Guided Review.

1. (a) \((+50) + (-17) = +33\); or "to the right" 33 yards.
   (b) \((-50) + (+17) = -33\); or "not to the left" ("to the right") 33 yards.

2. (a) \((+15.0 \text{ degrees F}) + (-15.0 \text{ degrees F}) = 0 \text{ degrees F}\)
   (b) \((-9.44 \text{ degrees C}) + (-8.33 \text{ degrees C}) = (-17.8 \text{ degrees C})\). In the two different units the ‘temperature change’ is different by a multiplicative factor, while the actual value of the temperature is different, in addition because of the different choice of zero.

3. \((+100 \text{ lbs}) + (-100 \text{ lbs}) = 0\); "+" means "pulling up" and "+" means "pulling down". The fact that the sum is zero tells us that the pulling on the sign is balanced.

4. (a)
   Al: \((+13)+(-13)=0\)
   Zn: \((+30)+(-30)=0\)
   N: \((+7)+(-7)=0\)
   C: \((+6)+(-6)=0\)

   (b) Al: \((+13)+(-10)=+3\)
       Zn: \((+30)+(-28)=+2\)
       N: \((+7)+(-10)=-3\)
       C: \((+6)+(-10)=-4\)

5. (a) \(1830\) (b) \(6.68 \times 10^{-27} \text{ kg}\). (The mass of the electrons is negligible since our precision is to 3 significant figures.)

6. \(d=0.8706 \text{ m}\) (4 significant figures)

7. \(3.4 \text{ cm} = .034 \text{ m}\)

8. \(5 \text{ in} = 0.127 \text{ m}\)

   \(140 \text{ lbs} = 627 \text{ N}\)

   \(30 \text{ miles/hour} = 13.4 \text{ m/s}\)

   \(14.7 \text{ lbs/sq inch} = 101 \times 10^3 \text{ Pa (atmospheric pressure)}\)

   \((2000 \text{ Cal/d})(41875 \text{ J/Cal})(d/(24h)(3600s)) = 96.9 \text{ J/s} = 96.9 \text{ W}\)

9. (a) Graph with time \(t\) on the horizontal axis and water consumed \(W\) on the vertical axis: \(W = 1/24 \text{ t gallons}\)
   (b) water consumed = 0.0417t
   (c) 0.0417 gal/min
   (d) 4.0 hours

10. (a) leaves on tree = 800 - 26.7t (The equation is of the form \(y = mx + b\), where \(m\) is the slope and \(b\) is the y-intercept (the value of \(y\) when \(x\) is zero).
(b) 30 days

11. (a) \(x=0, y=13; x=1, y=10; x=2, y=9; x=3, y=10; x=4, y=13; x=5, y=18\)
(b) The shape is that of a parabola with its minimum at \(x=2\).
(c) At \(t = 2\), the slope is zero (at the minimum), at \(t = 4\), the slope = +4

12. (a) \(\sin 50 = 0.766\)
(b) \(4 \cos 50 = 4.643\m\)

13. \((6.67 \times 10^{-11})(60)(60)/4 = 6 \times 10^{-8} \text{ N}\)
(This force is equal to the weight of an object whose mass is about 6 nanograms.

14. (a) weight = \(GmM/R^2\).
Ratio of weight at the earth’s surface to that on Everest is \((1/R_e^2)/(1/(R_e + 8850)^2)) =\)
\((R_e + 8850)^2/R_e^2 = (R_e^2 + 2R_e \times 8850 + \ldots)/R_e^2 \sim 1 + (2)(8850)/R_e = 1 + 2.77 \times 10^{-3}\).
Weight on Everest = .997 times that on earth = 9.77N.
(b) \(G \times 5.98 \times 10^{24}/(6.38 \times 10^{22}) = 9.77N\)
The height of Mt. Everest is so small compared to the radius of the earth that the difference in weight is negligible when we use only two significant figures, and barely shows up with three.

15. (We assume that the numbers are given to three significant figures.)
\(9 \times 10^9 \times 15 \times 10^{-9} \times 15 \times 10^{-9}/2^2 = 5.06 \times 10^{-7} \text{ N}\)

Problems and Reasoning Skill Building.

1. \(4 + (-8) = -4 \text{ deg.} \) The final temperature is -4 deg. the minus sign indicates that the final temperature is on the other side of zero.

2. \(D_1/C_1 = D_2/C_2\) \(100/314 = 135/C_2\) \(C_2 = 424 \text{ m}\)

4. (a) \(\sqrt{a^2 + b^2} = 38.0\) \(\theta = \tan^{-1}(a/b) = 18.4 \text{ deg.}\)

7. The distance to Jupiter is \(R_J =\) The distance to the physician is about \(R_p = 0.5 \text{ m.}\)

\[F_p = G \frac{M_p m}{R_p^2}\]
\[F_J = G \frac{M_J m}{R_J^2}\]
\[F_p/F_J = (M_p/M_J)(R_J^2/R_p^2) =\]

8. The earth turns through 360° in 24 h. It turns through 15° in one h. When the sun is 15° above the horizon, it is 1 h before sunset. To estimate the angle of 30°, use pencils, or sticks, one twice as long as the other, or just your hands, to construct the angle whose sine is \(\frac{1}{2}\).

11. (a) \(mg = 50 \text{ N.} \) \(m = 50/9.8 = 5.10 \text{ kg.}\)
(b) (b) \(mg = GmM_m/R_m^2 \) \(g = (6.67 \times 10^{-11})(7.35 \times 10^{22})/(1.74 \times 10^6)^2 = 1.62 \text{ N/kg or about 1/6 of its value on the earth.}\)
(c) The mass remains the same: \(m = 5.10 \text{ kg.}\) The weight is \(mg = (5.10)(1.62) = 8.26 \text{ N.}\)

13. \(F = G \frac{mM}{R^2}\) \(G = FR^2/mM \text{ Nm}^2/\text{kg}^2\) or, since \(N = \text{kg m/s}^2\), the units can also be written as
\[(\text{kg m/s}^2)(\text{m}^2/\text{kg}^2) = \text{m}^3/(\text{kg s}^2)\]

14. \(F_M = \frac{GmM_m}{R_{ME}^2}\quad F_S = \frac{GmM_s}{R_{SE}^2}\quad F_M/F_S = \frac{M_M}{M_S}\left(\frac{R_{SE}}{R_{ME}}\right)^2\)
\[
= \frac{[(7.35 \times 10^{22})/(1.99 \times 10^{30})]}{[(1.5 \times 10^{11})/(3.85 \times 10^{8})]^2} = \frac{3.69 \times 10^{-8}}{1.52 \times 10^5} = 5.6 \times 10^{-3},
\]
i.e., the force exerted by the sun is about 178 times as large.

15. The deuteron is about twice as massive and has the same charge. The gravitational force is twice as large, the electric force is the same. Since the electric force is much larger, the total force is very closely the same.

16. Since the mass does not change, it is only the speed that matters, and the factor is \(v_2^2/v_1^2\).
\[
v_1 = 5/22 \text{ km/min}, \quad v_2 = 5/19 \text{ km/min}
\]
\[
v_2^2/v_1^2 = (22/19)^2 = 1.34
\]

18. The weight in pounds of 1 million dollars worth of gold is
\[
(10^6 \text{ $})(1 \text{ oz.}/300 \text{ $})(1 \text{ lb.}/16 \text{ oz}) = 208 \text{ lbs.}
\]
Holmes quickly calculated this in his head. He saw that it was unlikely that Stiles could have been running down the street with a suitcase weighing more than 200 pounds and so he took the case.

**Synthesis Problems and Projects**

4. \(N = N_0e^{-\lambda t}\) where \(\lambda = \ln 2/T_{1/2} = .693/T_{1/2}\). We can also write \(N_0/N = e^{\lambda t}\). For \(^{238}\text{U}\) \(T_{1/2} = 4.5 \times 10^9\) y, for \(^{235}\text{U}\) it is \(0.71 \times 10^9\) y.
\[
N_{235}/N_{238} = 0.0072, \quad N_0 \text{ is the same for both.} \quad \frac{(N_0/N_{238})/N_0/N_{235}}{e^{\lambda_{238}t} e^{\lambda_{235}t}} = 0.0072.
\]
O find t: take natural logarithms, \(\ln\): \(\lambda_{238}t - \lambda_{235}t = \ln 0.0072 = -4.934\)
\[
0.693t/4.5 \times 10^9 - 0.693t/0.71 \times 10^9 = -4.934
\]
\[
0.693t/10^9(1/4.5 -1/0.71) = -4.934 \quad \text{so that} \quad t = 6.0 \times 10^9 \text{ y.}
\]

5. \(q_1q_2/d^2 = mg\quad q^2 = mgd^2/k = (.02)(9.8)(.1)^2/9 \times 10^9 = 2.2 \times 10^{-13}\) and \(q = 4.7 \times 10^{-7} \text{ C}\) or about 0.47 µC.