

## CHAPTER 1

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### MEASUREMENT AND PROBLEM SOLVING

Remind students that their answers to odd-numbered exercises may be slightly different from those given here because of rounding. Refer to Problem-Solving Hint: The "Correct" Answer in Chapter 1.

#### **Multiple Choice:**

1. (c).
2. (b).
3. (c).
4. (b). The gram is the mass of one  $\text{cm}^3$  of water, so the kilogram (1000 g) and tonne (1000 kg) are all related to a volume of water. Only the pound is not related to a volume of water.
5. (b).
6. (b).
7. (a).
8. (d). A quart is slightly less than a liter, 2000  $\mu\text{L}$  is 2 mL, and 2000 mL is 2 L, so 2000 mL has the greatest volume.
9. (c). Micro- is  $10^{-6}$ , centi- is  $10^{-2}$ , nano- is  $10^{-9}$ , and milli- is  $10^{-3}$ , so nano- is the smallest.
10. (d).
11. (d).
12. (c).
13. (a). The kg is a unit of mass and the lb is a unit of force. At the surface of the Earth, 1 kg is *equivalent* to 2.2 lb, which means that a 1-kg object weighs 2.2 lb.

14. (c). Because the  $\mu\text{L}$  is the smallest volume of those listed, you will need more of them to make up any given volume, and hence a *larger number* of  $\mu\text{L}$ .
15. (a).
16. (c).
17. (b).
18. (a).
19. (c).
20. (d).

### **Conceptual Questions:**

1. Because there are no more fundamental units. The units of all quantities can be expressed in terms of the fundamental, or base, units.
2. Weight depends on the force of gravity, which can vary with location.
3. The mean solar day replaced the original definition. No, because this has been replaced by atomic clocks.
4. One major difference is the decimal versus duodecimal basis. Another difference is that SI basic units are meters, kilograms and seconds, whereas the British system uses feet, pounds and seconds.
5. No, because 3 cm is over an inch. Ladybugs are on the order of several mm long. Yes, a 10-kg salmon would weigh on the order of 22 pounds, which is typical for a medium sized fish like that.
6. This is by definition  $1\text{ L} = 1000\text{ mL}$  and  $1\text{ L} = 1000\text{ cm}^3$ .
7. The metric ton is actually a misnomer since it is not a weight unit but a mass unit, defined as the mass of 1 cubic meter of water. But  $1\text{ m}^3 = 1000\text{ L}$  and 1 L of water has a mass of 1 kg. So one metric ton is equal to 1000 kg.
8. No, it only tells if the equation is dimensionally correct. You could be missing (or have extra) dimensionless numbers such as  $\frac{1}{2}$  or  $\pi$ .

9. No, unit analysis can only tell if it is dimensionally correct. Dimensionless factors such as  $\pi$  may be missing.
10. By putting in units and solving for those of the unknown quantity.
11.  $\pi$  is dimensionless and therefore also unitless because it is defined as the ratio of two lengths, the circumference to the diameter of a circle.
12. No, they are not the same. An equivalent statement is not dimensionally correct.
13. Yes, whether you multiply or divide should be consistent with unit analysis for the final answer.
14. Give him 2.54 cm and he'll take 1.61 km, since  $2.54 \text{ cm} = 1.00 \text{ in.}$  and  $1.61 \text{ km} = 1.00 \text{ mi.}$
15. To provide an estimate of the accuracy of a quantity.
16. No, there is always one doubtful digit, the last digit.
17. For (a) and (b), the result should have the least number of significant figures. For (c) and (d), the result should have the least number of decimal places.
18. Because 5 is midway between the upper and lower extremes of 9 and 1.
19. See the six steps as listed in Chapter 1.
20. No, since an order of magnitude calculation is only an estimate.
21. The accuracy of the answer is expected to be within a factor of 10 of the correct answer.
22. Approximate the area of skin-covered body parts using familiar geometric shapes. For example, use a sphere for the head and cylinders for the arms, legs, and torso.
23. Since a liter is close to a quart and there are four quarts in a gallon, this volume is about 75 gallons which is *not* reasonable for a car (but might be for a large truck or other large vehicle such as an RV).
24. No, since  $30 \text{ km/h} \approx 19 \text{ mi/h} < 25 \text{ mi/h.}$

**Exercises:**

- The decimal system (base 10) has a dime worth 10¢ and a dollar worth 10 dimes, or 100¢. By analogy, a duodecimal system would have a dime worth 12¢ and a dollar worth 12 “dimes,” or \$1.44 in decimal dollars. Then a penny would be  $\frac{1}{144}$  of a dollar.
- Different ounces are used for volume and weight measurements. 16 oz = 1 pt is a volume measure and 16 oz = 1 lb is a weight measure.
  - Two different pound units are used. Avoirdupois lb = 16 oz, troy lb = 12 oz.
- $40,000,000 \text{ bytes} \times \left( \frac{1 \text{ MB}}{10^6 \text{ bytes}} \right) = \boxed{40 \text{ MB}}$
  - $0.5722 \text{ mL} \times \left( \frac{1 \text{ L}}{1000 \text{ mL}} \right) = \boxed{5.722 \times 10^{-4} \text{ L}}$
  - $2.684 \text{ m} \times \left( \frac{100 \text{ cm}}{1 \text{ m}} \right) = \boxed{268.4 \text{ cm}}$
  - $5,500 \text{ bucks} \times \left( \frac{1 \text{ kilobuck}}{1000 \text{ bucks}} \right) = \boxed{5.5 \text{ kilobucks}}$
- That is because  $\boxed{1 \text{ nautical mile} = 6076 \text{ ft}} = 1.15 \text{ mi}$ . A nautical mile is larger than a (statute) mile.
- $(25 \text{ cm})(35 \text{ cm})(55 \text{ cm}) \times \left( \frac{1 \text{ g water}}{1 \text{ cm}^3 \text{ water}} \right) = 48,100 \text{ g} = \boxed{48 \text{ kg}}$
- Let  $x$  be the length of each side of the cube.  

$$x^3 = (1 \text{ qt}) \times \left( \frac{3.788 \text{ L}}{4 \text{ qt}} \right) \left( \frac{1000 \text{ cm}^3}{1 \text{ L}} \right) = 947 \text{ cm}^3$$

$$x = (947 \text{ cm})^{1/3} = \boxed{9.82 \text{ cm}}$$
- $(20 \text{ cm})^3 (1 \text{ L}/1000 \text{ cm}^3) = \boxed{8.0 \text{ L}}$
  - $m = \rho V = (1000 \text{ kg/m}^3)(8.0 \text{ L}) \left( \frac{1 \text{ m}^3}{1000 \text{ L}} \right) = \boxed{8.0 \text{ kg}}$

8.  $(\text{Length}) = (\text{Length}) + \frac{(\text{Length})}{(\text{Time})} \times (\text{Time}) = (\text{Length}) + (\text{Length})$ .
9. (d).
10.  $\text{m}^2 = (\text{m})^2 = \text{m}^2$ .
11. Since  $ax^2$  is in meters,  $a = \frac{\text{m}}{\text{m}^2} = \boxed{1/\text{m}}$ .
- Since  $bx$  is in meters,  $b = \frac{\text{m}}{\text{m}} = \boxed{\text{dimensionless}}$ .  $c$  is in  $\boxed{\text{m}}$ .
12.  $\boxed{\text{Yes}}$ , since  $[\text{m}^3] = [\text{m}]^3 = [\text{m}^3]$ .
13.  $\boxed{\text{No}}$ .  $V = 4\pi r^3/3 = 4\pi(8r^3)/24 = 4\pi(2r)^3/24 = \pi d^3/6$ . So it should be  $\boxed{V = \pi d^3/6}$ .
14. Since  $p = \rho v^2$ , the unit of pressure is  $(\text{kg}/\text{m}^3)(\text{m}/\text{s})^2 = \text{kg}/(\text{m} \cdot \text{s}^2)$ .
- $\boxed{\text{No}}$ , this does not prove that this relationship is physically correct, because there might be a coefficient in the equation.
15.  $\boxed{\text{Yes}}$ , because  $\text{m}^2 = \frac{1}{2} \text{m}(\text{m} + \text{m}) = \text{m}^2 + \text{m}^2$ .
16. (a) Since  $F = ma$ , newton  $= (\text{kg})(\text{m}/\text{s}^2) = \boxed{\text{kg} \cdot \text{m}/\text{s}^2}$ .
- (b)  $\boxed{\text{Yes}}$ , because  $(\text{kg}) \times \frac{\text{m}^2/\text{s}^2}{\text{m}} = \text{kg} \cdot \text{m}/\text{s}^2$  ( $F = mv^2/r$ ).
17. (a) The unit of angular momentum is  $(\text{kg})(\text{m}/\text{s})(\text{m}) = \boxed{\text{kg} \cdot \text{m}^2/\text{s}}$ .
- (b) The unit of  $\frac{L^2}{2mr^2}$  is  $\frac{(\text{kg} \cdot \text{m}^2/\text{s})^2}{\text{kg} \cdot \text{m}^2} = \frac{\text{kg} \cdot \text{m}^2}{\text{s}^2}$ , which is the unit of kinetic energy,  $K$ .
- (c) The unit of moment of inertia is  $(\text{kg})(\text{m})^2 = \boxed{\text{kg} \cdot \text{m}^2}$ .
18. (a) Since  $E = mc^2$ , the units of energy  $= (\text{kg})(\text{m}/\text{s})^2 = \boxed{\text{kg} \cdot \text{m}^2/\text{s}^2}$ .
- (b)  $\boxed{\text{Yes}}$ , because  $(\text{kg})(\text{m}/\text{s}^2)(\text{m}) = \text{kg} \cdot \text{m}^2/\text{s}^2$  ( $E = mgh$ ).

19.  $130 \text{ ft} = (130 \text{ ft}) \times \frac{1 \text{ m}}{3.28 \text{ ft}} = \boxed{39.6 \text{ m}}.$

20. (a) The answer is  $\boxed{(4) \text{ centimeter}}$ , as it is the smallest unit among those listed.

(b) Since  $1 \text{ ft} = 30.5 \text{ cm}$ ,  $6.00 \text{ ft} = (6.00 \text{ ft}) \times \frac{30.5 \text{ cm}}{1 \text{ ft}} = \boxed{183 \text{ cm}}.$

21.  $40\,000 \text{ mi} = (40\,000 \text{ mi}) \times \frac{1609 \text{ m}}{1 \text{ mi}} = 64\,400\,000 \text{ m}.$

So  $\frac{64\,400\,000 \text{ m}}{1.75 \text{ m}} = \boxed{37\,000\,000 \text{ times}}.$

22. (a) Since  $1 \text{ gal} = 3.785 \text{ L} < 4 \text{ L}$ , or  $\frac{1}{2} \text{ gal} < 2 \text{ L}$ ,  $\frac{1}{2} \text{ gal}$  holds  $\boxed{(3) \text{ less}}$  soda.

(b)  $0.5 \text{ gal} = (0.5 \text{ gal}) \times \frac{3.785 \text{ L}}{1 \text{ gal}} = 1.89 \text{ L}.$   $2 \text{ L} - 1.89 \text{ L} = 0.11 \text{ L}.$  So  $\boxed{2 \text{ L by } 0.11 \text{ L more}}.$

23. (a)  $300 \text{ ft} = (300 \text{ ft}) \times \frac{1 \text{ m}}{3.28 \text{ ft}} = 91.5 \text{ m}.$   $160 \text{ ft} = (160 \text{ ft}) \times \frac{1 \text{ m}}{3.28 \text{ ft}} = 48.8 \text{ m}.$

So the dimensions are  $\boxed{91.5 \text{ m by } 48.8 \text{ m}}.$

(b)  $11 \text{ in.} = (11.0 \text{ in.}) \times \frac{2.54 \text{ cm}}{1 \text{ in.}} = 27.9 \text{ cm}.$   $11.25 \text{ in.} = (11.25 \text{ in.}) \times \frac{2.54 \text{ cm}}{1 \text{ in.}} = 28.6 \text{ cm}.$

So the length is  $\boxed{27.9 \text{ cm to } 28.6 \text{ cm}}.$

24. From Exercise 1.23, the  $\boxed{\text{metric}}$  field is larger.

$A_{\text{current}} = (91.4 \text{ m})(48.8 \text{ m}) = 4.46 \times 10^3 \text{ m}^2.$   $A_{\text{metric}} = (100 \text{ m})(54 \text{ m}) = 5.4 \times 10^3 \text{ m}^2.$

So the difference is  $5.4 \times 10^3 \text{ m}^2 - 4.46 \times 10^3 \text{ m}^2 = \boxed{9.4 \times 10^2 \text{ m}^2}.$

25.  $(1 \text{ pt}) \times \left( \frac{1 \text{ qt}}{2 \text{ pts}} \right) \left( \frac{3.788 \text{ L}}{4 \text{ qt}} \right) \left( \frac{1000 \text{ cm}^3}{1 \text{ L}} \right) \left( \frac{1 \text{ g}}{1 \text{ cm}^3} \right) = \boxed{474 \text{ g}}$

26.  $(10 \text{ L}) \times \left( \frac{1 \text{ gal}}{3.788 \text{ L}} \right) \left( \frac{4 \text{ qt}}{1 \text{ gal}} \right) = \boxed{10.6 \text{ qt}}$

27.  $(175 \text{ fathoms}) \times \left( \frac{2 \text{ yd}}{1 \text{ fathom}} \right) \left( \frac{3 \text{ ft}}{1 \text{ yd}} \right) \left( \frac{1 \text{ m}}{3.281 \text{ ft}} \right) = \boxed{320 \text{ m}}$

28.  $763 \text{ mi/h} = (763 \text{ mi/h}) \times \frac{1609 \text{ m}}{1 \text{ mi}} \times \frac{1 \text{ h}}{3600 \text{ s}} = \boxed{341 \text{ m/s}}.$

(b)  $300 \text{ ft} = (300 \text{ ft}) \times \frac{1 \text{ m}}{3.28 \text{ ft}} = 91.46 \text{ m}.$

So the time is  $\frac{91.46 \text{ m}}{341 \text{ m/s}} = \boxed{0.268 \text{ s}}.$

29. (a)  $1 \text{ km/h} = (1 \text{ km/h}) \times \frac{1000 \text{ m}}{1 \text{ km}} \times \frac{1 \text{ h}}{3600 \text{ s}} = 0.8 \text{ m/s} < 1 \text{ m/s}.$

$1 \text{ ft/s} = (1 \text{ ft/s}) \times \frac{1 \text{ m}}{3.28 \text{ ft}} = 0.30 \text{ m/s} < 1 \text{ m/s}.$

$1 \text{ mi/h} = (1 \text{ mi/h}) \times \frac{1609 \text{ m}}{1 \text{ mi}} \times \frac{1 \text{ h}}{3600 \text{ s}} = 0.45 \text{ m/s} < 1 \text{ m/s}.$

So  $\boxed{(1) 1 \text{ m/s}}$  represents the greatest speed.

(b)  $15.0 \text{ m/s} = (15.0 \text{ m/s}) \times \frac{1 \text{ mi}}{1609 \text{ m}} \times \frac{3600 \text{ s}}{1 \text{ h}} = \boxed{33.6 \text{ mi/h}}.$

30. (a)  $10 \text{ mi/h} = (10 \text{ mi/h}) \times \frac{1.609 \text{ km}}{1 \text{ mi}} = \boxed{16 \text{ km/h for each } 10 \text{ mi/h}}.$

(b)  $70 \text{ mi/h} = (70 \text{ mi/h}) \times \frac{1.609 \text{ km}}{1 \text{ mi}} = \boxed{1.1 \times 10^2 \text{ km/h}}.$

31. (a)  $1 \text{ kg} = 2.2 \text{ lb}$  (equivalent). So  $170 \text{ lb} = (170 \text{ lb}) \times \frac{1 \text{ kg}}{2.2 \text{ lb}} = \boxed{77.3 \text{ kg}}.$

(b) The density of water is  $1000 \text{ kg/m}^3$ .

$\rho = \frac{m}{V}, \quad \Rightarrow \quad V = \frac{m}{\rho} = \frac{77.3 \text{ kg}}{1000 \text{ kg/m}^3} = \boxed{0.0773 \text{ m}^3 \text{ or about } 77.3 \text{ L}}.$

Using liter avoids the small decimals.

32. The circumference of the Moon of diameter  $3500 \text{ km}$ , is  $\pi d = \pi(3500 \text{ km}) = 1.1 \times 10^4 \text{ km}.$

So the answer is  $\boxed{\text{yes}}.$   $\frac{1.0 \times 10^5 \text{ km}}{1.1 \times 10^4 \text{ km}} = \boxed{9.1 \text{ times}}.$

33. In one day, there are  $24 \times 60 \text{ min} = 1440 \text{ min}.$  So the volume of blood pumped per day is

$(60 \text{ beats/min})(1440 \text{ min/day})(75 \text{ mL/beat}) = 6.5 \times 10^6 \text{ mL/day} = \boxed{6.5 \times 10^3 \text{ L/day}}.$

34. (a)  $2 \text{ fl. oz} = (2 \text{ fl. oz}) \times \frac{473 \text{ mL}}{16 \text{ fl. oz}} = \boxed{59.1 \text{ mL}}.$

(b)  $100 \text{ g} = (100 \text{ g}) \times \frac{14.5 \text{ oz}}{411 \text{ g}} = \boxed{3.53 \text{ oz}}.$

35.  $(250 \text{ mL/min})(4.5 \times 10^6 / \text{mm}^3) \times \frac{1 \text{ min}}{60 \text{ s}} \times \frac{1 \text{ L}}{10^{-3} \text{ mL}} \times \frac{10^6 \text{ mm}^3}{1 \text{ L}} = \boxed{1.9 \times 10^{10} / \text{s}}.$

36.  $18 \text{ in.} = (18 \text{ in.}) \times \frac{2.54 \text{ cm}}{1 \text{ in.}} = 45.7 \text{ cm.}$   $5 \text{ ft, } 6 \text{ in.} = 66 \text{ in.} = (66 \text{ in.}) \times \frac{2.54 \text{ cm}}{1 \text{ in.}} = 167.6 \text{ cm.}$

So the growth per year is  $\frac{167.6 \text{ cm} - 45.7 \text{ cm}}{20} = \boxed{6.1 \text{ cm}}.$

37. The Earth rotates  $360^\circ$  in 24 hr ( $= 24 \times 60 \text{ min} = 1440 \text{ min}$ ), so in one minute it will rotate  $1/1440$  of  $360^\circ$ , which is  $0.250^\circ = \boxed{15.0 \text{ min of arc}}.$

38. (a)  $13.6 \text{ g/cm}^3 = (13.6 \text{ g/cm}^3) \times \frac{1 \text{ kg}}{1000 \text{ g}} \times \left(\frac{100 \text{ cm}}{1 \text{ m}}\right)^3 = \boxed{1.36 \times 10^4 \text{ kg/m}^3}.$

(b)  $\rho = \frac{m}{V}, \quad m = \rho V = (13.6 \text{ g/cm}^3)(0.250 \text{ L}) \times \frac{1000 \text{ cm}^3}{1 \text{ L}} = 3.40 \times 10^3 \text{ g} = \boxed{3.40 \text{ kg}}.$

39. (a) The volume is equal to  $V = Ah = \pi r^2 h = \pi (125 \text{ m})^2 (10 \text{ ft})(0.305 \text{ m/ft}) = \boxed{1.5 \times 10^5 \text{ m}^3}.$

(b) The water density of is  $1000 \text{ kg/m}^3$ .

$\rho = \frac{m}{V}, \quad m = \rho V = (1000 \text{ kg/m}^3)(1.5 \times 10^5 \text{ m}^3) = \boxed{1.5 \times 10^8 \text{ kg}}.$

(c) One kg is equivalent to 2.2 lb.  $1.5 \times 10^8 \text{ kg} = (1.5 \times 10^8 \text{ kg}) \times \frac{2.2 \text{ lb}}{1 \text{ kg}} = \boxed{3.3 \times 10^8 \text{ lb}}.$

40.  $L = 300 \text{ cubits} = (300 \text{ cubits}) \times \frac{0.5 \text{ yd}}{1 \text{ cubit}} \times \frac{3 \text{ ft}}{1 \text{ yd}} \times \frac{1 \text{ m}}{3.28 \text{ ft}} = 137 \text{ m.}$

$W = 50.0 \text{ cubits} = 22.9 \text{ m,} \quad H = 30.0 \text{ cubits} = 13.7 \text{ m.}$

So the dimensions are  $\boxed{137 \text{ m} \times 22.9 \text{ m} \times 13.7 \text{ m}}.$

(b)  $V = LWH = (137 \text{ m})(22.9 \text{ m})(13.7 \text{ m}) = \boxed{4.30 \times 10^4 \text{ m}^3}.$

41.  $50\,500 \mu\text{m} = (50\,500 \mu\text{m}) \times \frac{1 \text{ cm}}{10\,000 \mu\text{m}} = \boxed{5.05 \text{ cm}} = \boxed{5.05 \times 10^{-1} \text{ dm}} = \boxed{5.05 \times 10^{-2} \text{ m}}.$



42.  $\boxed{0.001 \text{ m or } 1 \text{ mm}}$ .

43. (a)  $\boxed{4}$ . (b)  $\boxed{3}$ . (c)  $\boxed{5}$ . (d)  $\boxed{2}$ .

44. (a)  $\boxed{1.0 \text{ m}}$ . (b)  $\boxed{8.0 \text{ cm}}$ . (c)  $\boxed{16 \text{ kg}}$ . (d)  $\boxed{1.5 \times 10^{-2} \mu\text{s}}$ .

45. (a)  $\boxed{96}$  (b)  $\boxed{0.0021}$  (c)  $\boxed{9400}$  (d)  $\boxed{0.00034}$

46.  $\boxed{\text{(b) and (d)}}$ ;  $\boxed{\text{(a) has four and (c) has six}}$ .

47.  $A = LW = (0.274 \text{ m})(0.222 \text{ m}) = \boxed{6.08 \times 10^{-2} \text{ m}^2}$ .

48.  $V = LWH = (1.3 \text{ m})(3.281 \text{ ft/m})(1.05 \text{ m})(3.281 \text{ ft/m})(0.67 \text{ m})(3.281 \text{ ft/m}) = \boxed{32 \text{ ft}^3}$ .

49. (a) The smallest division is  $\boxed{(2) \text{ cm}}$ , as the last digit is estimated.

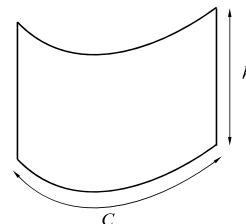
(b)  $A = LW = (1.245 \text{ m})(0.760 \text{ m}) = \boxed{0.946 \text{ m}^2}$ .

50. (a)  $\boxed{(2) \text{ Three}}$ , since the height has only three significant figures.

(b) The area is the sum of that of the top, the bottom, and the side. The side of the can is a rectangle with a length equal to the circumference and width equal to the height of the can.

$$A = \frac{\pi d^2}{4} + \frac{\pi d^2}{4} + Ch = \frac{\pi d^2}{4} + \frac{\pi d^2}{4} + (\pi d)h$$

$$= \frac{\pi (12.559 \text{ cm})^2}{4} + \frac{\pi (12.559 \text{ cm})^2}{4} + \pi (12.559 \text{ cm})(5.62 \text{ cm}) = \boxed{469 \text{ cm}^2}.$$



51. (a)  $12.634 + 2.1 = \boxed{14.7}$ . (b)  $13.5 - 2.134 = \boxed{11.4}$ .

(c)  $\pi (0.25 \text{ m})^2 = \boxed{0.20 \text{ m}^2}$ . (d)  $\sqrt{2.37/3.5} = \boxed{0.82}$ .

52. (a) The answer is  $\boxed{(1) \text{ zero}}$ , since 38 m has zero decimal places.

(b)  $46.9 \text{ m} + 5.72 \text{ m} - 38 \text{ m} = \boxed{15 \text{ m}}$ .

53. (a)  $v = \frac{x}{t} = \frac{8.5 \text{ m}}{2.7 \text{ s}} = 3.1 \text{ m/s}$ ,  $p = mv = (0.66 \text{ kg})(3.1 \text{ m/s}) = \boxed{2.0 \text{ kg}\cdot\text{m/s}}$ .

(b)  $p = \frac{mx}{t} = \frac{(0.66 \text{ kg})(8.5 \text{ m})}{2.7 \text{ s}} = \boxed{2.1 \text{ kg}\cdot\text{m/s}}$ .

(c) **No**, the results are not the same. The difference comes from **rounding difference**.

54. According to the Pythagorean theorem,

$$c = \sqrt{a^2 + b^2} = \sqrt{(37 \text{ m})^2 + (42.3 \text{ m})^2} = \boxed{56 \text{ m}}.$$

55. Since  $1 \text{ m} = 100 \text{ cm}$ ,  $(1 \text{ m})^3 = (100 \text{ cm})^3$  or  $1 \text{ m}^3 = 10^6 \text{ cm}^3$ .

$$\rho = \frac{m}{V}, \quad m = \rho V = (0.10 \text{ g/cm}^3)(1 \text{ m}^3) \times \frac{10^6 \text{ cm}^3}{1 \text{ m}^3} = 1.0 \times 10^5 \text{ g} = \boxed{100 \text{ kg}}.$$

56.  $(3.0 \text{ m}^3) \times \left( \frac{3.281 \text{ ft}}{1 \text{ m}} \right) \left( \frac{1 \text{ cord}}{8.0 \text{ ft} \times 4.0 \text{ ft} \times 4.0 \text{ ft}} \right) = \boxed{0.83 \text{ cord}}$

57. (a) The percentage is  $\frac{(18 \text{ g})(9 \text{ cal/g})}{310 \text{ cal}} = 0.52 = \boxed{52\%}$ .

(b) Total fat =  $\frac{18 \text{ g}}{0.28} = \boxed{64 \text{ g}}$ ; saturated fat =  $\frac{7 \text{ g}}{0.35} = \boxed{20 \text{ g}}$ .

58. (a) One sheet has two pages. 860 pages have 430 sheets.

The average thickness per sheet is  $\frac{3.75 \text{ cm}}{430 \text{ sheets}} = \boxed{8.72 \times 10^{-3} \text{ cm}}$ .

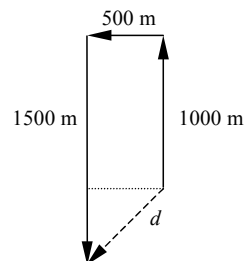
(b)  $\frac{1 \text{ cm}}{100 \text{ sheets}} = \boxed{\text{about } 10^{-2} \text{ cm}}$ .

59.  $\rho = \frac{m}{V} = \frac{m}{\frac{4}{3}\pi R_E^3} = \frac{5.98 \times 10^{24} \text{ kg}}{\frac{4}{3}\pi (6.4 \times 10^6 \text{ m})^3} = \boxed{5.4 \times 10^3 \text{ kg/m}^3}$

60. (a) From the sketch, it is clear that the stadium is **(4) south of west**, relative to your house.

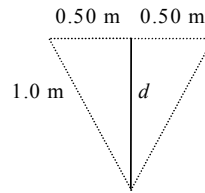
(b) Consider the right triangle on the bottom of the sketch. The two sides perpendicular to each other are 500 m each.

Using Pythagorean theorem,  $d = \sqrt{(500 \text{ m})^2 + (500 \text{ m})^2} = \boxed{707 \text{ m}}$ .



61. According to the Pythagorean theorem,  $(1.0 \text{ m})^2 = (0.50 \text{ m})^2 + d^2$ .

So  $d = \sqrt{(1.0 \text{ m})^2 - (0.50 \text{ m})^2} = \boxed{0.87 \text{ m}}$ .



62. The **12-in.** pizza is a better buy. A better buy gives you more *area* (more pepperoni) per dollar, and the area of a pizza depends on the square of the diameter.

For the 9.0 in.:  $\frac{\pi(4.5 \text{ in.})^2}{\$7.95} = \boxed{8.0 \text{ in.}^2/\text{dollar}}$ . For the 12 in.:  $\frac{\pi(6.0 \text{ in.})^2}{\$13.50} = \boxed{8.4 \text{ in.}^2/\text{dollar}}$ .

63. The area of a 12-in. pizza is  $\pi R^2 = \pi(6.0 \text{ in.})^2 = 113 \text{ in.}^2$ . The area of two 8-in. pizzas is  $2(\pi R^2) = 2\pi(4.0 \text{ in.})^2 = 101 \text{ in.}^2$ . **This is not such a good deal!**

64. For the center circle:  $A = \pi r^2 = \pi(0.640 \text{ cm})^2 = 1.3 \text{ cm}^2$ .

For the outer ring:  $A = \pi(r_2^2 - r_1^2) = \pi[(1.78 \text{ cm})^2 - (1.66 \text{ cm})^2] = 1.3 \text{ cm}^2$ .

So it is the **same area for both**, **1.3 cm<sup>2</sup>** if calculated to two significant figures.

65.  $t = \frac{x}{v} = \frac{31 \text{ mi}}{75 \text{ mi/h}} = 0.41 \text{ h} = \boxed{25 \text{ min}}$ .

66. One liter has  $1000 \text{ cm}^3$ , and each  $\text{cm}^3$  has  $1000 \text{ mm}^3$ , so 1 liter has  $1.0 \times 10^6 \text{ mm}^3$ .

$(1 \text{ cm}^3) = (10 \text{ mm})^3 = 1000 \text{ mm}^3$

The total number of white cells in 5.0 L of blood is

$(7\,000/\text{mm}^3)(5 \times 10^6 \text{ mm}^3) = \boxed{3.5 \times 10^{10} \text{ white cells}}$ .

The total number of platelets in 5.0 L of blood is

$(250\,000/\text{mm}^3)(5 \times 10^6 \text{ mm}^3) = \boxed{1.3 \times 10^{12} \text{ platelets}}$ .

67. (a) The number of hairs lost in a month is  $(65 \text{ hairs/day})(30 \text{ days}) = \boxed{1950 \text{ hairs}}$ .

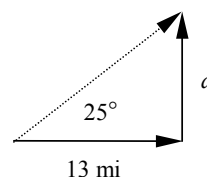
(b) 15% bald means 85% with hair. So in one day, the “bald is beautiful” person loses

$(0.85)(65 \text{ hairs}) = 55 \text{ hairs}$ .

In one year, the total is  $(365)(55 \text{ hairs}) = \boxed{2.0 \times 10^4 \text{ hairs}}$ .

68. (a) Since  $d = (13 \text{ mi}) \tan 25^\circ$  and  $\tan 25^\circ < 1$  ( $\tan 45^\circ = 1$ ),  
 $d$  is **(1) less than** 13 mi.

(b)  $d = (13 \text{ mi}) \tan 25^\circ = \boxed{6.1 \text{ mi}}$ .



69. (a) It will be **(3) less than the 190 mi/h**. More time spent at lower speeds, so affect average speed to be below average of all speeds.

(b) The time intervals for each lap is, respectively,

Lap 1:  $t_1 = \frac{2.5 \text{ mi}}{160 \text{ mi/h}} = 0.015625 \text{ h}$ ;      Lap 2:  $t_2 = \frac{2.5 \text{ mi}}{180 \text{ mi/h}} = 0.013889 \text{ h}$ ;

Lap 3:  $t_3 = \frac{2.5 \text{ mi}}{200 \text{ mi/h}} = 0.012500 \text{ h}$ ;      Lap 4:  $t_4 = \frac{2.5 \text{ mi}}{220 \text{ mi/h}} = 0.011364 \text{ h}$ .

So the total time is  $t_{\text{total}} = t_1 + t_2 + t_3 + t_4 = 0.053378 \text{ h}$ .

Therefore the average speed for four laps is  $\frac{4(2.5 \text{ mi})}{0.053378 \text{ h}} = \boxed{187 \text{ mi/h}}$ .

70.  $118 \text{ mi} = (118 \text{ mi}) \times \frac{1609 \text{ m}}{1 \text{ mi}} = 10^5 \text{ m}$ ,       $307 \text{ mi} = (307 \text{ mi}) \times \frac{1609 \text{ m}}{1 \text{ mi}} = 10^5 \text{ m}$ ,

$279 \text{ ft} = (279 \text{ ft}) \times \frac{1 \text{ m}}{3.28 \text{ ft}} = 10^2 \text{ m}$ .

So  $V = LWD \approx (10^5 \text{ m})(10^5 \text{ m})(10^2 \text{ m}) = \boxed{\text{about } 10^{12} \text{ m}^3}$ .

71. (a) The answer is **(2) between  $5^\circ$  and  $7^\circ$** . The sketch below illustrates why it is the answer.

(b) The elevation for the 2.0 km segment is

$(2.0 \text{ km}) \sin 5^\circ = 0.174 \text{ km}$ .

The horizontal distance for the 2.0 km segment is

$(2.0 \text{ km}) \cos 5^\circ = 1.99 \text{ km}$ .

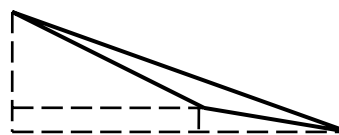
The elevation for the 3.0 km segment is

$(3.0 \text{ km}) \sin 7^\circ = 0.366 \text{ km}$ .

The horizontal distance for the 3.0 km segment is  $(3.0 \text{ km}) \cos 7^\circ = 2.98 \text{ km}$ .

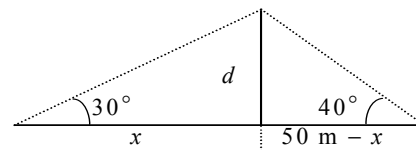
So the tangent of the net angle of rise is  $\tan \theta = \frac{0.174 \text{ km} + 0.366 \text{ km}}{1.99 \text{ km} + 2.98 \text{ km}} = 0.109$ .

Therefore  $\theta = \tan^{-1}(0.109) = \boxed{6.2^\circ}$ .



72.  $d = x \tan 30^\circ = (50 \text{ m} - x) \tan 40^\circ = (50 \text{ m}) \tan 40^\circ - x \tan 40^\circ$ .

$x = \frac{(50 \text{ m}) \tan 40^\circ}{\tan 30^\circ + \tan 40^\circ} = 29.6 \text{ m}$ . So  $d = (29.6 \text{ m}) \tan 30^\circ = \boxed{17 \text{ m}}$ .



73. Expressing the area of the horse pasture,  $A_H$ , in terms of  $h$  gives

$$A_H = (200 \text{ m})h - 2\left(\frac{1}{2}\frac{h}{\sqrt{3}}h\right) = (200 \text{ m})h - \frac{h^2}{\sqrt{3}}$$

The total area of his lot is  $A_{Tot} = 2\left(\frac{1}{2}\frac{200 \text{ m}}{2}(200 \text{ m})\sin 60^\circ\right) = \frac{\sqrt{3}}{4}(200 \text{ m})^2$ . The area for the horse pasture,  $A_H$ , is

1/3 of the total area of the triangular lot, giving

$$(200 \text{ m})h - \frac{h^2}{\sqrt{3}} = \frac{1}{3}\left[\frac{\sqrt{3}}{4}(200 \text{ m})^2\right]$$

Solving for  $h$  gives  $h = 314.6 \text{ m}$  and  $h = 31.78 \text{ m}$ . Since  $h$  cannot be larger than the side of the triangle, we discard the first solution, giving  $h = \boxed{31.8 \text{ m}}$ .

74. (a) The volume of the drilled hole is

$$V = \pi r^2 L = \pi (0.0100 \text{ m})^2 (8.00 \text{ in.})(0.0254 \text{ m/in.}) = 6.38 \times 10^{-5} \text{ m}^3.$$

The density of water is  $1000 \text{ kg/m}^3$ , so the density of lead is  $(11.4)(1000 \text{ kg/m}^3) = 1.14 \times 10^4 \text{ kg/m}^3$ .

$$\rho = \frac{m}{V}, \quad m = \rho V = (1.14 \times 10^4 \text{ kg/m}^3)(6.38 \times 10^{-5} \text{ m}^3) = \boxed{0.727 \text{ kg}}.$$

- (b) The total volume of the brick is

$$(2.00 \text{ in.})(0.0254 \text{ m/in.}) \times (4.00 \text{ in.})(0.0254 \text{ m/in.}) \times (8.00 \text{ in.})(0.0254 \text{ m/in.}) = 1.049 \times 10^{-3} \text{ m}^3.$$

The percentage of the original lead remaining in the brick is  $\frac{1.049 \times 10^{-3} \text{ m}^3 - 6.38 \times 10^{-5} \text{ m}^3}{1.049 \times 10^{-3} \text{ m}^3} = \boxed{93.9\%}$ .

- (c) The mass of the plastic is  $m_p = [(2)(1000 \text{ kg/m}^3)](6.38 \times 10^{-5} \text{ m}^3) = 0.1276 \text{ kg}$ .

The mass of the lead brick with the hole drilled is

$$m_L = (1.14 \times 10^4 \text{ kg/m}^3)(1.049 \times 10^{-3} \text{ m}^3 - 6.38 \times 10^{-5} \text{ m}^3) = 11.23 \text{ kg}.$$

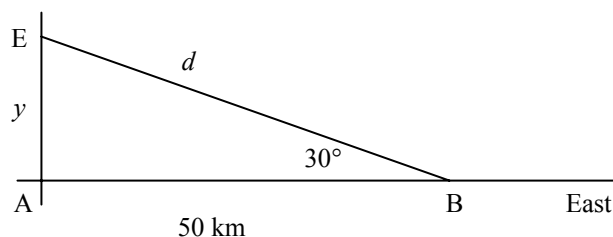
Therefore the overall density is  $\frac{11.23 \text{ kg} + 0.1276 \text{ kg}}{1.049 \times 10^{-3} \text{ m}^3} = \boxed{1.08 \times 10^4 \text{ kg/m}^3}$ .

75. (a) Calling  $r$  the radius of the inner surface and using the fact that  $V_r = 0.900V_{Tot}$ , we have

$$\frac{4}{3}\pi r^3 = (0.900)\frac{4}{3}\pi(20.0 \text{ cm})^3, \text{ which gives } r = \boxed{19.3 \text{ cm}}.$$

- (b)  $\frac{A_{outer}}{A_{inner}} = \frac{4\pi(20.0 \text{ cm})^2}{4\pi(19.3 \text{ cm})^2} = \boxed{1.07}$ , or the outer area is 7% larger than the inner area.

76. (a)



$$\tan 30^\circ = y/50 \text{ km} \quad \rightarrow \quad y = (50 \text{ km}) \tan 30^\circ = \boxed{28.9 \text{ km}}$$

$$(b) \cos 30^\circ = (50 \text{ km})/d \quad \rightarrow \quad d = (50 \text{ km})/\cos 30^\circ = \boxed{57.7 \text{ km}}$$

(c) Calling  $\theta$  the angle subtended by  $y$  from point C, which is 70 km from point A, we have:  $\tan \theta = y/(70 \text{ km})$ , which gives  $\theta = \boxed{22.4^\circ \text{ north of due west}}$ .

77. (a) At constant speed, the distance  $x$  traveled is  $x = vt$ , which gives  $t = x/v$ . Since  $v$  is the same in both cases, taking the ratio of  $t$  for both trips gives

$$\frac{t_{\text{circumf}}}{t_{\text{diam}}} = \frac{\frac{x_{\text{circumf}}}{v}}{\frac{x_{\text{diam}}}{v}} = \frac{x_{\text{circumf}}}{x_{\text{diam}}} = \frac{\pi x_{\text{diam}}}{x_{\text{diam}}} = \pi$$

$$t_{\text{circumf}} = \pi t_{\text{diam}} = \pi(30.0 \text{ s}) = \boxed{94.2 \text{ s}}$$

(b) The diameter of the pool is  $x = vt = (0.500 \text{ m/s})(30.0 \text{ s}) = 15.0 \text{ m}$ , its radius is  $R = 7.50 \text{ m}$  and its depth is  $d = 1.50 \text{ m}$ . The volume is  $V = (\pi R^2)d = \pi(7.50 \text{ m})^2(1.50 \text{ m}) = 265 \text{ m}^3$ . Converting this result to gallons gives

$$(265 \text{ m}^3) \times \left( \frac{1 \text{ L}}{10^{-3} \text{ m}^3} \right) \left( \frac{1 \text{ gal}}{3.788 \text{ L}} \right) = \boxed{7.00 \times 10^4 \text{ gal}}$$

78. (a)  $m = \rho V = (9.0 \text{ g/cm}^3)(1.0 \text{ cm})(2.0 \text{ cm})(4.0 \text{ cm}) = 72 \text{ g} = \boxed{0.072 \text{ kg}}$

(b) Calling  $x$  the length of each side of the cube and using the fact that  $V = m/\rho$  gives

$$x^3 = \frac{m}{\rho} = \frac{144 \text{ g}}{9.0 \text{ g/cm}^3} \quad \rightarrow \quad x = \boxed{2.5 \text{ cm}}$$