1.13: Units and Measurement (Answers)

Check your Understanding

1.1. 4.79×10^2 Mg

1.2. $3 \times 10^8 m/s$

1.3. $10^8 km^2$

1.4. The numbers were too small, by a factor of 4.45.

1.5. $4\pi r^3/3$

1.6. yes

1.7. $3 \times 10^4 m$ or 30 km. It is probably an underestimate because the density of the atmosphere decreases with altitude. (In fact, 30 km does not even get us out of the stratosphere.)

1.8. No, the coach's new stopwatch will not be helpful. The uncertainty in the stopwatch is too great to differentiate between the sprint times effectively.

Conceptual Questions

1. Physics is the science concerned with describing the interactions of energy, matter, space, and time to uncover the fundamental mechanisms that underlie every phenomenon.

3. No, neither of these two theories is more valid than the other. Experimentation is the ultimate decider. If experimental evidence does not suggest one theory over the other, then both are equally valid. A given physicist might prefer one theory over another on the grounds that one seems more simple, more natural, or more beautiful than the other, but that physicist would quickly acknowledge that he or she cannot say the other theory is invalid. Rather, he or she would be honest about the fact that more experimental evidence is needed to determine which theory is a better description of nature.

5. Probably not. As the saying goes, "Extraordinary claims require extraordinary evidence."

7. Conversions between units require factors of 10 only, which simplifies calculations. Also, the same basic units can be scaled up or down using metric prefixes to sizes appropriate for the problem at hand.

9. a. Base units are defined by a particular process of measuring a base quantity whereas derived units are defined as algebraic combinations of base units.

b. A base quantity is chosen by convention and practical considerations. Derived quantities are expressed as algebraic combinations of base quantities.

c. A base unit is a standard for expressing the measurement of a base quantity within a particular system of units. So, a measurement of a base quantity could be expressed in terms of a base unit in any system of units using the same base quantities. For example, length is a base quantity in both SI and the English system, but the meter is a base unit in the SI system only.

11. a. Uncertainty is a quantitative measure of precision. b. Discrepancy is a quantitative measure of accuracy.

13. Check to make sure it makes sense and assess its significance.

Problems

15. a. 10^3;

b. 10^5;

c. 10^2;

d. 10^{15};

e. 10^2;

f. 10^{57}

17. 10^2 generations

19. 10^{11} atoms

21. 10^3 nerve impulses/s

23. 10^{26} floating-point operations per human lifetime

25. a. 957 ks;

b. 4.5 cs or 45 ms;

c. 550 ns;

d. 31.6 Ms

27. a. 75.9 Mm;

b. 7.4 mm;

c. 88 pm;

d. 16.3 Tm

29. a. 3.8 cg or 38 mg;

b. 230 Eg;

c. 24 ng;

d. 8 Eg

e. 4.2 g

31. a. 27.8 m/s;

b. 62 mi/h

33. a. 3.6 km/h;

b. 2.2 mi/h

35. $1.05 \times 10^5 ft^2$

37. 8.847 km

39. a. $1.3 \times 10^{-9} m$;

b. 40 km/My

41. $10^6 Mg/\mu L$

43. 62.4 lbm/ft^3

45. 0.017 rad

47. 1 light-nanosecond

49. $3.6 \times 10^{-4} m^3$

51. a. Yes, both terms have dimension L^2T^{-2}

b. No.

c. Yes, both terms have dimension LT^{-1}

d. Yes, both terms have dimension LT^{-2}

53. a. $[v] = LT^{-1}$;

b. $[a] = LT^{-2}$;

c. $[\int v dt] = L$;

d. $[\int a dt] = LT^{-1}$;

e. $[\frac{da}{dt}] = LT^{-3}$

55. a. L;

b. L;

c. $L^0 = 1$ (that is, it is dimensionless)

57. 10^{28} atoms

59. 10^{51} molecules

61. 10^{16} solar systems

63. a. Volume = $10^{27} m^3$, diameter is 10^9 m.;

b. 10^{11} m

65. a. A reasonable estimate might be one operation per second for a total of 10^ in a lifetime.;

b. about $(10^9)(10^{-17} s) = 10^{-8} s$, or about 10 ns

67. 2 kg

69. 4%

71. 67 mL

73. a. The number 99 has 2 significant figures; 100. has 3 significant figures.

b. 1.00%;

c. percent uncertainties

75. a. 2%;

b. 1 mm Hg

77. 7.557 cm^2

79. a. 37.2 lb; because the number of bags is an exact value, it is not considered in the significant figures;

b. 1.4 N; because the value 55 kg has only two significant figures, the final value must also contain two significant figures

Additional Problems

81. a. $[s_0] = L$ and units are meters (m);

b. $[v_0] = LT^{-1}$ and units are meters per second (m/s);

c. $[a_0] = LT^{-2}$ and units are meters per second squared (m/s^2);

d. $[j_0] = LT^{-3}$ and units are meters per second cubed (m/s^3);

e. $[S_0] = LT^{-4}$ and units are m/s^4;

f. $[c] = LT^{-5}$ and units are m/s^5.

83. a. 0.059%;

b. 0.01%;

c. 4.681 m/s;

d. 0.07%,

0.003 m/s

85. a. 0.02%;

b. 1×10^4 lbm

87. a. 143.6 cm^3;

b. 0.2 cm^3 or 0.14%

Challenge Problems

89. Since each term in the power series involves the argument raised to a different power, the only way that every term in the power series can have the same dimension is if the argument is dimensionless. To see this explicitly, suppose $[x] = L^a M^b T^c$. Then, $[x^n] = [x]^n = L^{an} M^{bn} T^{cn}$. If we want $[x] = [x^n]$, then an = a, bn = b, and cn = c for all n. The only way this can happen is if a = b = c = 0.

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