1
Introduction

ANSWERS TO WARM-UP EXERCISES

1. (a) The number given, 568 017, has six significant figures, which we will retain in converting the number to scientific notation. Moving the decimal five spaces to the left gives us the answer, $\boxed{5.680\ 17 \times 10^5}$.

(b) The number given, 0.000 309, has three significant figures, which we will retain in converting the number to scientific notation. Moving the decimal four spaces to the right gives us the answer, $\boxed{3.09 \times 10^{-4}}$.

2. We first collect terms, then simplify:

$$\frac{[M][L]^2}{[T]^3}\cdot\frac{[T]}{[L]}[T] = \frac{[M][L]^2[T]^2}{[T]^3[L]} = \boxed{\frac{[M][L]}{[T]}}$$

As we will see in Chapter 6, these are the units for momentum.

3. Examining the expression shows that the units of meters and seconds squared (s^2) appear in both the numerator and the denominator, and therefore cancel out. We combine the numbers and units separately, squaring the last term before doing so:

$$\left(7.00\frac{\text{m}}{\text{s}^2}\right)\left(\frac{1.00\,\text{km}}{1.00\times10^3\text{m}}\right)\left(\frac{60.0\,\text{s}}{1.00\,\text{min}}\right)^2$$

$$= (7.00)\left(\frac{1.00}{1.00\times10^3}\right)\left(\frac{3600}{1.00}\right)\left(\frac{\cancel{\text{m}}}{\cancel{\text{s}^2}}\right)\left(\frac{\text{km}}{\cancel{\text{m}}}\right)\left(\frac{\cancel{\text{s}^2}}{\text{min}^2}\right)$$

$$= \boxed{25.2\frac{\text{km}}{\text{min}^2}}$$

4. The required conversion can be carried out in one step:

$$h = (2.00\ \cancel{\text{m}})\left(\frac{1.00\,\text{cubitus}}{0.445\ \cancel{\text{m}}}\right) = \boxed{4.49\,\text{cubiti}}$$

5 The area of the house in square feet (1 420 ft^2) contains 3 significant figures. Our answer will therefore also contain three significant figures. Also note that the conversion from feet to meters is squared to account for the ft^2 units in which the area is originally given.

$$A = \left(1\ 420\ \text{ft}^2\right)\left(\frac{1.00\ \text{m}}{3.281\ \text{ft}}\right)^2 = 131.909\ \text{m}^2 = \boxed{132\ \text{m}^2}$$

6. Using a calculator to multiply the length by the width gives a raw answer of 6 783 m^2. This answer must be rounded to contain the same number of significant figures as the least accurate factor in the product. The least accurate factor is the length, which contains 2 significant figures, since the trailing zero is not significant (see Section 1.6). The correct answer for the area of the airstrip is $\boxed{6.80 \times 10^3\ \text{m}^2}$.

7. Adding the three numbers with a calculator gives 21.4 + 15 + 17.17 + 4.003 = 57.573. However, this answer must be rounded to contain the same number of significant figures as the least accurate number in the sum, which is 15, with two significant figures. The correct answer is therefore $\boxed{58}$.

8. The given Cartesian coordinates are $x = -5.00$ and $y = 12.00$. The least accurate of these coordinates contains 3 significant figures, so we will express our answer in three significant figures. The specified point, (–5.00, 12.00), is in the second quadrant since $x < 0$ and $y > 0$. To find the polar coordinates $(r,\ \theta)$ of this point, we use

$$r = \sqrt{x^2 + y^2} = \sqrt{(5.00)^2 + (12.00)^2} = 13.0$$

and

$$\theta = \tan^{-1}\left(\frac{y}{x}\right) = \tan^{-1}\left(\frac{12.00}{-5.00}\right) = -67.3°$$

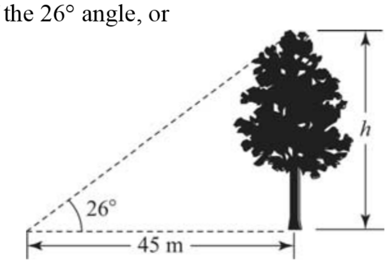
Since the point is in the second quadrant, we add 180° to this angle to obtain $\theta = -67.3° + 180° = 113°$. The polar coordinates of the point are therefore $\boxed{(13.0, 113°)}$.

9. Refer to ANS. FIG 9. The height of the tree is described by the tangent of the 26° angle, or

$$\tan 26° = \frac{h}{45\text{ m}}$$

from which we obtain

$$h = (45\text{ m})\tan 26° = \boxed{22\text{ m}}$$



ANS. FIG 9

ANSWERS TO EVEN NUMBERED CONCEPTUAL QUESTIONS

2. Atomic clocks are based on the electromagnetic waves that atoms emit. Also, pulsars are highly regular astronomical clocks.

4. **(a)** $\sim 0.5\text{ lb} \approx 0.25\text{ kg}$ or $\sim 10^{-1}\text{ kg}$

(b) $\sim 4\text{ lb} \approx 2\text{ kg}$ or $\sim 10^{0}\text{ kg}$

(c) $\sim 4000\text{ lb} \approx 2000\text{ kg}$ or $\sim 10^{3}\text{ kg}$

6. Let us assume the atoms are solid spheres of diameter 10^{-10} m. Then, the volume of each atom is of the order of 10^{-30} m^3. (More precisely, volume $= 4\pi r^3/3 = \pi d^3/6$.) Therefore, since $1\text{ cm}^3 = 10^{-6}\text{ m}^3$, the number of atoms in the 1 cm^3 solid is on the order of $10^{-6}/10^{-30} = 10^{24}$ atoms. A more precise calculation would require knowledge of the density of the solid and the mass of each atom. However, our estimate agrees with the more precise calculation to within a factor of 10.

8. Realistically, the only lengths you might be able to verify are the length of a football field and the length of a housefly. The only time intervals subject to verification would be the length of a day and the time between normal heartbeats.

10. In the metric system, units differ by powers of ten, so it's very easy and accurate to convert from one unit to another.

12. Both answers (d) and (e) could be physically meaningful. Answers (a), (b), and (c) must be meaningless since quantities can be added or subtracted only if they have the same dimensions.

ANSWERS TO EVEN NUMBERED PROBLEMS

2. **(a)** L/T^2 **(b)** L

4. All three equations are dimensionally incorrect.

6. **(a)** $\text{kg}\cdot\text{m/s}$ **(b)** $Ft = p$

8. **(a)** 22.6 **(b)** 22.7 **(c)** 22.6 is more reliable

10. **(a)** 3.00×10^8 m/s **(b)** $2.997\,9\times10^8$ m/s **(c)** $2.997\,925\times10^8$ m/s

12. **(a)** $346\text{ m}^2 \pm 13\text{ m}^2$ **(b)** $66.0\text{ m} \pm 1.3\text{ m}$

14. **(a)** 797 **(b)** 1.1 **(c)** 17.66

16. 3.09 cm/s

18. **(a)** $5.60\times10^2\text{ km} = 5.60\times10^5\text{ m} = 5.60\times10^7\text{ cm}$

(b) $0.491\,2\text{ km} = 491.2\text{ m} = 4.912\times10^4\text{ cm}$

(c) $6.192 \text{ km} = 6.192 \times 10^3 \text{ m} = 6.192 \times 10^5 \text{ cm}$

(d) $2.499 \text{ km} = 2.499 \times 10^3 \text{ m} = 2.499 \times 10^5 \text{ cm}$

20. 10.6 km/L

22. 9.2 nm/s

24. $2.9 \times 10^2 \text{ m}^3 = 2.9 \times 10^8 \text{ cm}^3$

26. $2.57 \times 10^6 \text{ m}^3$

28. $\sim 10^8$ steps

30. $\sim 10^8$ people with colds on any given day

32. **(a)** $4.2 \times 10^{-18} \text{ m}^3$ (b) $\sim 10^{-1} \text{ m}^3$ (c) $\sim 10^{16}$ cells

34. **(a)** $\sim 10^{29}$ prokaryotes (b) $\sim 10^{14}$ kg

(c) The very large mass of prokaryotes implies they are important to the biosphere. They are responsible for fixing carbon, producing oxygen, and breaking up pollutants, among many other biological roles. Humans depend on them!

36. 2.2 m

38. 8.1 cm

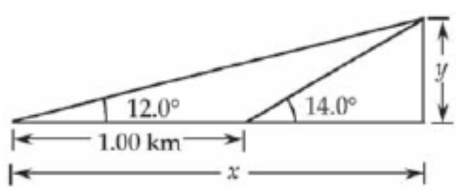
40. $\Delta s = \sqrt{r_1^2 + r_2^2 - 2r_1r_2\cos(\theta_1 - \theta_2)}$

42. 2.33 m

44. **(a)** 1.50 m **(b)** 2.60 m

46. 8.60 m

48. **(a)** and **(b)**



(c) $y/x = \tan 12.0°$, $y/(x - 1.00 \text{ km}) = \tan 14.0°$ **(d)** $1.44 \times 10^3 \text{ m}$

50. $y = \dfrac{d \cdot \tan\theta \cdot \tan\phi}{\tan\phi - \tan\theta}$

52. **(a)** 1.609 km/h **(b)** 88 km/h **(c)** 16 km/h

54. Assumes population of 300 million, average of 1 can/week per person, and 0.5 oz per can.

(a) $\sim 10^{10}$ cans/yr **(b)** $\sim 10^5$ tons/yr

56. **(a)** 7.14×10^{-2} gal/s **(b)** $2.70 \times 10^{-4} \text{ m}^3/\text{s}$ **(c)** 1.03 h

58. **(a)** $A_2/A_1 = 4$ **(b)** $V_2/V_1 = 8$

60. **(a)** 500 yr **(b)** 6.6×10^4 times

62. $\sim 10^4$ balls/yr. Assumes 1 lost ball per hitter, 10 hitters per inning, 9 innings per game, and 81 games per year.