ m} = \boxed{0.013\text{ m}}$

21. **Strategy** Multiply and give the answer in scientific notation with the number of significant figures determined by the number with the fewest significant figures.

Solution Solve the problem.

$(3.2\text{ m})\times(4.0\times10^{-3}\text{ m})\times(1.3\times10^{-8}\text{ m}) = \boxed{1.7\times10^{-10}\text{ m}^3}$

22. **Strategy** Follow the rules for identifying significant figures.

Solution

(a) All three digits are significant, so 7.68 g has $\boxed{3}$ significant figures.

(b) The first zero is not significant, since it is used only to place the decimal point. The digits 4 and 2 are significant, as is the final zero, so 0.420 kg has $\boxed{3}$ significant figures.

(c) The first two zeros are not significant, since they are used only to place the decimal point. The digits 7 and 3 are significant, so 0.073 m has $\boxed{2}$ significant figures.

(d) All three digits are significant, so 7.68×10^5 g has $\boxed{3}$ significant figures.

(e) The zero is significant, since it comes after the decimal point. The digits 4 and 2 are significant as well, so 4.20×10^3 kg has $\boxed{3}$ significant figures.

(f) Both 7 and 3 are significant, so 7.3×10^{-2} m has $\boxed{2}$ significant figures.

(g) Both 2 and 3 are significant. The two zeros are significant as well, since they come after the decimal point, so 2.300×10^4 s has $\boxed{4}$ significant figures.

23. **Strategy** Divide and give the answer with the number of significant figures determined by the number with the fewest significant figures.

Solution Solve the problem.

$$\frac{3.21\text{ m}}{7.00\text{ ms}} = \frac{3.21\text{ m}}{7.00\times10^{-3}\text{ s}} = \boxed{459\text{ m/s}}$$

24. **Strategy** Convert each length to meters. Then, rewrite the numbers so that the power of 10 is the same for each. Finally, add and give the answer with the number of significant figures determined by the less precise of the two numbers.

Solution Solve the problem.

$$3.08\times10^{-1}\text{ km} + 2.00\times10^{3}\text{ cm} = 3.08\times10^{2}\text{ m} + 2.00\times10^{1}\text{ m} = 3.08\times10^{2}\text{ m} + 0.200\times10^{2}\text{ m} = \boxed{3.28\times10^{2}\text{ m}}$$

25. Strategy Use the rules for determining significant figures and for writing numbers in scientific notation.

Solution

(a) 0.00574 kg has three significant figures, 5, 7, and 4. The zeros are not significant, since they are used only to place the decimal point. To write this measurement in scientific notation, we move the decimal point three places to the right and multiply by 10^{-3}.

(b) 2 m has one significant figure, 2. This measurement is already written in scientific notation

(c) 0.450×10^{-2} m has three significant figures, 4, 5, and the 0 to the right of 5. The zero is significant, since it comes after the decimal point and is not used to place the decimal point. To write this measurement in scientific notation, we move the decimal point one place to the right and multiply by 10^{-1}.

(d) 45.0 kg has three significant figures, 4, 5, and 0. The zero is significant, since it comes after the decimal point and is not used to place the decimal point. To write this measurement in scientific notation, we move the decimal point one place to the left and multiply by 10^{1}.

(e) 10.09×10^{4} s has four significant figures, 1, 9, and the two zeros. The zeros are significant, since they are between two significant figures. To write this measurement in scientific notation, we move the decimal point one place to the left and multiply by 10^{1}.

(f) 0.09500×10^{5} mL has four significant figures, 9, 5, and the two zeros to the right of 5. The zeros are significant, since they come after the decimal point and are not used to place the decimal point. To write this measurement in scientific notation, we move the decimal point two places to the right and multiply by 10^{-2}.

The results of parts (a) through (f) are shown in the table below.

	Measurement	**Significant Figures**	**Scientific Notation**
(a)	0.00574 kg	3	5.74×10^{-3} kg
(b)	2 m	1	2 m
(c)	0.450×10^{-2} m	3	4.50×10^{-3} m
(d)	45.0 kg	3	4.50×10^{1} kg
(e)	10.09×10^{4} s	4	1.009×10^{5} s
(f)	0.09500×10^{5} mL	4	9.500×10^{3} mL

26. Strategy Convert each length to scientific notation.

Solution In scientific notation, the lengths are: (a) 1 μm $=1\times10^{-6}$ m, (b) 1000 nm $=1\times10^{3}\times10^{-9}$ m $=1\times10^{-6}$ m, (c) 100 000 pm $=1\times10^{5}\times10^{-12}$ m $=1\times10^{-7}$ m, (d) 0.01 cm $=1\times10^{-2}\times10^{-2}$ m $=1\times10^{-4}$ m, and (e) 0.000 000 0001 km $=1\times10^{-10}\times10^{3}$ m $=1\times10^{-7}$ m.
From smallest to greatest, we have c= e, a = b, d.

27. Strategy Convert each length to meters and each time to seconds. Recall that 1.0 mi = 1600 m.

Solution In scientific notation, we have:
(a) $55\text{ mi/h}\times 1600\text{ m/mi}\times 1\text{ h}/3600\text{ s} = 24\text{ m/s}$, (b) $82\text{ km/h}\times 1\text{ h}/3600\text{ s}\times 1000\text{ m/km} = 23\text{ m/s}$,
(c) 33 m/s, (d) $3.0\text{ cm/ms}\times 1\text{ m}/100\text{ cm}\times 1000\text{ ms/s} = 30\text{ m/s}$, and
(e) $1.0\text{ mi/min}\times 1\text{ min}/60\text{ s}\times 1600\text{ m/mi} = 27\text{ m/s}$.
From smallest to greatest, we have $\boxed{\text{b, a, e, d, c}}$.

28. Strategy Recall that 1 kg = 1000 g and 100 cm = 1 m.

Solution Convert the density of body fat from g/cm^3 to kg/m^3.

$$0.9\text{ g/cm}^3\times 1\text{ kg}/1000\text{ g}\times(100\text{ cm/m})^3 = \boxed{900\text{ kg/m}^3}$$

29. Strategy There are approximately 39.37 inches per meter.

Solution Find the thickness of the cell membrane in inches.

$$7.0\times 10^{-9}\text{ m}\times 39.37\text{ inches/m} = \boxed{2.8\times 10^{-7}\text{ inches}}$$

30. (a) Strategy There are approximately 3.785 liters per gallon and 128 ounces per gallon.

Solution Find the number of fluid ounces in the bottle.

$$\frac{128\text{ fl oz}}{1\text{ gal}}\times\frac{1\text{ gal}}{3.785\text{ L}}\times 355\text{ mL}\times\frac{1\text{ L}}{10^3\text{ mL}} = \boxed{12.0\text{ fluid ounces}}$$

(b) Strategy From part (a), we have 355 mL = 12.0 fluid ounces.

Solution Find the number of milliliters in the drink.

$$16.0\text{ fl oz}\times\frac{355\text{ mL}}{12.0\text{ fl oz}} = \boxed{473\text{ mL}}$$

31. Strategy There are approximately 3.281 feet per meter.

Solution Convert to meters.

(a) $$1595.5\text{ ft}\times\frac{1\text{ m}}{3.281\text{ ft}} = \boxed{4.863\times 10^2\text{ m}}$$

(b) $$6016\text{ ft}\times\frac{1\text{ m}}{3.281\text{ ft}} = \boxed{1.834\times 10^3\text{ m}}$$

32. Strategy For (a), convert milliliters to liters; then convert liters to cubic centimeters using the conversion $1\text{ L} = 10^3\text{ cm}^3$. For (b), convert cubic centimeters to cubic meters using the fact that 100 cm = 1 m.

Solution Convert each volume.

(a) $$255\text{ mL}\times\frac{10^{-3}\text{ L}}{1\text{ mL}}\times\frac{10^3\text{ cm}}{1\text{ L}} = \boxed{255\text{ cm}^3}$$

(b) $$255\text{ cm}^3\times\left(\frac{1\text{ m}}{100\text{ cm}}\right)^3 = 255\text{ cm}^3\times\frac{1\text{ m}^3}{10^6\text{ cm}^3} = \boxed{2.55\times 10^{-4}\text{ m}}$$

33. Strategy For (a), convert meters per second to miles per hour using the conversion 1 mi/h = 0.4470 m/s. For (b), convert meters per second to centimeters per millisecond using the conversions 1 m = 100 cm and 1 s = 1000 ms.

Solution Convert each speed.

(a) $80\text{ m/s}\times\frac{1\text{ mi/h}}{0.4470\text{ m/s}}=\boxed{180\text{ mi/h}}$

(b) $80\text{ m/s}\times\frac{10^2\text{ cm}}{1\text{ m}}\times\frac{1\text{ s}}{10^3\text{ ms}}=\boxed{8.0\text{ cm/ms}}$

34. Strategy There are 0.6214 miles in 1 kilometer.

Solution Find the length of the marathon race in miles.

$$42.195\text{ km}\times\frac{0.6214\text{ mi}}{1\text{ km}}=\boxed{26.22\text{ mi}}$$

35. Strategy Calculate the change in the exchange rate and divide it by the original price to find the drop.

Solution Find the actual drop in the value of the dollar over the first year.

$$\frac{1.27-1.45}{1.45}=\frac{-0.18}{1.45}=-0.12$$

The actual drop is $\boxed{0.12\text{ or }12\%}$.

36. Strategy There are 1000 watts in one kilowatt and 100 centimeters in one meter.

Solution Convert 1.4 kW/m^2 to W/cm^2.

$$\frac{1.4\text{ kW}}{1\text{ m}^2}\times\frac{1000\text{ W}}{1\text{ kW}}\times\left(\frac{1\text{ m}}{100\text{ cm}}\right)^2=\boxed{0.14\text{ W/cm}^2}$$

37. Strategy Convert the radius to centimeters; then use the conversions 1 L = 10^3 cm^3 and 60 s = 1 min.

Solution Find the volume rate of blood flow

$$\textit{volume rate of blood flow}=\pi r^2v=\pi(1.2\text{ cm})^2(18\text{ cm/s})\times\frac{1\text{ L}}{10^3\text{ cm}^3}\times\frac{60\text{ s}}{1\text{ min}}=\boxed{4.9\text{ L/min}}$$

38. Strategy The distance traveled *d* is equal to the rate of travel *r* times the time of travel *t*. There are 1000 milliseconds in one second.

Solution Find the distance the molecule would move.

$$d=rt=\frac{459\text{ m}}{1\text{ s}}\times7.00\text{ ms}\times\frac{1\text{ s}}{1000\text{ ms}}=\boxed{3.21\text{ m}}$$

39. Strategy There are 1000 meters in a kilometer and 1,000,000 millimeters in a kilometer.

Solution Find the product and express the answer in km^3 with the appropriate number of significant figures.

$$(3.2\text{ km})\times(4.0\text{ m})\times(13\times10^{-3}\text{mm})\times\frac{1\text{ km}}{1000\text{ m}}\times\frac{1\text{ km}}{1{,}000{,}000\text{ mm}}=\boxed{1.7\times10^{-10}\text{km}^3}$$

40. **(a)** **Strategy** There are 12 inches in one foot and 2.54 centimeters in one inch.

Solution Find the number of square centimeters in one square foot.

$$1\text{ ft}^2\times\left(\frac{12\text{ in}}{1\text{ ft}}\right)^2\times\left(\frac{2.54\text{ cm}}{1\text{ in}}\right)^2=\boxed{929\text{ cm}^2}$$

(b) **Strategy** There are 100 centimeters in one meter.

Solution Find the number of square centimeters in one square meter.

$$1\text{ m}^2\times\left(\frac{100\text{ cm}}{1\text{ m}}\right)^2=\boxed{1\times10^4\text{cm}^2}$$

(c) **Strategy** Divide one square meter by one square foot. Estimate the quotient.

Solution Find the approximate number of square feet in one square meter.

$$\frac{1\text{ m}^2}{1\text{ ft}^2}=\frac{10{,}000\text{ cm}^2}{929\text{ cm}^2}\approx\boxed{11}$$

41. **(a)** **Strategy** There are 12 inches in one foot, 2.54 centimeters in one inch, and 60 seconds in one minute.

Solution Express the snail's speed in feet per second.

$$\frac{5.0\text{ cm}}{1\text{ min}}\times\frac{1\text{min}}{60\text{ s}}\times\frac{1\text{ in}}{2.54\text{ cm}}\times\frac{1\text{ ft}}{12\text{ in}}=\boxed{2.7\times10^{-3}\text{ ft/s}}$$

(b) **Strategy** There are 5280 feet in one mile, 12 inches in one foot, 2.54 centimeters in one inch, and 60 minutes in one hour.

Solution Express the snail's speed in miles per hour.

$$\frac{5.0\text{ cm}}{1\text{ min}}\times\frac{60\text{ min}}{1\text{ h}}\times\frac{1\text{ in}}{2.54\text{ cm}}\times\frac{1\text{ ft}}{12\text{ in}}\times\frac{1\text{ mi}}{5280\text{ ft}}=\boxed{1.9\times10^{-3}\text{ mi/h}}$$

42. **Strategy** A micrometer is 10^{-6} m and a millimeter is 10^{-3} m; therefore, a micrometer is $10^{-6}/10^{-3}=10^{-3}$ mm.

Solution Find the area in square millimeters.

$$150\ \mu\text{m}^2\times\left(\frac{10^{-3}\text{ mm}}{1\ \mu\text{m}}\right)^2=\boxed{1.5\times10^{-4}\text{ mm}^2}$$

43. **Strategy** Replace each quantity in $U=mgh$ with its SI base units.

Solution Find the combination of SI base units that are equivalent to joules.

$$U=mgh\Rightarrow\text{J}=\text{kg}\times\text{m/s}^2\times\text{m}=\boxed{\text{kg}\cdot\text{m}^2\cdot\text{s}^{-2}}$$

44. **(a)** **Strategy** Replace each quantity in ma and kx with its dimensions.

Solution Show that the dimensions of ma and kx are equivalent.

ma has dimensions $[\text{M}]\times\dfrac{[\text{L}]}{[\text{T}]^2}$ and kx has dimensions $\dfrac{[\text{M}]}{[\text{T}]^2}\times[\text{L}]=[\text{M}]\times\dfrac{[\text{L}]}{[\text{T}]^2}$.

Since $\boxed{[\text{M}][\text{L}][\text{T}]^{-2}=[\text{M}][\text{L}][\text{T}]^{-2}}$, the dimensions are equivalent.

(b) Strategy Use the results of part (a).

Solution Since $F = ma$ and $F = -kx$, the dimensions of the force unit are $\boxed{[\text{M}][\text{L}][\text{T}]^{-2}}$.

45. Strategy Replace each quantity in $T^2 = 4\pi^2 r^3/(GM)$ with its dimensions.

Solution Show that the equation is dimensionally correct.

T^2 has dimensions $[\text{T}]^2$ and $\dfrac{4\pi^2 r^3}{GM}$ has dimensions $\dfrac{[\text{L}]^3}{\frac{[\text{L}]^3}{[\text{M}][\text{T}]^2}\times[\text{M}]} = \dfrac{[\text{L}]^3}{[\text{M}]}\times\dfrac{[\text{M}][\text{T}]^2}{[\text{L}]^3} = [\text{T}]^2.$

Since $\boxed{[\text{T}]^2 = [\text{T}]^2}$, the equation is dimensionally correct.

46. Strategy Determine the SI unit of momentum using a process of elimination.

Solution Find the SI unit of momentum.

$K = \dfrac{p^2}{2m}$ has units of $\dfrac{\text{kg}\cdot\text{m}^2}{\text{s}^2}$. Since the SI unit for m is kg, the SI unit for p^2 is $\dfrac{\text{kg}^2\cdot\text{m}^2}{\text{s}^2}$. Taking the square root, we find that the SI unit for momentum is $\boxed{\text{kg}\cdot\text{m}\cdot\text{s}^{-1}}$.

47. (a) Strategy Replace each quantity (except for V) in $F_\text{B} = \rho g V$ with its dimensions.

Solution Find the dimensions of V.

$V = \dfrac{F_\text{B}}{\rho g}$ has dimensions $\dfrac{[\text{MLT}^{-2}]}{[\text{ML}^{-3}]\times[\text{LT}^{-2}]} = \boxed{[\text{L}^3]}$.

(b) Strategy and Solution Since velocity has dimensions $[\text{LT}^{-1}]$ and volume has dimensions $[\text{L}^3]$, the correct interpretation of V is that is represents $\boxed{\text{volume}}$.

48. (a) Strategy a has dimensions $\frac{[\text{L}]}{[\text{T}]^2}$; v has dimensions $\frac{[\text{L}]}{[\text{T}]}$; r has dimension [L].

Solution If we square v and divide by r, we have $\frac{v^2}{r}$, which implies that $\frac{[\text{L}]^2}{[\text{T}]^2}\cdot\frac{1}{[\text{L}]} = \frac{[\text{L}]}{[\text{T}]^2}$, which are the dimensions for a. Therefore, we can write $\boxed{a = K\frac{v^2}{r}, \text{ where } K \text{ is a dimensionless constant}}$.

(b) Strategy Divide the new acceleration by the old, and use the fact that the new speed is 1.100 times the old.

Solution Find the percent increase in the radial acceleration.

$$\frac{a_2}{a_1} = \frac{K\frac{v_2^2}{r}}{K\frac{v_1^2}{r}} = \left(\frac{v_2}{v_1}\right)^2 = \left(\frac{1.100v_1}{v_1}\right)^2 = 1.100^2 = 1.210$$

$1.210 - 1 = 0.210,$ so the radial acceleration increases by $\boxed{21.0\%}$.

49. Strategy Approximate the distance from your eyes to a book held at your normal reading distance.

Solution The normal reading distance is about 30-40 cm, so the approximate distance from your eyes to a book you are reading is $\boxed{\text{30-40 cm}}$.

50. Strategy Estimate the length, width, and height of your textbook. Then use $V = \ell wh$ to estimate its volume.

Solution Find the approximate volume of your physics textbook in cm^3.
The length, width, and height of your physics textbook are approximately 30 cm, 20 cm, and 4.0 cm, respectively.

$$V = \ell wh = (30\text{ cm})(20\text{ cm})(4.0\text{ cm}) = \boxed{2400\text{ cm}^3}$$

51. Strategy and Solution The mass of the lower leg is about 5 kg and that of the upper leg is about 7 kg, so an order of magnitude estimate of the mass of a person's leg is $\boxed{\text{10 kg}}$.

52. Strategy and Solution A normal heart rate is about 70 beats per minute and a person lives for about 70 years, so the heart beats about $\frac{70\text{ beats}}{1\text{ min}} \times \frac{70\text{ y}}{\text{lifetime}} \times \frac{5.26\times10^5\text{ min}}{1\text{ y}} = 2.6\times10^9$ times per lifetime, or about $\boxed{3\times10^9}$.

53. Strategy One story is about 3 m high.

Solution Find the order of magnitude of the height in meters of a 40-story building.

$$(3\text{ m})(40) \sim \boxed{100\text{ m}}$$

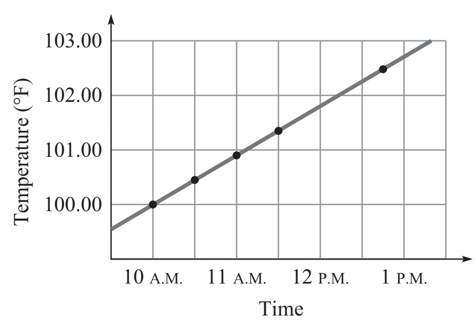
54. Strategy The area of skin is the area of the sides of the cylinder approximating the human torso plus 2 times the area of each arm. The surface of a cylinder, including the ends, is $2\pi rh + 2\pi r^2$ (see Appendix A.6).

Solution Estimate the surface area of skin covering a human body.

$$A_{\text{skin}} \approx A_{\text{t}} + 2A_{\text{a}} = 2\pi r_{\text{t}}h_{\text{t}} + 2\pi r_{\text{t}}^2 + 2\times2\pi r_{\text{a}}h_{\text{a}} + 2\times2\pi r_{\text{a}}^2$$
$$= 2\pi(0.15\text{ m})(2.0\text{ m}) + 2\pi(0.15\text{ m})^2 + 2\times2\pi(0.050\text{ m})(1.0\text{ m}) + 2\times2\pi(0.050\text{ m})^2 = \boxed{2.7\text{ m}^2}$$

The contributions of the ends of the cylinders to the total area are small, so for an estimate it would be ok to ignore them (and the estimate would be 2.5 m^2).

55. Strategy The plot of temperature versus elapsed time is shown. Use the graph to answer the questions.



Solution

(a) By inspection of the graph, it appears that the temperature at noon was $\boxed{101.8°\text{F}}$.

(b) Estimate the slope of the line.

$$m = \frac{102.6°\text{F} - 100.0°\text{F}}{1{:}00\text{ P.M.} - 10{:}00\text{ A.M.}} = \frac{2.6°\text{F}}{3\text{ h}} = \boxed{0.9°\text{F/h}}$$

(c) In twelve hours, the temperature would, according to the trend, be approximately
$T = (0.9\ °\text{F/h})(12\ \text{h}) + 102.5°\text{F} = 113°\text{F}.$
The patient would be dead before the temperature reached this level. So, the answer is $\boxed{\text{no}}$.

56. Strategy Use the two temperatures and their corresponding times to find the rate of temperature change with respect to time (the slope of the graph of temperature vs. time). Then, write the linear equation for the temperature with respect to time and find the temperature at 3:35 P.M.

Solution Find the rate of temperature change.

$$m = \frac{\Delta T}{\Delta t} = \frac{101.0°\text{F} - 97.0°\text{F}}{4.0\ \text{h}} = 1.0°\text{F/h}$$

Use the slope-intercept form of a graph of temperature vs. time to find the temperature at 3:35 P.M.

$$T = mt + T_0 = (1.0\ °\text{F/h})(3.5\ \text{h}) + 101.0°\text{F} = \boxed{104.5°\text{F}}$$

57. Strategy Put the equation that describes the line in slope-intercept form, $y = mx + b$.

$$at = v - v_0$$
$$v = at + v_0$$

Solution

(a) v is the dependent variable and t is the independent variable, so $\boxed{a}$ is the slope of the line.

(b) The slope-intercept form is $y = mx + b$. Find the vertical-axis intercept.
$v \leftrightarrow y,\ t \leftrightarrow x,\ a \leftrightarrow m,$ so $v_0 \leftrightarrow b.$
Thus, $\boxed{+v_0}$ is the vertical-axis intercept of the line.

58. (a) Strategy The equation of the speed versus time is given by $v = at + v_0$, where $a = 6.0\ \text{m/s}^2$ and $v_0 = 3.0\ \text{m/s}$.

Solution Find the change in speed.

$$\begin{aligned} v_2 &= at_2 + v_0 \\ -(v_1 &= at_1 + v_0) \\ \hline v_2 - v_1 &= a(t_2 - t_1) \\ v_2 - v_1 &= (6.0\ \text{m/s}^2)(6.0\ \text{s} - 4.0\ \text{s}) = \boxed{12\ \text{m/s}} \end{aligned}$$

(b) Strategy Use the equation found in part (a).

Solution Find the speed when the elapsed time is equal to 5.0 seconds.

$$v = (6.0\ \text{m/s}^2)(5.0\ \text{s}) + 3.0\ \text{m/s} = \boxed{33\ \text{m/s}}$$

59. (a) Strategy Refer to the figure. Use the definition of the slope of a line and the fact that the vertical axis intercept is the x-value corresponding to $t = 0$.

Solution Compute the slope.

$$\frac{\Delta x}{\Delta t} = \frac{17.0\ \text{km} - 3.0\ \text{km}}{9.0\ \text{h} - 0.0\ \text{h}} = \boxed{1.6\ \text{km/h}}.$$

When $t = 0$, $x = 3.0$ km; therefore, the vertical axis intercept is $\boxed{3.0\ \text{km}}$.

(b) Strategy and Solution The physical significance of the slope of the graph is that it represents the speed of the object. The physical significance of the vertical axis intercept is that it represents the starting position of the object (position at time zero).

60. Strategy To determine if c and A_0 are correct, graph A versus B^3.

Solution To graph A versus B^3, graph A on the vertical axis and B^3 on the horizontal axis.

61. Strategy Use the slope-intercept form, $y = mx + b$.

Solution Since x is on the vertical axis, it corresponds to y. Since t^4 is on the horizontal axis, it corresponds to x (in $y = mx + b$). So, the equation for x as a function of t is $x = (25\ \text{m/s}^4)t^4 + 3\ \text{m}$.

62. Strategy Use graphing rules 3, 5, and 7 under Graphing Data in Section 1.9 Graphs.

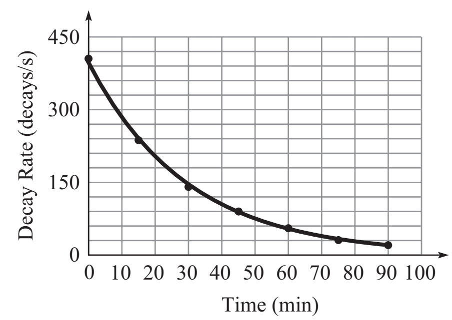
Solution

(a) To obtain a linear graph, the students should plot v versus r^2, where v is the dependent variable and r^2 is the independent variable.

(b) The students should measure the slope of the best-fit line obtained from the graph of the data; set the value of the slope equal to $2g(\rho - \rho_f)/(9\eta)$; and solve for η.

63. (a) Strategy Plot the decay rate on the vertical axis and the time on the horizontal axis.

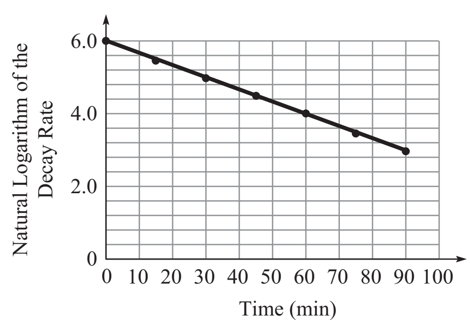
Solution The plot is shown.



(b) Strategy Plot the natural logarithm of the decay rate on the vertical axis and the time on the horizontal axis.

Solution The plot is shown.

Presentation of the data in this form—as the natural logarithm of the decay rate—might be useful because the graph is linear.



64. (a) Strategy Make an order-of-magnitude estimate. Assume 4 seconds per breath.

Solution Estimate the number of breaths you take in one year.

$$\textit{breaths per year} = \frac{1\text{ breath}}{4\text{ s}} \times \frac{3.156\times10^7\text{ s}}{1\text{ y}} = 8\times10^6\text{ breaths/y} \approx \boxed{10^7\text{ breaths/y}}$$

(b) Strategy Assume 0.5 L per breath.

Solution Estimate the volume of air you breathe in during one year.

$$\textit{volume} = 8\times10^6\text{ breaths}\times\frac{0.5\text{ L}}{1\text{ breath}} = 4\times10^6\text{ L}\times\frac{10^{-3}\text{ m}^3}{1\text{ L}} = \boxed{4000\text{ m}^3}$$

65. Strategy Replace v, r, ω, and m with their dimensions. Then use dimensional analysis to determine how v depends upon some or all of the other quantities.

Solution v, r, ω, and m have dimensions $\frac{[\text{L}]}{[\text{T}]}$, [L], $\frac{1}{[\text{T}]}$, and [M], respectively. No combination of r, ω, and m gives dimensions without [M], so v does not depend upon m. Since $[\text{L}]\times\frac{1}{[\text{T}]} = \frac{[\text{L}]}{[\text{T}]}$ and there is no dimensionless constant involved in the relation, v is equal to the product of ω and r, or $\boxed{v = \omega r}$.

66. Strategy (Answers will vary.) In this case, we use San Francisco, CA for the city. The population of San Francisco is approximately 750,000. Assume that there is one automobile for every two residents of San Francisco, that an average automobile needs three repairs or services per year, and that the average shop can service 10 automobiles per day.

Solution Estimate the number of automobile repair shops in San Francisco.

If an automobile needs three repairs or services per year, then it needs $\frac{3\text{ repairs}}{\text{auto}\cdot\text{y}}\times\frac{1\text{ y}}{365\text{ d}} \approx \frac{0.01\text{ repairs}}{\text{auto}\cdot\text{d}}$.

If there is one auto for every two residents, then there are $\frac{1\text{ auto}}{2\text{ residents}}\times750{,}000\text{ residents} \approx 4\times10^5\text{ autos}$.

If a shop requires one day to service 10 autos, then the number of shops-days per repair is

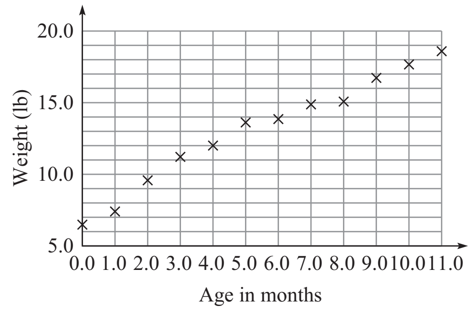
$$1\text{ shop}\times\frac{1\text{ d}}{10\text{ repairs}} = \frac{0.1\text{ shop}\cdot\text{d}}{\text{repair}}.$$

The estimated number of auto shops is $4\times10^5\text{ autos}\times\frac{0.01\text{ repairs}}{\text{auto}\cdot\text{d}}\times\frac{0.1\text{ shop}\cdot\text{d}}{\text{repair}} = \boxed{400\text{ shops}}$.

Checking the phone directory, we find that there are approximately 463 automobile repair and service shops in San Francisco. The estimate is off by $\frac{400-463}{400}\times100\% = \boxed{-16\%}$. The estimate was 16% too low, but in the ball park!

67. (a) Strategy Plot the weights and ages on a weight versus age graph.

Solution See the graph.



(b) Strategy Find the slope of the best-fit line between age 0.0 and age 5.0 months.

Solution Find the slope.

$$m=\frac{13.6\text{ lb}-6.6\text{ lb}}{5.0\text{ mo}-0.0\text{ mo}}=\frac{7.0\text{ lb}}{5.0\text{ mo}}=\boxed{1.4\text{ lb/mo}}$$

(c) Strategy Find the slope of the best-fit line between age 5.0 and age 10.0 months.

Solution Find the slope.

$$m=\frac{17.5\text{ lb}-13.6\text{ lb}}{10.0\text{ mo}-5.0\text{ mo}}=\frac{3.9\text{ lb}}{5.0\text{ mo}}=\boxed{0.78\text{ lb/mo}}$$

(d) Strategy Write a linear equation for the weight of the baby as a function of time. The slope is that found in part (b), 1.4 lb/mo. The intercept is the weight of the baby at five months of age.

Solution Find the projected weight of the child at age 12.

$$W=(1.4\text{ lb/mo})(144\text{ mo}-5\text{ mo})+13.6\text{ lb}=\boxed{210\text{ lb}}$$

68. Strategy For parts (a) through (d), perform the calculations.

Solution

(a) $186.300+0.0030=\boxed{186.303}$

(b) $186.300-0.0030=\boxed{186.297}$

(c) $186.300\times 0.0030=\boxed{0.56}$

(d) $186.300/0.0030=\boxed{62,000}$

(e) Strategy For cases (a) and (b), the percent error is given by $\dfrac{0.0030}{\textit{Actual Value}}\times 100\%$.

Solution Find the percent error.

Case (a): $\dfrac{0.0030}{186.303}\times 100\%=\boxed{0.0016\%}$

Case (b): $\dfrac{0.0030}{186.297}\times 100\% = \boxed{0.0016\%}$

For case (c), ignoring 0.0030 causes you to multiply by zero and get a zero result. For case (d), ignoring 0.0030 causes you to divide by zero.

(f) Strategy Make a rule about neglecting small values using the results obtained above.

Solution

You can neglect small values when they are added to or subtracted from sufficiently large values. The term "sufficiently large" is determined by the number of significant figures required.

69. Strategy There are about 10^3 hairs in a one-square-inch area of the average human head. An order-of-magnitude estimate of the area of the average human head is 10^2 square inches.

Solution Calculate the estimate.

$$10^3 \text{ hairs}/\text{in}^2 \times 10^2 \text{ in}^2 = \boxed{10^5 \text{ hairs}}$$

70. Strategy Use the metric prefixes n (10^{-9}), μ (10^{-6}), m (10^{-3}), or M (10^6).

Solution

(a) M (or mega) is equal to 10^6, so $6\times 10^6 \text{ m} = \boxed{6 \text{ Mm}}$.

(b) There are approximately 3.28 feet in one meter, so $6 \text{ ft}\times\dfrac{1 \text{ m}}{3.28 \text{ ft}} = \boxed{2 \text{ m}}$.

(c) μ (or micro) is equal to 10^{-6}, so $10^{-6} \text{ m} = \boxed{1\ \mu\text{m}}$.

(d) n (or nano) is equal to 10^{-9}, so $3\times 10^{-9} \text{ m} = \boxed{3 \text{ nm}}$.

(e) n (or nano) is equal to 10^{-9}, so $3\times 10^{-10} \text{ m} = \boxed{0.3 \text{ nm}}$.

71. Strategy The volume of the spherical virus is given by $V_{\text{virus}} = (4/3)\pi r_{\text{virus}}{}^3$. The volume of viral particles is one billionth the volume of the saliva.

Solution Calculate the number of viruses that have landed on you.

$$\text{number of viral particles} = \frac{10^{-9} V_{\text{saliva}}}{V_{\text{virus}}} = \frac{0.010 \text{ cm}^3}{10^9 \left(\frac{4}{3}\pi\right)\left(\frac{85 \text{ nm}}{2}\right)^3 \left(\frac{10^{-7} \text{cm}}{1 \text{ nm}}\right)^3} = \boxed{10^4 \text{ viruses}}$$

72. Strategy The circumference of a viroid is approximately 300 times 0.35 nm. The diameter is given by $C = \pi d$, or $d = C/\pi$.

Solution Find the diameter of the viroid in the required units.

(a) $d = \frac{300(0.35\text{ nm})}{\pi} \times \frac{10^{-9}\text{ m}}{1\text{ nm}} = \boxed{3.3\times10^{-8}\text{ m}}$

(b) $d = \frac{300(0.35\text{ nm})}{\pi} \times \frac{10^{-3}\,\mu\text{m}}{1\text{ nm}} = \boxed{3.3\times10^{-2}\,\mu\text{m}}$

(c) $d = \frac{300(0.35\text{ nm})}{\pi} \times \frac{10^{-7}\text{ cm}}{1\text{ nm}} \times \frac{1\text{ in}}{2.54\text{ cm}} = \boxed{1.3\times10^{-6}\text{ in}}$

73. (a) Strategy There are 3.28 feet in one meter.

Solution Find the length in meters of the largest recorded blue whale.

$1.10\times10^2\text{ ft}\times\frac{1\text{ m}}{3.28\text{ ft}} = \boxed{33.5\text{ m}}$

(b) Strategy Divide the length of the largest recorded blue whale by the length of a double-decker London bus.

Solution Find the length of the blue whale in double-decker-bus lengths.

$\frac{1.10\times10^2\text{ ft}}{8.0\frac{\text{m}}{\text{bus length}}}\times\frac{1\text{ m}}{3.28\text{ ft}} = \boxed{4.2\text{ bus lengths}}$

74. Strategy The volume of the blue whale can be found by dividing the mass of the whale by its average density.

Solution Find the volume of the blue whale in cubic meters.

$V = \frac{m}{\rho} = \frac{1.9\times10^5\text{ kg}}{0.85\text{ g/cm}^3}\times\frac{1000\text{ g}}{1\text{ kg}}\times\left(\frac{1\text{ m}}{100\text{ cm}}\right)^3 = \boxed{2.2\times10^2\text{ m}^3}$

75. Strategy Assuming that the capillaries are completely filled with blood, the total volume of blood is given by the cross-sectional area of the blood vessel times the length.

Solution Estimate the total volume of blood in the human body.

$V = \pi r^2 l = \pi\left(4\times10^{-6}\text{ m}\right)^2\left(10^8\text{ m}\right) = 0.005\text{ m}^3 = \boxed{5\text{ L}}$

In reality, blood flow through the capillaries is regulated, so they are not always full of blood. On the other hand, we've neglected the additional blood found in the larger vessels (arteries, arterioles, veins, venules).

76. Strategy The shape of a sheet of paper (when not deformed) is a rectangular prism. The volume of a rectangular prism is equal to the product of its length, width, and height (or thickness).

Solution Find the volume of a sheet of paper in cubic meters.

$27.95\text{ cm}\times8.5\text{ in}\times0.10\text{ mm}\times\frac{1\text{ m}}{100\text{ cm}}\times\frac{0.0254\text{ m}}{1\text{ in}}\times\frac{1\text{ m}}{1000\text{ mm}} = \boxed{6.0\times10^{-6}\text{ m}^3}$

77. Strategy If s is the speed of the molecule, then $s \propto \sqrt{T}$ where T is the temperature.

Solution Form a proportion.

$$\frac{s_{\text{cold}}}{s_{\text{warm}}} = \frac{\sqrt{T_{\text{cold}}}}{\sqrt{T_{\text{warm}}}}$$

Find s_{cold}.

$$s_{\text{cold}} = s_{\text{warm}}\sqrt{\frac{T_{\text{cold}}}{T_{\text{warm}}}} = (475\ \text{m/s})\sqrt{\frac{250.0\ \text{K}}{300.0\ \text{K}}} = \boxed{434\ \text{m/s}}$$

78. Strategy Use dimensional analysis to convert from furlongs per fortnight to the required units.

Solution

(a) Convert to $\mu\text{m/s}$.

$$\frac{1\ \text{furlong}}{1\ \text{fortnight}} \times \frac{220\ \text{yd}}{1\ \text{furlong}} \times \frac{1\ \text{fortnight}}{14\ \text{days}} \times \frac{1\ \text{day}}{86{,}400\ \text{s}} \times \frac{3\ \text{ft}}{1\ \text{yd}} \times \frac{1\ \text{m}}{3.28\ \text{ft}} \times \frac{1{,}000{,}000\ \mu\text{m}}{1\ \text{m}} = \boxed{166\ \mu\text{m/s}}$$

(b) Convert to km/day.

$$\frac{1\ \text{furlong}}{1\ \text{fortnight}} \times \frac{220\ \text{yd}}{1\ \text{furlong}} \times \frac{1\ \text{fortnight}}{14\ \text{days}} \times \frac{3\ \text{ft}}{1\ \text{yd}} \times \frac{1\ \text{m}}{3.28\ \text{ft}} \times \frac{1\ \text{km}}{1000\ \text{m}} = \boxed{0.0144\ \text{km/day}}$$

79. Strategy There are 2.54 cm in one inch and 3600 seconds in one hour.

Solution Find the conversion factor for changing meters per second to miles per hour.

$$\frac{1\ \text{m}}{1\ \text{s}} \times \frac{100\ \text{cm}}{1\ \text{m}} \times \frac{1\ \text{in}}{2.54\ \text{cm}} \times \frac{1\ \text{ft}}{12\ \text{in}} \times \frac{1\ \text{mi}}{5280\ \text{ft}} \times \frac{3600\ \text{s}}{1\ \text{h}} = \boxed{2.24\ \text{mi/h} = 1\ \text{m/s}}$$

So, $\boxed{\text{for a quick, approximate conversion, multiply by 2}}$.

80. (a) Strategy There are 10,000 (10^4) half dollars in \$5000. The mass of a half-dollar coin is about 10 grams, or 10^{-2} kilograms.

Solution Estimate the mass of the coins.

$$10^4\ \text{coins} \times 10^{-2}\ \text{kg/coin} = 10^2\ \text{kg, or } \boxed{100\ \text{kg}}.$$

(b) Strategy There are $\$1{,}000{,}000/\$20 = 50{,}000$ twenty-dollar bills in \$1,000,000. The mass of a twenty-dollar bill is about 1 gram, or 10^{-3} kilograms.

Solution Estimate the mass of the bills.

$$50{,}000\ \text{bills} \times 10^{-3}\ \text{kg/bill} = \boxed{50\ \text{kg}}.$$

81. Strategy The SI base unit for mass is kg. Replace each quantity in $W = mg$ with its SI base units.

Solution Find the SI unit for weight.

$$\text{kg} \cdot \frac{\text{m}}{\text{s}^2} = \boxed{\frac{\text{kg} \cdot \text{m}}{\text{s}^2}}$$

82. Strategy It is given that $T^2 \propto r^3$. Divide the period of Mars by that of Venus.

Solution Compare the period of Mars to that of Venus.

$$\frac{T_{\text{Mars}}^2}{T_{\text{Venus}}^2}=\frac{r_{\text{Mars}}^3}{r_{\text{Venus}}^3},\text{ so } T_{\text{Mars}}^2=\left(\frac{r_{\text{Mars}}}{r_{\text{Venus}}}\right)^3 T_{\text{Venus}}^2,\text{ or } T_{\text{Mars}}=\left(\frac{2r_{\text{Venus}}}{r_{\text{Venus}}}\right)^{3/2} T_{\text{Venus}}=\boxed{2^{3/2}T_{\text{Venus}}\approx 2.8T_{\text{Venus}}}.$$

83. Strategy \$59,000,000,000 has a precision of 1 billion dollars; \$100 has a precision of 100 dollars, so the net worth is the same to one significant figure.

Solution Find the net worth.

$$\$59,000,000,000-\$100=\boxed{\$59,000,000,000}$$

84. Strategy Solutions will vary. One example follows:
The radius of the Earth is about 10^6 m. The area of a sphere is $4\pi r^2$, or about $10^1\cdot r^2$. The average depth of the oceans is about 4×10^3 m. The oceans cover more than two-thirds of the Earth's surface, but in this rough estimation, we assume that oceans cover the entire Earth.

Solution Calculate an order-of-magnitude estimate of the volume of water contained in Earth's oceans.
The surface area of the Earth is about $10^1\cdot(10^6\text{ m})^2=10^{13}\text{ m}^2$; therefore, the volume of water in the oceans is about $\text{area}\times\text{depth}=(10^{13}\text{ m}^2)(4\times10^3\text{ m})=4\times10^{16}\text{ m}^3\sim\boxed{10^{16}\text{ m}^3}$.

85. (a) Strategy There are 7.0 leagues in one pace and 4.8 kilometers in one league.

Solution Find your speed in kilometers per hour.

$$\frac{120\text{ paces}}{1\text{ min}}\times\frac{7.0\text{ leagues}}{1\text{ pace}}\times\frac{4.8\text{ km}}{1\text{ league}}\times\frac{60\text{ min}}{1\text{ h}}=\boxed{2.4\times10^5\text{ km/h}}$$

(b) Strategy The circumference of the earth is approximately 40,000 km. The time it takes to march around the Earth is found by dividing the distance by the speed.

Solution Find the time of travel.

$$40{,}000\text{ km}\times\frac{1\text{ h}}{2.4\times10^5\text{ km}}\times\frac{60\text{ min}}{1\text{ h}}=\boxed{10\text{ min}}$$

86. Strategy Use the conversion factors from the inside cover of the book.

Solution

(a) $$\frac{12.5\text{ US gal}}{1}\times\frac{3.785\text{ L}}{\text{US gal}}\times\frac{10^3\text{ mL}}{\text{L}}\times\frac{0.06102\text{ in}^3}{\text{mL}}=\boxed{2890\text{ in}^3}$$

(b) $$\frac{2887\text{ in}^3}{1}\times\left(\frac{1\text{ cubit}}{18\text{ in}}\right)^3=\boxed{0.495\text{ cubic cubits}}$$

87. Strategy The weight is proportional to the mass and inversely proportional to the square of the radius, so $W \propto m/r^2$. Thus, for Earth and Jupiter, we have $W_E \propto m_E/r_E^2$ and $W_J \propto m_J/r_J^2$.

Solution Form a proportion.

$$\frac{W_J}{W_E} = \frac{m_J/r_J^2}{m_E/r_E^2} = \frac{m_J}{m_E}\left(\frac{r_E}{r_J}\right)^2 = \frac{320m_E}{m_E}\left(\frac{r_E}{11r_E}\right)^2 = \frac{320}{121}$$

On Jupiter, the apple would weigh $\frac{320}{121}(1.0\text{ N}) = \boxed{2.6\text{ N}}$.

88. Strategy Replace each quantity in $v = K\lambda^p g^q$ by its units. Then, use the relationships between p and q to determine their values.

Solution Find the values of p and q.

In units, $\frac{\text{m}}{\text{s}} = \text{m}^p \cdot \frac{\text{m}^q}{\text{s}^{2q}} = \frac{\text{m}^{p+q}}{\text{s}^{2q}}$.

So, we have the following restrictions on p and q: $p + q = 1$ and $2q = 1$.

Solve for q and p.

$$2q = 1 \qquad q = \boxed{\frac{1}{2}}$$

$$p + q = 1 \qquad p + \frac{1}{2} = 1 \qquad p = \boxed{\frac{1}{2}}$$

Thus, $v = K\lambda^{1/2}g^{1/2} = \boxed{K\sqrt{\lambda g}}$.

89. Strategy Since there are about 3×10^8 people in the U.S., a reasonable estimate of the number of automobiles is 1.5×10^8. There are 365 days per year. A reasonable estimate for the average volume of gasoline used per day per car is greater than 1 gal, but less than 10 gal; for a rough estimate, let's guess 2 gallons per day.

Solution Calculate the estimate.

$$1.5\times10^8 \text{ cars} \times 365 \text{ days} \times 2\,\frac{\text{gal}}{\text{car}\cdot\text{day}} \approx \boxed{10^{11}\text{ gal}}$$

90. Strategy The order of magnitude of the volume of water required to fill a bathtub is 10^1 ft^3. The order of magnitude of the number of cups in a cubic foot is 10^2.

Solution Find the order of magnitude of the number of cups of water required to fill a bathtub.

$$10^1\text{ ft}^3 \times 10^2\text{ cups/ft}^3 = \boxed{10^3\text{ cups}}$$

91. (a) Strategy Inspect the units of G, c, and h and use trial-and-error to find the correct combination of these constants.

Solution Through a process of trial and error, we find that the only combination of G, c, and h that has the dimensions of time is $\boxed{\sqrt{\frac{hG}{c^5}}}$.

(b) Strategy Substitute the values of the constants into the formula found in part (a).

Solution Find the time in seconds.

$$\sqrt{\frac{hG}{c^5}} == \sqrt{\frac{\left(6.6\times10^{-34}\ \frac{\text{kg}\cdot\text{m}^2}{\text{s}}\right)\left(6.7\times10^{-11}\ \frac{\text{m}^3}{\text{kg}\cdot\text{s}^2}\right)}{\left(3.0\times10^{8}\ \frac{\text{m}}{\text{s}}\right)^5}} = \boxed{1.3\times10^{-43}\ \text{s}}$$

92. Strategy The dimensions of L, g, and m are length, length per time squared, and mass, respectively. The period has units of time, so T cannot depend upon m. (There are no other quantities with units of mass with which to cancel the units of m.) Use a combination of L and g.

Solution The square root of L/g has dimensions of time, so

$\boxed{T = C\sqrt{\frac{L}{g}},\ \text{where } C \text{ is a constant of proportionality}}$.

93. Strategy The dimensions of k and m are mass per time squared and mass, respectively. Dividing either quantity by the other will eliminate the mass dimension.

Solution The square root of k/m has dimensions of inverse time, which is correct for frequency.

So, $f = \sqrt{k/m}$. Find k.

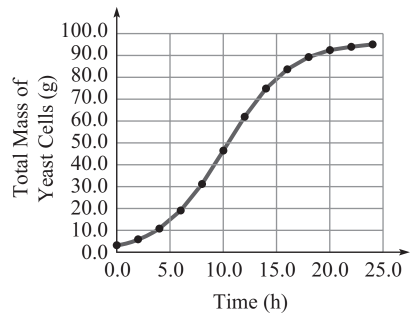
$$f_1 = \sqrt{\frac{k}{m_1}},\ \text{so } f_1^2 = \frac{k}{m_1},\ \text{or } k = m_1 f_1^2.$$

Find the frequency of the chair with the 75-kg astronaut.

$$f_2 = \sqrt{\frac{k}{m_2}} = \sqrt{\frac{m_1 f_1^2}{m_2}} = f_1\sqrt{\frac{m_1}{m_2}} = (0.50\ \text{s}^{-1})\sqrt{\frac{62\ \text{kg} + 10.0\ \text{kg}}{75\ \text{kg} + 10.0\ \text{kg}}} = \boxed{0.46\ \text{s}^{-1}}$$

94. (a) Strategy Plot the data on a graph with mass on the vertical axis and time on the horizontal axis. Then, draw a best-fit smooth curve.

Solution See the graph.



(b) Strategy Answers will vary. Estimate the value of the total mass that the graph appears to be approaching asymptotically.

Solution The graph appears to be approaching asymptotically a maximum value of 100 g, so the carrying capacity is $\boxed{\text{about 100 g}}$.

(c) Strategy Plot the data on a graph with the natural logarithm of m/m_0 on the vertical axis and time on the horizontal axis. Draw a line through the points and find its slope to estimate the intrinsic growth rate.

Solution See the graph. From the plot of $\ln \frac{m}{m_0}$ vs. t, the slope r appears to be

$$r = \frac{1.8 - 0.0}{6.0\text{ s} - 0.0\text{ s}} = \frac{1.8}{6.0\text{ s}} = \boxed{0.30\text{ s}^{-1}}.$$