Appendix C
Solutions for Practice Problems

Chapter 1

No practice problems.

Chapter 2

1. a. 5.8×10^3 m; **b.** 4.5×10^5 m

c. 3.02×10^8 m; **d.** 8.6×10^{10} m

2. a. 5.08×10^{-4} kg; **b.** 4.5×10^{-7} kg

c. 3.600×10^{-4} kg; **d.** 4×10^{-3} kg

3. a. 3×10^5 s; **b.** 1.86×10^5 s

c. 9.3×10^7 s

4. a. $(1.1\text{ cm})\dfrac{(1 \times 10^{-2}\text{ m})}{(1\text{ cm})} = 1.1 \times 10^{-2}\text{ m}$

b. $(76.2\text{ pm})\dfrac{(1 \times 10^{-12}\text{ m})}{(1\text{ pm})}\left(\dfrac{1 \times 10^3\text{ mm}}{\text{m}}\right)$

$= 7.62 \times 10^{-8}\text{ mm}$

c. $(2.1\text{ km})\dfrac{(1 \times 10^3\text{ m})}{(1\text{ km})} = 2.1 \times 10^3\text{ m}$

d. $(2.278 \times 10^{11}\text{ m})\left(\dfrac{1\text{ km}}{1 \times 10^3\text{ m}}\right)$

$= 2.278 \times 10^8\text{ km}$

5. a. $1\text{ kg} = 1 \times 10^3\text{ g}$ so $147\text{g}\left[\dfrac{1\text{ kg}}{1 \times 10^3\text{ g}}\right]$

$= 147 \times 10^{-3}\text{ kg}$

$= 1.47 \times 10^{-1}\text{ kg}$

b. $1\text{ Mg} = 1 \times 10^6\text{ g}$ and $1\text{ kg} = 1 \times 10^3\text{ g}$

so $11\text{ Mg}\left(\dfrac{1 \times 10^6\text{ g}}{1\text{ Mg}}\right)\left(\dfrac{1\text{ kg}}{1 \times 10^3\text{ g}}\right)$

$= 1.1 \times 10^4\text{ kg}$

c. $1\ \mu\text{g} = 1 \times 10^{-6}\text{ g}$

$7.23\ \mu\text{g}\left(\dfrac{1\text{ g}}{1 \times 10^6\ \mu\text{g}}\right)\left(\dfrac{1\text{ kg}}{1 \times 10^3\text{ g}}\right)$

$= 7.23 \times 10^{-9}\text{ kg}$

d. $478\text{ mg}\left[\dfrac{1 \times 10^{-3}\text{ g}}{1\text{ mg}}\right]\left[\dfrac{1\text{ kg}}{1 \times 10^3\text{ g}}\right]$

$= 4.78 \times 10^{-4}\text{ kg}$

6. a. 8×10^{-7} kg; **b.** 7×10^{-3} kg

c. 3.96×10^{-19} kg; **d.** 4.6×10^{-12} kg

7. a. $2 \times 10^{-8}\text{ m}^2$; **b.** $-1.52 \times 10^{-11}\text{ m}^2$

c. $3.0 \times 10^{-9}\text{ m}^2$

d. $0.46 \times 10^{-18}\text{ m}^2 = 4.6 \times 10^{-19}\text{ m}^2$

8. a. $5.0 \times 10^{-7}\text{ mg} + 4 \times 10^{-8}\text{ mg}$

$= 5.0 \times 10^{-7}\text{ mg} + 0.4 \times 10^{-7}\text{ mg}$

$= 5.4 \times 10^{-7}\text{ mg}$

b. $6.0 \times 10^{-3}\text{ mg} + 2 \times 10^{-4}\text{ mg}$

$= 6.0 \times 10^{-3}\text{ mg} + 0.2 \times 10^{-3}\text{ mg}$

$= 6.2 \times 10^{-3}\text{ mg}$

c. $3.0 \times 10^{-2}\text{ pg} - 2 \times 10^{-6}\text{ ng}$

$= 3.0 \times 10^{-2} \times 10^{-12}\text{ g} - 2 \times 10^{-6} \times 10^{-9}\text{ g}$

$= 3.0 \times 10^{-14}\text{ g} - 0.2 \times 10^{-14}\text{ g}$

$= 2.8 \times 10^{-14}\text{ g}$

d. $8.2\text{ km} - 3 \times 10^2\text{ m}$

$= 8.2 \times 10^3\text{ m} - 0.3 \times 10^3\text{ m}$

$= 7.9 \times 10^3\text{ m}$

9. a. $(2 \times 10^4\text{ m})(4 \times 10^8\text{ m}) = 8 \times 10^{4+8}\text{ m}^2$

$= 8 \times 10^{12}\text{ m}^2$

b. $(3 \times 10^4\text{ m})(2 \times 10^6\text{ m}) = 6 \times 10^{4+6}\text{ m}^2$

$= 6 \times 10^{10}\text{ m}^2$

c. $(6 \times 10^{-4}\text{ m})(5 \times 10^{-8}\text{ m})$

$= 30 \times 10^{-4-8}\text{ m}^2$

$= 3 \times 10^{-11}\text{ m}^2$

d. $(2.5 \times 10^{-7}\text{ m})(2.5 \times 10^{16}\text{ m})$

$= 6.25 \times 10^{-7+16}\text{ m}^2$

$= 6.3 \times 10^9\text{ m}^2$

10. a. $\dfrac{6 \times 10^8\text{ kg}}{2 \times 10^4\text{ m}^3} = 3 \times 10^{8-4}\text{ kg/m}^3$

$= 3 \times 10^4\text{ kg/m}^3$

b. $\dfrac{6 \times 10^8\text{ kg}}{2 \times 10^{-4}\text{ m}^3} = 3 \times 10^{8-(-4)}\text{ kg/m}^3$

$= 3 \times 10^{12}\text{ kg/m}^3$

c. $\dfrac{6 \times 10^{-8}\ \text{m}}{2 \times 10^{4}\ \text{s}} = 3 \times 10^{-8-4}\ \text{m/s}$

$= 3 \times 10^{-12}\ \text{m/s}$

d. $\dfrac{6 \times 10^{-8}\ \text{m}}{2 \times 10^{-4}\ \text{s}} = 3 \times 10^{-8-(-4)}\ \text{m/s}$

$= 3 \times 10^{-4}\ \text{m/s}$

11. a. $\dfrac{(3 \times 10^{4}\ \text{kg})(4 \times 10^{4}\ \text{m})}{6 \times 10^{4}\ \text{s}}$

$= \dfrac{12 \times 10^{4+4}\ \text{kg} \cdot \text{m}}{6 \times 10^{4}\ \text{s}}$

$= 2 \times 10^{8-4}\ \text{kg} \cdot \text{m/s} = 2 \times 10^{4}\ \text{kg} \cdot \text{m/s}$

The evaluation may be done in several other ways. For example

$(3 \times 10^{4}\ \text{kg})(4 \times 10^{4}\ \text{m})/(6 \times 10^{4}\ \text{s})$

$= (0.5 \times 10^{4-4}\ \text{kg/s})(4 \times 10^{4}\ \text{m})$

$= (0.5\ \text{kg/s})(4 \times 10^{4}\ \text{m})$

$= 2 \times 10^{4}\ \text{kg} \cdot \text{m/s}$

b. $(2.5 \times 10^{6}\ \text{kg})(6 \times 10^{4}\ \text{m})/(5 \times 10^{-2}\ \text{s}^2)$

$= 15 \times 10^{6+4}\ \text{kg} \cdot \text{m}/(5 \times 10^{-2}\ \text{s}^2)$

$= 3 \times 10^{10-(-2)}\ \text{kg} \cdot \text{m/s}^2$

$= 3 \times 10^{12}\ \text{kg} \cdot \text{m/s}^2$

12. a. $(4 \times 10^{3}\ \text{mg})(5 \times 10^{4}\ \text{kg})$

$= (4 \times 10^{3} \times 10^{-3}\ \text{g})(5 \times 10^{4} \times 10^{3}\ \text{g})$

$= 20 \times 10^{7}\ \text{g}^2$

$= 2 \times 10^{8}\ \text{g}^2$

b. $(6.5 \times 10^{-2}\ \text{m})(4.0 \times 10^{3}\ \text{km})$

$= (6.5 \times 10^{-2}\ \text{m})(4.0 \times 10^{3} \times 10^{3}\ \text{m})$

$= 26 \times 10^{4}\ \text{m}^2$

$= 2.6 \times 10^{5}\ \text{m}^2$

c. $(2 \times 10^{3}\ \text{ms})(5 \times 10^{-2}\ \text{ns})$

$= (2 \times 10^{3} \times 10^{-3}\ \text{s})(5 \times 10^{-2} \times 10^{-9}\ \text{s})$

$= 10 \times 10^{-11}\ \text{s}^2$

$= 1 \times 10^{-10}\ \text{s}^2$

13. a. $\dfrac{2.8 \times 10^{-2}\ \text{mg}}{2.0 \times 10^{4}\ \text{g}} = \dfrac{2.8 \times 10^{-2} \times 10^{-3}\ \text{g}}{2.0 \times 10^{4}\ \text{g}}$

$= 1.4 \times 10^{-9}$

b. $\dfrac{(6 \times 10^{2}\ \text{kg})(9 \times 10^{3}\ \text{m})}{(2 \times 10^{4}\ \text{s})(3 \times 10^{6}\ \text{ms})}$

$= \dfrac{(6 \times 10^{2}\ \text{kg})(9 \times 10^{3}\ \text{m})}{(2 \times 10^{4}\ \text{s})(3 \times 10^{6} \times 10^{-3}\ \text{s})}$

$= \dfrac{54 \times 10^{5}\ \text{kg} \cdot \text{m}}{6 \times 10^{7}\ \text{s}^2}$

$= 9 \times 10^{-2}\ \text{kg} \cdot \text{m/s}^2$

14. $\dfrac{(7 \times 10^{-3}\ \text{m}) + (5 \times 10^{-3}\ \text{m})}{(9 \times 10^{7}\ \text{km}) + (3 \times 10^{7}\ \text{km})}$

$= \dfrac{12 \times 10^{-3}\ \text{m}}{12 \times 10^{7}\ \text{km}}$

$= \dfrac{12 \times 10^{-3}\ \text{m}}{12 \times 10^{7} \times 10^{3}\ \text{m}} = \dfrac{12 \times 10^{-3}\ \text{m}}{12 \times 10^{10}\ \text{m}}$

$= 1 \times 10^{-13}$

15. a. 4 **b.** 3 **c.** 2

d. 4 **e.** 2 **f.** 3

16. a. 2 **b.** 4 **c.** 4

d. 3 **e.** 4 **f.** 3

17. a. 26.3 cm (rounded from 26.281 cm)

b. 1600 m or 1.6 km (rounded from 1613.62 m)

18. a. 2.5 g (rounded from 2.536 g)

b. 475 m (rounded from 474.5832 m)

19. a. $3.0 \times 10^{2}\ \text{cm}^2$ (the result 301.3 cm^2 expressed to two significant digits. Note that the expression in the form 300 cm^2 would not indicate how many of the digits are significant.)

b. 13.6 km^2 (the result 13.597335 expressed to three significant digits)

c. 35.7 N · m (the result 35.7182 N · m expressed to three significant digits)

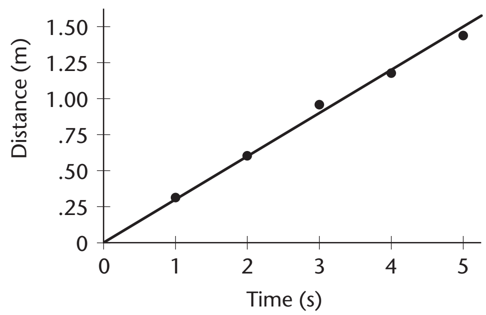
20. a. 2.73 cm/s (the result 2.726045 . . . cm/s expressed to three significant digits)

b. 0.253 cm/s (the result 0.253354 . . . cm/s expressed to three significant digits)

c. 1.22×10^{3} g (the result $1.219469 \ldots \times 10^{3}$ g expressed to three significant digits)

d. 4.1 g/cm^3 (the result 4.138636 . . . g/cm^3 expressed to two significant digits)

21. a.



Solutions for Practice Problems

b. straight line **c.** linear relationship

d. $M = \dfrac{\Delta y}{\Delta x} = \dfrac{1.5 - 0.60}{5.0 - 2.0} = \dfrac{0.90}{3.0} = 0.30 \text{ m/s}$

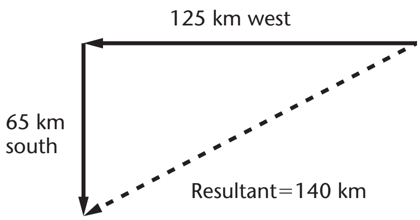
e. $d = 0.30(t)$

Chapter 3

No practice problems.

Chapter 4

1.



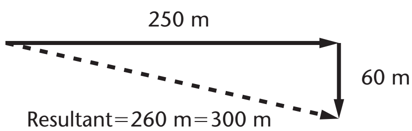
$R^2 = A^2 + B^2$

$R^2 = (65 \text{ km})^2 + (125 \text{ km})^2$

$R^2 = 19\ 850 \text{ km}^2$

$R = 140 \text{ km}$

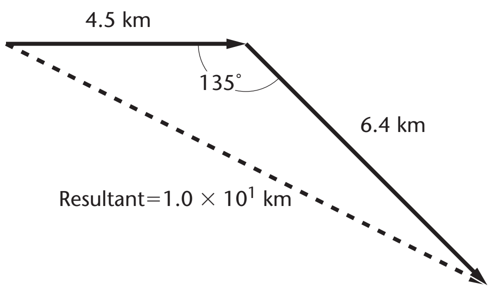
2.



$R^2 = (250 \text{ m})^2 + (60 \text{ m})^2 = 66\ 100 \text{ m}^2$

$R = 260 \text{ m} = 300 \text{ m}$

3.

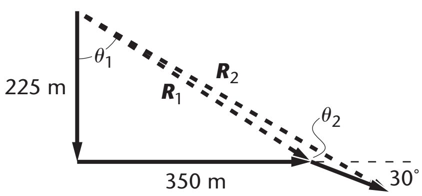


$R^2 = A^2 + B^2 - 2AB\cos\theta$

$R = [(4.5 \text{ km})^2 + (6.4 \text{ km})^2 - (2)(4.5 \text{ km})(6.4 \text{ km})(\cos 135°)]^{1/2}$

$R = 1.0 \times 10^1 \text{ km}$

4.



$R_1 = [(225 \text{ m})^2 + (350 \text{ m})^2]^{1/2} = 416 \text{ m}$

$\theta_1 = \tan^{-1}\dfrac{350 \text{ m}}{225 \text{ m}} = 57.3$

$\theta_2 = 180 - (60 - 57.3) = 177.3°$

$R_2 = [(416 \text{ m})^2 + (125 \text{ m})^2 - 2(416 \text{ m})(125 \text{ m})(\cos 177.3°)]^{1/2}$

$R_2 = 540 \text{ m}$

5. Magnitude of change in velocity

$= 45 - (-30) = 75 \text{ km/h}$

direction of change is from east to west

6. $+2.0 \text{ m/s} + 4.0 \text{ m/s} = 6.0 \text{ m/s}$ relative to street

7. $v_{result} = [v_b^2 + v_r^2]^{1/2}$

$= [(11 \text{ m/s})^2 + (5.0 \text{ m/s})^2]^{1/2} = 12 \text{ m/s}$

$\theta = \tan^{-1}\dfrac{5.0 \text{ m/s}}{11 \text{ m/s}} = 24°$

$v_{result} = 12$ m/s, 66° east of north

8. 2.5 m/s

$\longrightarrow$ boat

2.0 m/s river

$\longleftarrow$

$\rightarrow$

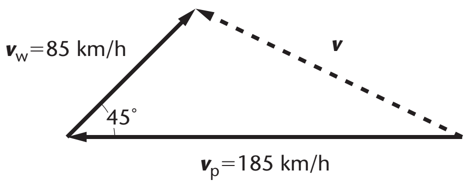
0.5 m/s Resultant

2.5 m/s − 0.5 m/s = 2.0 m/s against the boat

9. $v = [v_p^2 + v_w^2]^{1/2} = [(150 \text{ km/h})^2 + (75 \text{ km/h})^2]^{1/2}$

$= 170 \text{ km/h}$

10.

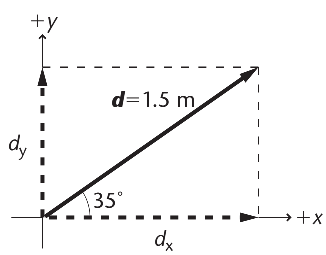


$v = [v_p^2 + v_w^2 - 2v_p v_w \cos\theta]^{1/2}$

$= [(185 \text{ km/h})^2 + (85 \text{ km/h})^2 - (2)(185 \text{ km/h})(85 \text{ km/h})(\cos 45°)]^{1/2}$

$= 140 \text{ km/h}$

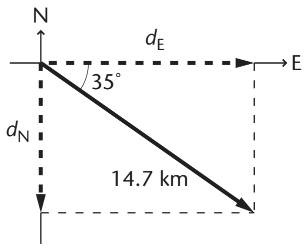
11.



$d_x = 1.5 \text{ m} \cos 35° = 1.2 \text{ m}$

$d_y = 1.5 \text{ m} \sin 35° = 0.86 \text{ m}$

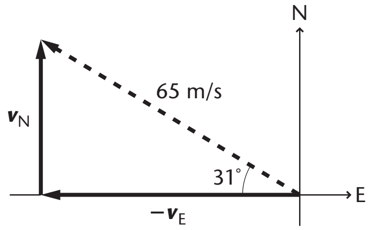
12.



d_E = 14.7 km cos 35° = 12.0 km

d_N = –14.7 km sin 35° = –8.43 km

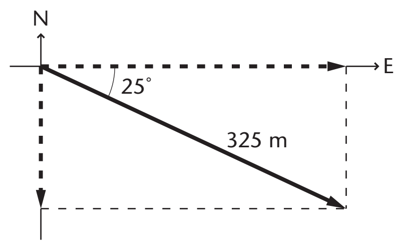
13.



v_E = –65 m/s cos 31° = –56 m/s

v_N = 65 m/s sin 31° = 33 m/s

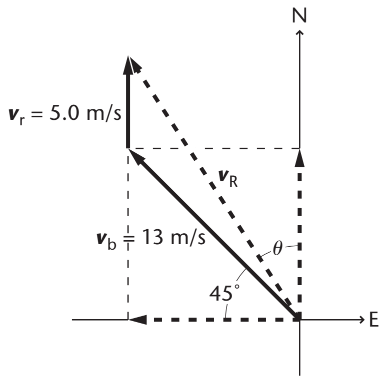
14.



d_E = 325 m cos 25° = 295 m

d_N = –325 m sin 25° = –137 m

15.



v_{bW} = (13 m/s) cos 45° = 9.2 m/s

v_{bN} = (13 m/s) sin 45° = 9.2 m/s

v_{rN} = 5.0 m/s

v_{rW} = 0.0

v_{RW} = 9.2 m/s + 0.0 = 9.2 m/s

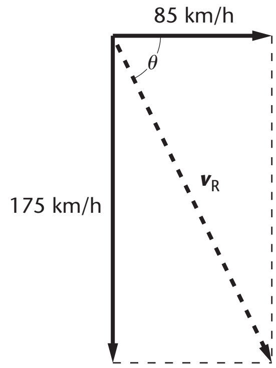
v_{RN} = 9.2 m/s + 5.0 m/s = 14.2 m/s

$v_R = [(9.2\text{ m/s})^2 + (14.2\text{ m/s})^2]^{1/2}$ = 17 m/s

$\theta = \tan^{-1}\dfrac{9.2\text{ m/s}}{14.2\text{ m/s}} = \tan^{-1} 0.648 = 33°$

v_R = 17 m/s, 33° west of north

16.

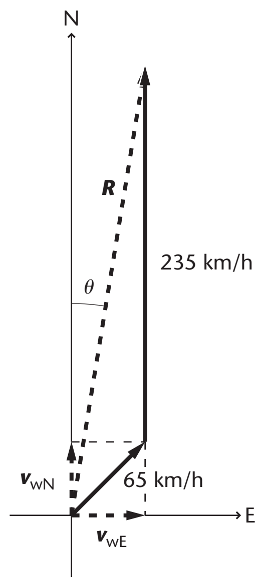


$v_R = [(175\text{ km/h})^2 + (85\text{ km/h})^2]^{1/2}$ = 190 km/h

$\theta = \tan^{-1}\dfrac{175\text{ km/h}}{85\text{ km/h}} = \tan^{-1} 2.06 = 64°$

v_R = 190 km/h, 64° south of east

17.



v_{wN} = 65 km/h sin 45° = 46 km/h

v_{wE} = 65 km/h cos 45° = 46 km/h

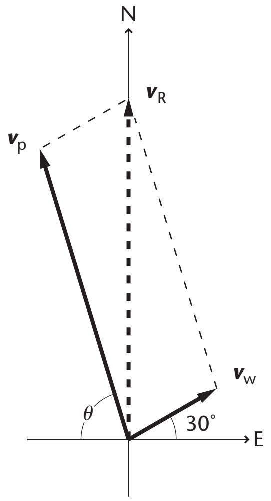
R_N = 46 km/h + 235 km/h = 281 km/h

R_E = 46 km/h

$R = [(281\text{ km/h})^2 + (46\text{ km/h})^2]^{1/2}$ = 280 km/h

$\theta = \tan^{-1}\dfrac{46\text{ km/h}}{281\text{ km/h}}$ = 9.3° east of north

18.



To travel north, the east components must be equal and opposite.

$v_{pE} = v_{wE} = 95$ km/h cos 30° = 82 km/h

$\theta = \cos^{-1} \dfrac{82 \text{ km/h}}{285 \text{ km/h}} = 73°$

$v_{pN} = 285$ km/h sin 73° = 273 km/h

$v_{wN} = 95$ km/h sin 30° = 47.5

$v_R = 320$ km/h north

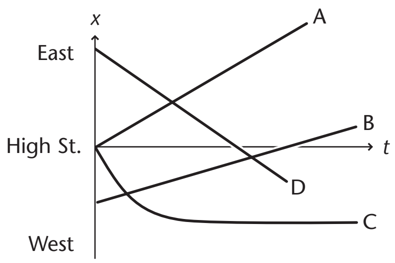
Chapter 5

1. A starts at High St., walking east at constant velocity.

B starts west of High St., walking east at slower constant velocity.

C walks west from High St., first fast, but slowing to a stop.

D starts east of High St., walking west at constant velocity.



2. The car starts at the origin, moves backward (selected to be the negative direction) at a constant speed of 2 m/s for 10 s, then stops and stays at that location (–20 m) for 20 seconds. It then moves forward at 2.5 m/s for 20 seconds when it is at +30 m. It immediately goes backward at a speed of 1.5 m/s for 20 s, when it has returned to the origin.

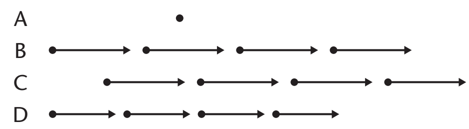
3. a. Between 10 and 30 s.

b. 30 m east of the origin

c. At point D, 30 m east of the origin at 50 s.

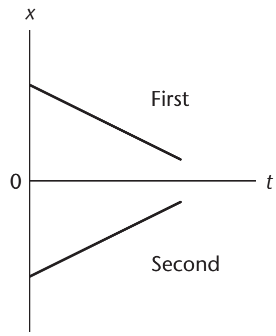
4. a. A remains stationary. B starts at the origin; moves forward at a constant speed. C starts east (positive direction) of the origin, moves forward at the same speed as B. D starts at the origin, moves forward at a slower speed than B.

b.



c. B = C > D > A

5.



6. Average velocity is 75 m/s. At one second

$\dfrac{d}{t} = \dfrac{(115 \text{ m})}{(1 \text{ s})} = 115$ m/s

while at 3 seconds, $\dfrac{d}{t} = 88$ m/s.

7. a. Into mph:

10.0 m/s × (3600 s/h) × (0.6214 mi/km) × (0.001 km/m)

= 22.4 mph

Into km/h:

10.0 m/s × (3600 s/h) × (0.001 km/m) = 36.0 km/h

b. Into km/h:

$65 \text{ mph} \times (5280 \text{ ft/mi}) \times \left(\dfrac{0.3048 \text{ m/ft}}{1000 \text{ m/km}}\right)$

$= 1.0 \times 10^2$ km/h

Into m/s:

$65 \text{ mph} \times (5280 \text{ ft/mi}) \times \dfrac{(0.3048 \text{ m/ft})}{(3600 \text{ s/h})}$

= 29 m/s

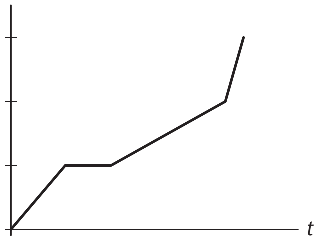
c. Into km/h:

$4 \text{ mph} \times (5280 \text{ ft/mi}) \times \left(\dfrac{0.3048 \text{ m/ft}}{1000 \text{ m/km}}\right) = 6 \text{ km/h}$

Into m/s:

$4 \text{ mph} \times (5280 \text{ ft/mi}) \times \dfrac{(0.3048 \text{ m/ft})}{(3600 \text{ s/h})} = 2 \text{ m/s}$

8.



9. a. $v = \frac{8.0 \text{ m}}{0.80 \text{ s}} = 1.0 \times 10^1 \text{ m/s}$

so $x = (-2.0 \text{ m}) + (1.0 \times 10^1 \text{ m/s})t$

b. At +8.0 m.

10. a. $v = \frac{-4.0 \text{ m}}{0.60 \text{ s}} = -6.7 \text{ m/s}$

so $x = (-2.0 \text{ m}) - (6.7 \text{ m/s})t$

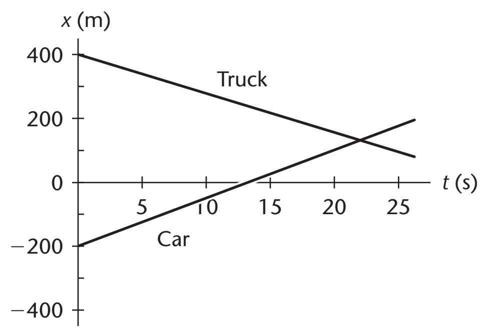
b. At 1.2 s.

11. a. $x = -(2.0 \times 10^2 \text{ m}) + (15 \text{ m/s})t$

b. x (at 6.00×10^2 s) = 8800 m

c. The time at which $x = 0$ is given by
$t = \frac{2.0 \times 10^2 \text{ m}}{15 \text{ m/s}} = 13 \text{ s}.$

12. a.



b. Equation for truck:
$x_T = (4.0 \times 10^2 \text{ m}) - (12 \text{ m/s})t.$
They pass each other when

$-(2.0 \times 10^2 \text{ m}) + (15 \text{ m/s})t = (4.0 \times 10^2 \text{ m}) - (12 \text{ m/s})t$

or $-6.0 \times 10^2 \text{ m} = -(27 \text{ m/s})t$

That is, $t = 22.2 \text{ s} = 22 \text{ s}$. $x_T = 133.6 \text{ m} = 130 \text{ m}$

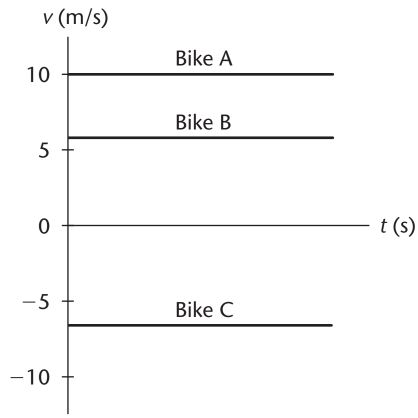
13. a. At 1.0 s, $v = 74$ m/s.

b. At 2.0 s, $v = 78$ m/s.

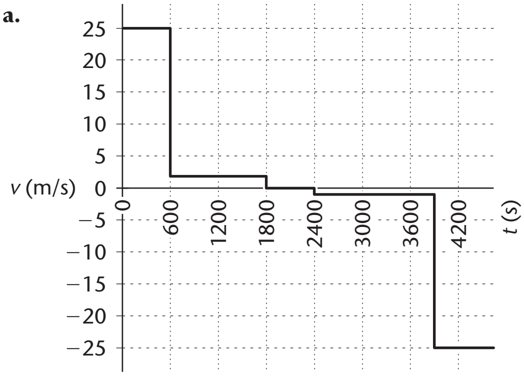
c. At 2.5 s, $v = 80$ m/s.

14. $\frac{(75 \text{ m/s}) \times (3600 \text{ s/h})}{1000 \text{ m/km}} = 270 \text{ km/h}$

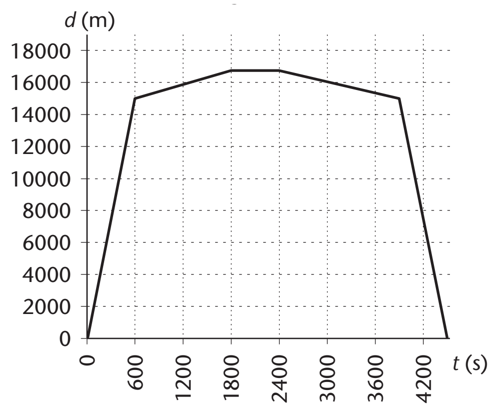
15.



16. a.



b.



17. $\bar{a} = \frac{\Delta v}{\Delta t} = \frac{36 \text{ m/s} - 4.0 \text{ m/s}}{4.0 \text{ s}} = 8.0 \text{ m/s}^2$

18. $\bar{a} = \frac{v_2 - v_1}{t_2 - t_1} = \frac{15 \text{ m/s} - 36 \text{ m/s}}{3.0 \text{ s}} = -7.0 \text{ m/s}^2$

Solutions for Practice Problems

19. $\bar{a} = \dfrac{v_2 - v_1}{t_2 - t_1} = \dfrac{4.5\text{ m/s} - (-3.0\text{ m/s})}{2.5\text{ s}} = 3.0\text{ m/s}^2$

20. a. $\bar{a} = \dfrac{v_2 - v_1}{t_2 - t_1} = \dfrac{0.0\text{ m/s} - 25.0\text{ m/s}}{3.0\text{ s}} = -8.3\text{ m/s}^2$

b. Half as great (-4.2 m/s^2).

21. a. 5 to 15 s and 21 to 28 s

b. 0 to 6 s **c.** 15 to 20 s, 28 to 40 s

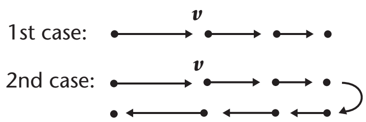
22. a. 2 m/s^2 **b.** -1 m/s^2

c. 0 m/s^2

23. a. $v = v_0 + at = 2.0\text{ m/s} + (-0.50\text{ m/s}^2)(2.0\text{ s})$
$= 1.0\text{ m/s}$

b. $v = v_0 + at = 2.0\text{ m/s} + (-0.50\text{ m/s}^2)(6.0\text{ s})$
$= -1.0\text{ m/s}$

c. The ball's velocity simply decreased in the first case. In the second case the ball slowed to a stop and then began rolling back down the hill.



24. $a = (3.5\text{ m/s}^2)(1\text{ km}/1000\text{ m})(3600\text{ s/h})$
$= 12.6\text{ (km/h)/s}$
$v = v_0 + at = 30.0\text{ km/h} + (12.6\text{(km/h)/s})(6.8\text{ s})$
$= 30.0\text{ km/h} + 86\text{ km/h}$
$= 116\text{ km/h}$

25. $v = v_0 + at$

so $t = \dfrac{v - v_0}{a} = \dfrac{28\text{ m/s} - 0.0\text{ m/s}}{5.5\text{ m/s}^2} = 5.1\text{ s}$

26. $v = v_0 + at$

so $t = \dfrac{v - v_0}{a} = \dfrac{3.0\text{ m/s} - 22\text{ m/s}}{-2.1\text{ m/s}^2} = 9.0\text{ s}$

27. $d = \dfrac{1}{2}(v + v_0)t = \dfrac{1}{2}(22\text{ m/s} + 44\text{ m/s})(11\text{ s})$
$= 3.6 \times 10^2\text{ m}$

28. $d = \dfrac{1}{2}(v - v_0)t$

so $t = \dfrac{2d}{v + v_0} = \dfrac{2(125\text{ m})}{25\text{ m/s} + 15\text{ m/s}} = 6.3\text{ s}$

29. $d = \dfrac{1}{2}(v + v_0)t$

so $v_0 = \dfrac{2d}{t} - v = \dfrac{2(19\text{ m})}{4.5\text{ s}} - 7.5\text{ m/s} = 0.94\text{ m/s}$

30. a. $d = v_0t + \dfrac{1}{2}at^2$
$= (0\text{ m/s})(30.0\text{ s}) + \dfrac{1}{2}(3.00\text{ m/s}^2)(30.0\text{ s})^2$
$= 0\text{ m} + 1350\text{ m} = 1.35 \times 10^3\text{ m}$

b. $v = v_0 + at = 0\text{ m/s} + (3.00\text{ m/s}^2)(30.0\text{ s})$
$= 90.0\text{ m/s}$

31. a. $v = v_0 + at$, $a = -g = -9.80\text{ m/s}^2$
$v = 0\text{ m/s} + (-9.80\text{ m/s}^2)(4.0\text{ s})$
$v = -39\text{ m/s}$ (downward)

b. $d = v_0t + \dfrac{1}{2}at^2$
$= 0 + \dfrac{1}{2}(-9.80\text{ m/s}^2)(4.0\text{ s})^2$
$= \dfrac{1}{2}(-9.80\text{ m/s}^2)(16\text{ s}^2)$
$d = -78\text{ m}$ (downward)

32. a. Since $a = -g$, and, at the maximum height, $v = 0$, using $v^2 = v_0^2 + 2a(d - d_0)$, gives

$v_0^2 = 2gd$

or $d = \dfrac{v_0^2}{2g} = \dfrac{(22.5\text{ m/s})^2}{2(9.80\text{ m/s}^2)} = 25.8\text{ m}$

b. Time to rise: use $v = v_0 + at$, giving

$t = \dfrac{v_0}{g} = \dfrac{22.5\text{ m/s}}{9.80\text{ m/s}^2} = 2.30\text{ s}$

So, it is in the air for 4.6 s. To show that the time to rise equals the time to fall, when $d = d_0$

$v^2 = v_0^2 + 2a(d - d_0)$

gives $v^2 = v_0^2$ or $v = -v_0$. Now, using $v = v_0 + at$ where, for the fall, $v_0 = 0$ and $v = -v_0$, we get $t = \dfrac{v_0}{g}$.

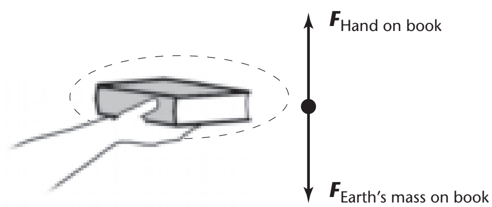
33. Given $v_0 = 65.0\text{ m/s}$, $v = 162.0\text{ m/s}$, and $t = 10.0\text{ s}$ and needing d, we use

$d = d_0 + \dfrac{1}{2}(v_0 + v)t$

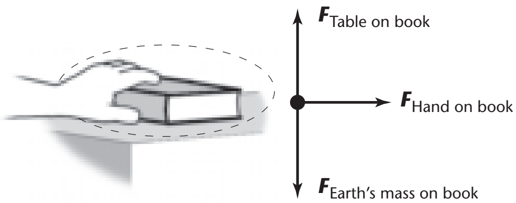
or $d = \dfrac{1}{2}(65.0\text{ m/s} + 162.0\text{ m/s})(10.0\text{ s})$
$= 1.14 \times 10^3\text{ m}$

Chapter 6

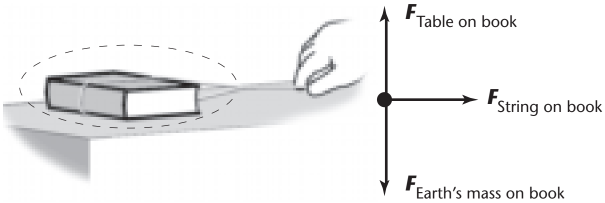
1. a.



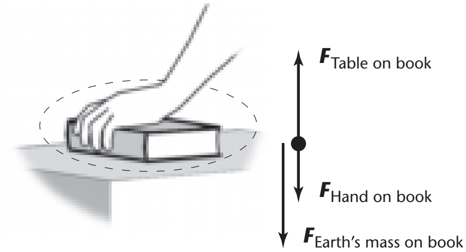
b.



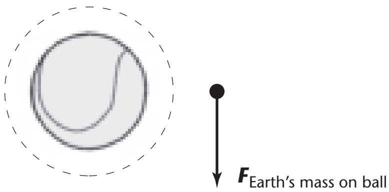
c.



d.



e.



2. Net force is

$225\ \text{N} + 165\ \text{N} = 3.90 \times 10^2\ \text{N}$

in the direction of the two forces.

3. Net force is

$225\ \text{N} - 165\ \text{N} = 6.0 \times 10^1\ \text{N}$

in the direction of the larger force.

4. Magnitude and direction

$F = \sqrt{(225\ \text{N})^2 + (165\ \text{N})^2} = 279\ \text{N}$

$\tan\theta = \dfrac{225}{165} = 1.36$

$\theta = 53.7°$ N of E

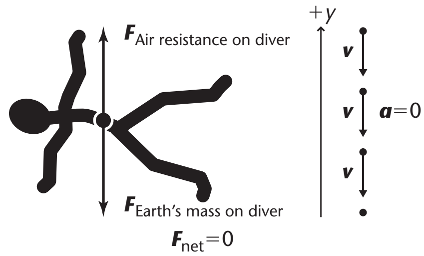
5. The downward force is one pound, or 4.5 N. The force is

$6.5\ \text{N} - 4.5\ \text{N} = 2.0\ \text{N}$ upward

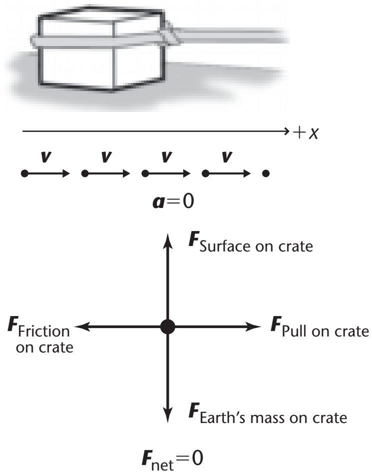
6. $F = mg = (0.454\ \text{kg/lb})(9.80\ \text{m/s}^2) = 4.45\ \text{N/lb}$

Same force if you lie on the floor.

7.



8.



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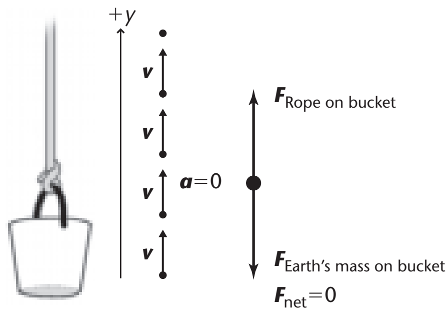
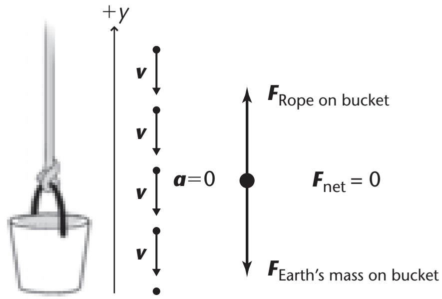
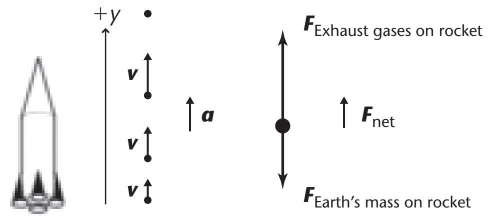


10.



Solutions for Practice Problems

11.



12. a. Scale reads 585 N. Since there is no acceleration your force equals the downward force of gravity.

Mass

$$m = \frac{F_g}{g} = 59.7 \text{ kg}$$

b. On the moon the scale would read 95.5 N.

13. a. Mass = 75 kg

b. Slows while moving up or speeds up while moving down,

$$F_{scale} = m(g + a)$$
$$= (75 \text{ kg})(9.80 \text{ m/s}^2 - 2.0 \text{ m/s}^2)$$
$$= 5.9 \times 10^2 \text{ N}$$

c. Slows while moving up or speeds up while moving down,

$$F_{scale} = m(g + a)$$
$$= (75 \text{ kg})(9.80 \text{ m/s}^2 - 2.0 \text{ m/s}^2)$$
$$= 5.9 \times 10^2 \text{ N}$$

d. $F_{scale} = 7.4 \times 10^2$ N

e. Depends on the magnitude of the acceleration.

14. $F_N = mg = 52$ N

Since the speed is constant, the friction force equals the force exerted by the boy, 36 N. But,

$$F_f = \mu_k F_N$$

$$\text{so } \mu_k = \frac{F_f}{F_N} = \frac{(36 \text{ N})}{(52 \text{ N})} = 0.69$$

15. At constant speed, applied force equals friction force, so

$$F_f = \mu F_N = (0.12)(52 \text{ N} + 650 \text{ N}) = 84 \text{ N}$$

16. The initial velocity is 1.0 m/s, the final velocity 2.0 m/s, and the acceleration 2.0 m/s^2, so

$$t = \frac{(v - v_0)}{a} = \frac{(1.0 \text{ m/s})}{(2.0 \text{ m/s}^2)} = 0.50 \text{ s}$$

17. For a pendulum

$$T = 2\pi\sqrt{\frac{l}{g}}$$

$$\text{so } l = g\left(\frac{T}{2\pi}\right)^2 = 9.80 \text{ m/s}^2\left[\frac{1.00 \text{ s}}{(2)(3.14)}\right]^2$$
$$= 0.248 \text{ m}$$

18. $l = g\left(\frac{T}{2\pi}\right)^2 = (9.80 \text{ m/s}^2)\left(\frac{10.0 \text{ s}}{(2)(3.14)}\right)^2 = 24.8 \text{ m}$

No. This is over 75 feet long!

19. $g = l\left(\frac{2\pi}{T}\right)^2 = (0.65 \text{ m})\left(\frac{(2)(3.14)}{(2.8 \text{ s})}\right)^2 = 3.3 \text{ m/s}^2$

20. The force of your hand on the ball, the gravitational force of Earth's mass on the ball. The force of the ball on your hand, the gravitational force of the ball's mass on Earth. The force of your feet on Earth, the force of Earth on your feet.

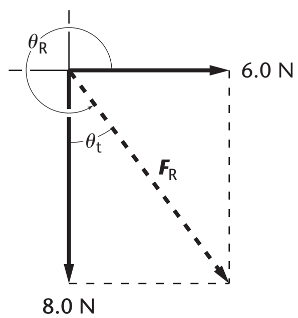
21. The backward (friction) and upward (normal) force of the road on the tires and the gravitational force of Earth's mass on the car. The forward (friction) and the downward force of the tires on the road and the gravitational force of the car's mass on Earth.

Chapter 7

1. $F_A = F_B$

$$F_A = \frac{F_g}{2 \sin \theta} = \frac{168 \text{ N}}{2 \times \sin 42°} = 126 \text{ N}$$

2.



a. $F_R = \sqrt{(6.0 \text{ N})^2 + (8.0 \text{ N})^2} = 1.0 \times 10^1$ N

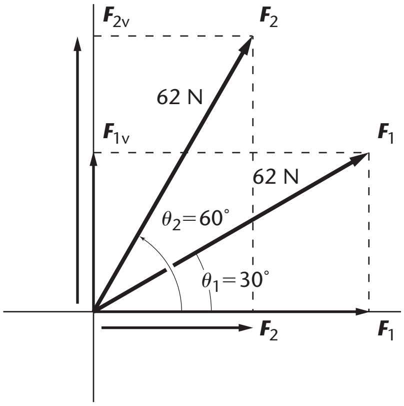
$$\theta_t = \tan^{-1}\left(\frac{6.0}{8.0}\right) = 37°$$

$$\theta_R = 270° + \theta_t = 307° = 310°$$

$$F_R = 1.0 \times 10^1 \text{ N at } 310°$$

b. $F_E = 1.0 \times 10^1$ N at $310° - 180° = 130°$

3.



a. Vector addition is most easily carried out by using the method of addition by components. The first step in this method is the resolution of the given vectors into their horizontal and vertical components.

$F_{1h} = F_1 \cos \theta_1 = (62\ \text{N}) \cos 30° = 54\ \text{N}$

$F_{1v} = F_1 \sin \theta_1 = (62\ \text{N}) \sin 30° = 31\ \text{N}$

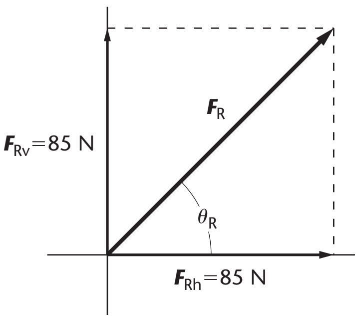
$F_{2h} = F_2 \cos \theta_2 = (62\ \text{N}) \cos 60° = 31\ \text{N}$

$F_{2v} = F_2 \sin \theta_2 = (62\ \text{N}) \sin 60° = 54\ \text{N}$

At this point, the two original vectors have been replaced by four components, vectors that are much easier to add. The horizontal and vertical components of the resultant vector are found by simple addition.

$F_{Rh} = F_{1h} + F_{2h} = 54\ \text{N} + 31\ \text{N} = 85\ \text{N}$

$F_{Rv} = F_{1v} + F_{2v} = 31\ \text{N} + 54\ \text{N} = 85\ \text{N}$



The magnitude and direction of the resultant vector are found by the usual method.

$$F_R = \sqrt{(F_{Rh})^2 + (F_{Rv})^2}$$
$$= \sqrt{(85\ \text{N})^2 + (85\ \text{N})^2} = 120\ \text{N}$$

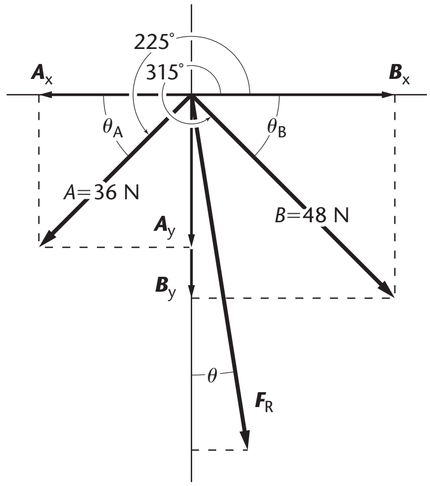
$$\tan \theta_R = \frac{F_{Rv}}{F_{Rh}} = \frac{85\ \text{N}}{85\ \text{N}} = 1.0$$

$\theta_R = 45°$

$F_R = 120\ \text{N at } 45°$

b. $F_E = 120\ \text{N, at } 45° + 180° = 225°$

4.



$\theta_A = 225° - 180° = 45°$

$\theta_B = 360° - 315° = 45°$

$A_x = -A \cos \theta_A = -(36\ \text{N}) \cos 45° = -25\ \text{N}$

$A_y = -A \sin \theta_A = (-36\ \text{N}) \sin 45° = -25\ \text{N}$

$B_x = B \cos \theta_B = (48\ \text{N}) \cos 45° = 34\ \text{N}$

$B_y = -B \sin \theta_B = -(48\ \text{N}) \sin 45° = -34\ \text{N}$

$F_x = A_x + B_x = -25\ \text{N} + 34\ \text{N} = 9\ \text{N}$

$F_y = A_y + B_y = -25\ \text{N} - 34\ \text{N} = -59\ \text{N}$

$$F_R = \sqrt{F_x^2 + F_y^2} = \sqrt{(+9\ \text{N})^2 + (-59\ \text{N})^2}$$
$$= 6.0 \times 10^1\ \text{N}$$

$$\tan \theta = \frac{9}{59} = 0.153 \quad \theta = 9°$$

$\theta_R = 270° + 9° = 279°$

$F_R = 6.0 \times 10^1\ \text{N at } 279°$

$F_E = 6.0 \times 10^1\ \text{N}$

$\theta_E = 279° - 180° = 99°$

5. a. $$a = \frac{F}{m} = \frac{+mg \sin \theta}{m}$$
$$= +g \sin \theta = (+9.80\ \text{m/s}^2)(\sin 30.0°)$$
$$= 4.90\ \text{m/s}^2$$

b. $v = v_0 + at = (4.90\ \text{m/s}^2)(4.00\ \text{s}) = 19.6\ \text{m/s}$

6. $F_{gx} = mg \sin \theta$

$= (62\ \text{kg})(9.80\ \text{m/s}^2)(0.60) = 3.6 \times 10^2\ \text{N}$

$F_{gy} = mg \cos \theta$

$= (62\ \text{kg})(9.80\ \text{m/s}^2)(0.80) = 4.9 \times 10^2\ \text{N}$

7. Since $a = g(\sin \theta - \mu \cos \theta)$,

$a = 9.80\ \text{m/s}^2(0.50 - (0.15)(0.866)) = 4.0\ \text{m/s}^2.$

8. $a = g(\sin\theta - \mu\cos\theta)$

$a = g\sin\theta - g\mu\cos\theta$

If $a = 0$,

$0 = g\sin\theta - g\mu\cos\theta$

$g\mu\cos\theta = g\sin\theta$

$\mu = \dfrac{g\sin\theta}{g\cos\theta} = \dfrac{\sin\theta}{\cos\theta}$

$\mu = \dfrac{\sin 37°}{\cos 37°} = 0.75$

If $a = 0$, velocity would be the same as before.

9. a. Since $v_y = 0$, $y - v_y t = -\frac{1}{2}gt^2$ becomes

$y = -\frac{1}{2}gt^2$

or $t^2 = -\dfrac{2y}{g} = \dfrac{-2(-78.4\text{ m})}{9.80\text{ m/s}^2} = 16\text{ s}^2$

$t = \sqrt{16\text{ s}^2} = 4.0\text{ s}$

b. $x = v_x t = (5.0\text{ m/s})(4.0\text{ s}) = 2.0 \times 10^1\text{ m}$

c. $v_x = 5.0$ m/s. This is the same as the initial horizontal speed because the acceleration of gravity influences only the vertical motion. For the vertical component, use $v = v_0 + gt$ with $v = v_y$ and v_0, the initial vertical component of velocity zero.

At $t = 4.0$ s

$v_y = gt = (9.80\text{ m/s}^2)(4.0\text{ s}) = 39\text{ m/s}$

10. a. (a) no change; 4.0 s

(b) twice the previous distance; 4.0×10^1 m

(c) v_x doubles; 1.0×10^1 m/s
no change in v_y; 39 m/s

b. (a) increases by $\sqrt{2}$, since $t = \sqrt{\dfrac{-2y}{g}}$ and y doubles; 5.7 s

(b) increases by $\sqrt{2}$, since t increases by $\sqrt{2}$; 28 m

(c) no change in v_x; 5.0 m/s
v_y increases by $\sqrt{2}$, since t increases by $\sqrt{2}$; 55 m/s

11. Since $v_y = 0$, $y = -\frac{1}{2}gt^2$ and the time to reach the ground is

$t = \sqrt{\dfrac{-2y}{g}} = \sqrt{\dfrac{-2(-0.950\text{ m})}{9.80\text{m/s}^2}} = 0.440\text{ s}$

From $x = v_x t$,

$v_x = \dfrac{x}{t} = \dfrac{0.352\text{ m}}{0.440\text{ s}} = 0.800\text{ m/s}$

12. $v_x = v_0\cos\theta = (27.0\text{ m/s})\cos 30.0° = 23.4\text{ m/s}$

$v_y = v_0\sin\theta = (27.0\text{ m/s})\sin 30.0° = 13.5\text{ m/s}$

When it lands, $y = v_y t - \frac{1}{2}gt^2 = 0$.

Therefore,

$t = \dfrac{2v_y}{g} = \dfrac{2(13.5\text{ m/s})}{9.80\text{ m/s}^2} = 2.76\text{ s}$

Distance:

$x = v_x t = (23.4\text{ m/s})(2.76\text{ s}) = 64.6\text{ m}$

Maximum height occurs at half the "hang time," or 1.38 s. Thus,

$y = v_y t - \frac{1}{2}gt^2$

$= (13.5\text{ m/s})(1.38\text{ s})$

$\quad - \frac{1}{2}(+9.80\text{ m/s}^2)(1.38\text{ s})^2$

$= 18.6\text{ m} - 9.33\text{ m} = 9.27\text{ m}$

13. Following the method of Practice Problem 5,

$v_x = v_0\cos\theta = (27.0\text{ m/s})\cos 60.0° = 13.5\text{ m/s}$

$v_y = v_0\sin\theta = (27.0\text{ m/s})\sin 60.0° = 23.4\text{ m/s}$

$t = \dfrac{2v_y}{g} = \dfrac{2(23.4\text{ m/s})}{9.80\text{ m/s}^2} = 4.78\text{ s}$

Distance:

$x = v_x t = (13.5\text{ m/s})(4.78\text{ s}) = 64.5\text{ m}$

Maximum height:

at $t = \frac{1}{2}(4.78\text{ s}) = 2.39\text{ s}$

$y = v_y t - \frac{1}{2}gt^2$

$= (23.4\text{ m/s})(2.39\text{ s}) - \frac{1}{2}(+9.80\text{ m/s}^2)(2.39\text{ s})^2$

$= 27.9\text{ m}$

14. a. Since r and T remain the same,

$v = \dfrac{2\pi r}{T}$ and $a = \dfrac{v^2}{r}$

remain the same. The new value of the mass is $m_2 = 2m_1$. The new force is $F_2 = m_2 a = 2m_1 a = 2F_1$, double the original force.

b. The new radius is $r_2 = 2r_1$, so the new velocity is

$v_2 = \dfrac{2\pi r_2}{T} = \dfrac{2\pi(2r_1)}{T} = 2v_1$

twice the original velocity. The new acceleration is

$a_2 = \dfrac{(v_2)^2}{r_2} = \dfrac{(2v_1)^2}{2r_1} = 2a_1$

twice the original. The new force is

$F_2 = ma_2 = m(2a_1) = 2F_1$

twice the original.

c. new velocity,

$$v_2 = \frac{2\pi r}{T_2} = \frac{2\pi\ r}{\left(\frac{1}{2}\ T\right)} = 2v_1$$

twice the original; new acceleration

$$a_2 = \frac{(v_2)^2}{r} = \frac{(2v_1)^2}{r} = 4a_1$$

four times original; new force,

$$F_2 = ma_2 = m(4a_1) = 4F_1$$

four times original

15. a. $a_c = \frac{v^2}{r} = \frac{(8.8\text{ m/s})^2}{25\text{ m}} = 3.1\text{ m/s}^2$

b. The frictional force of the track acting on the runner's shoes exerts the force on the runner.

16. a. $a_c = \frac{v^2}{r} = \frac{(32\text{ m/s})^2}{56\text{ m}} = 18\text{ m/s}^2$

b. Recall $F_f = \mu F_N$. The friction force must supply the centripetal force so $F_f = ma_c$. The normal force is $F_N = -mg$. The coefficient of friction must be at least

$$\mu = \frac{F_f}{F_N} = \frac{ma_c}{mg} = \frac{a_c}{g} = \frac{18\text{ m/s}^2}{9.80\text{ m/s}^2} = 1.8$$

Chapter 8

1. $\left[\frac{T_a}{T_E}\right]^2 = \left[\frac{r_a}{r_E}\right]^3$ with $r_a = 2r_E$

Thus, $T_a = \left[\left(\frac{r_a}{r_E}\right)^3\ T_E^2\right]^{1/2}$

$= \left[\left(\frac{2r_E}{r_E}\right)^3\ (1.0\text{ yr})^2\right]^{1/2} = 2.8\text{ yr}$

2. $\left[\frac{T_M}{T_E}\right]^2 = \left[\frac{r_M}{r_E}\right]^3$ with $r_M = 1.52r_E$

Thus, $T_M^2 = \left[\frac{r_M}{r_E}\right]^3 T_E^2 = \left[\frac{1.52r_E}{r_E}\right]^3 (365\text{ days})^2$

$= 4.68 \times 10^5\text{ days}^2$

$T_M = 684\text{ days}$

3. $\left[\frac{T_s}{T_m}\right]^2 = \left[\frac{r_s}{r_m}\right]^3$

$T_s^2 = \left[\frac{r_s}{r_m}\right]^3 T_m^2 = \left[\frac{6.70 \times 10^3\text{ km}}{3.90 \times 10^5\text{ km}}\right]^3 (27.3\text{ days})^2$

$= 3.78 \times 10^{-3}\text{ days}^2$

$T_s = 6.15 \times 10^{-2}\text{ days} = 88.6\text{ min}$

4. $\left[\frac{T_s}{T_m}\right]^2 = \left[\frac{r_s}{r_m}\right]^3$ so $r_s^3 = r_m^3\left[\frac{T_s}{T_m}\right]^2$

$= (3.90 \times 10^5\text{ km})^3 \left[\frac{1.00}{27.3}\right]^2$

$= 7.96 \times 10^{13}\text{ km}^3$

so $r_s = 4.30 \times 10^4\text{ km}$

5. a. $v = \sqrt{\frac{Gm_E}{r}}$

$= \sqrt{\frac{(6.67 \times 10^{-11}\text{ N}\cdot\text{m}^2/\text{kg}^2)(5.97 \times 10^{24}\text{ kg})}{6.52 \times 10^6}}$

$= 7.81 \times 10^3\text{ m/s}$

b. $T = 2\pi\sqrt{\frac{r^3}{Gm_E}}$

$= 2\pi\sqrt{\frac{(6.52 \times 10^6\text{ m})^3}{(6.67 \times 10^{-11}\text{ N}\cdot\text{m}^2/\text{kg}^2)(5.97 \times 10^{24}\text{ kg})}}$

$= 5.24 \times 10^3\text{ s} = 87.3\text{ min}$

6. a. $v = \sqrt{\frac{Gm_M}{r}}$ with $r = r_M + 265\text{ km}$

$r = 2.44 \times 10^6\text{ m} + 0.265 \times 10^6\text{ m}$

$= 2.71 \times 10^6\text{ m}$

$v = \sqrt{\frac{(6.67 \times 10^{-11}\text{ N}\cdot\text{m}^2/\text{kg}^2)(3.30 \times 10^{23}\text{ kg})}{2.71 \times 10^6\text{ m}}}$

$= 2.85 \times 10^3\text{ m/s}$

b. $T = 2\pi\sqrt{\frac{r^3}{Gm_M}}$

$= 2\pi\sqrt{\frac{(2.71 \times 10^6\text{ m})^3}{(6.67 \times 10^{-11}\text{ N}\cdot\text{m}^2/\text{kg}^2)(3.30 \times 10^{23}\text{ kg})}}$

$= 5.97 \times 10^3\text{ s} = 1.66\text{ h}$

7. $v = \sqrt{\frac{Gm}{r}}$, where here m is the mass of the sun.

$v_M = \sqrt{\frac{(6.67 \times 10^{-11}\text{ N}\cdot\text{m}^2/\text{kg}^2)(1.99 \times 10^{30}\text{ kg})}{5.79 \times 10^{10}\text{ m}}}$

$= 4.79 \times 10^4\text{ m/s}$

$v_S = \sqrt{\frac{(6.67 \times 10^{-11}\text{ N}\cdot\text{m}^2/\text{kg}^2)(1.99 \times 10^{30}\text{ kg})}{1.43 \times 10^{12}\text{ m}}}$

$= 9.63 \times 10^3$ m/s, about 1/5 as fast as Mercury

8. a. Use $T = 2\pi\sqrt{\frac{r^3}{Gm}}$, with

$T = 2.5 \times 10^8\text{ y} = 7.9 \times 10^{15}\text{ s}$

$m = \frac{4\pi^2 r^3}{GT^2}$

$= \frac{4\pi^2(2.2 \times 10^{20}\text{ m})^3}{(6.67 \times 10^{-11}\text{ N}\cdot\text{m}^2/\text{kg}^2)(7.9 \times 10^{15}\text{ s})^2}$

$= 1.0 \times 10^{41}\text{ kg}$

b. number of stars $= \frac{\text{total galaxy mass}}{\text{mass per star}}$

$= \frac{1.0 \times 10^{41}\text{ kg}}{2.0 \times 10^{30}\text{ kg}} = 5.0 \times 10^{10}$

c. $v = \sqrt{\frac{Gm}{r}}$

$= \sqrt{\frac{(6.67 \times 10^{-11}\text{ N}\cdot\text{m}^2/\text{kg}^2)(1.0 \times 10^{41}\text{ kg})}{2.2 \times 10^{20}\text{ m}}}$

$= 1.7 \times 10^5\text{ m/s} = 6.1 \times 10^5\text{ km/h}$

Chapter 9

1. a. 1.00×10^2 km/h = 27.8 m/s

$p = mv = (725\text{ kg})(27.8\text{ m/s})$

$= 2.01 \times 10^4\text{ kg}\cdot\text{m/s}$ eastward

b. $v = \dfrac{p}{m} = \dfrac{(2.01 \times 10^4\text{ kg}\cdot\text{m/s})}{(2175\text{ kg})}$

$= 9.24\text{ m/s} = 33.3\text{ km/h}$ eastward

2. a. Impulse $= F\,\Delta t = (-5.0 \times 10^3\text{ N})(2.0\text{ s})$

$= -1.0 \times 10^4\text{ kg}\cdot\text{m/s}$ westward

The impulse is directed westward and has a magnitude of 1.0×10^4 kg · m/s.

b. $p_1 = mv_1$

$= (725\text{ kg})(27.8\text{ m/s})$

$= 2.01 \times 10^4\text{ kg}\cdot\text{m/s}$ eastward

$F\,\Delta t = \Delta p = p_2 - p_1$

$p_2 = F\,\Delta t + p_1$

$= -1.0 \times 10^4\text{ kg}\cdot\text{m/s} + 2.01 \times 10^4\text{ kg}\cdot\text{m/s}$

$p_2 = 1.0 \times 10^4\text{ kg}\cdot\text{m/s}$ eastward

c. $p_2 = mv_2$

$v_2 = \dfrac{p_2}{m} = \dfrac{1.0 \times 10^4\text{ kg}\cdot\text{m/s}}{725\text{ kg}}$

$= 14\text{ m/s} = 50\text{ km/h}$ eastward

3. a. $p_1 = mv_1 = (7.0\text{ kg})(2.0\text{ m/s}) = 14\text{ kg}\cdot\text{m/s}$

$\text{impulse}_A = (5.0\text{ N})(2.0\text{ s} - 1.0\text{ s})$

$= 5.0\text{ N}\cdot\text{s} = 5.0\text{ kg}\cdot\text{m/s}$

$F\,\Delta t = \Delta p = p_2 - p_1$

$p_2 = F\,\Delta t + p_1$

$p_2 = 5.0\text{ kg}\cdot\text{m/s} + 14\text{ kg}\cdot\text{m/s}$

$= 19\text{ kg}\cdot\text{m/s}$

$p_2 = mv_2$

$v_2 = \dfrac{p_2}{m} = \dfrac{19\text{ kg}\cdot\text{m/s}}{7.0\text{ kg}}$

$= 2.7$ m/s in the same direction

b. impulse $= F\,\Delta t$

$\text{impulse}_B = (-5.0\text{ N})(2.0\text{ s} - 1.0\text{ s})$

$= -5.0\text{ N}\cdot\text{s} = -5.0\text{ kg}\cdot\text{m/s}$

$F\,\Delta t = \Delta p = p_2 - p_1$

$p_2 = F\,\Delta t + p_1$

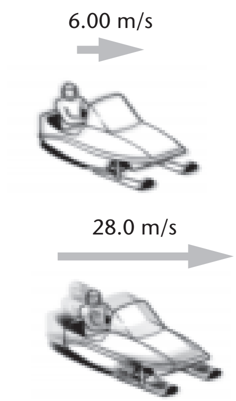
$p_2 = -5.0\text{ kg}\cdot\text{m/s} + 14\text{ kg}\cdot\text{m/s} = 9.0\text{ kg}\cdot\text{m/s}$

$p_2 = mv_2$

$v_2 = \dfrac{p_2}{m} = \dfrac{9.0\text{ kg}\cdot\text{m/s}}{7.0\text{ kg}}$

$= 1.3$ m/s in the same direction

4. a.



b. $\Delta p = F\,\Delta t$

$= m(v_2 - v_1) = 240.0\text{ kg}(28.0\text{ m/s} - 6.00\text{ m/s})$

$= 5.28 \times 10^3\text{ kg}\cdot\text{m/s}$

c. $F = \dfrac{\Delta p}{\Delta t} = \dfrac{(5.28 \times 10^3\text{ kg}\cdot\text{m/s})}{60.0\text{ s}} = 88.0\text{ N}$

5. a. Given: $m = 0.144$ kg
initial velocity,
$v_1 = +38.0$ m/s
final velocity,
$v_2 = -38.0$ m/s

Unknown: impulse

Basic equation: $F\,\Delta t = \Delta p$

b. Take the positive direction to be the direction of the ball after it leaves the bat.

$\Delta p = mv_2 - mv_1 = m(v_2 - v_1)$

$= (0.144\text{ kg})(+38.0\text{ m/s} - (-38.0\text{ m/s}))$

$= (0.144\text{ kg})(76.0\text{ m/s}) = 10.9\text{ kg}\cdot\text{m/s}$

c. $F\,\Delta t = \Delta p = 10.9\ \text{kg}\cdot\text{m/s}$

d. $F\,\Delta t = \Delta p$

so $F = \dfrac{\Delta p}{\Delta t} = \dfrac{10.9\ \text{kg}\cdot\text{m/s}}{8.0\times10^{-4}\ \text{s}} = 1.4\times10^{4}\ \text{N}$

6. a. $p_1 = mv_1 \quad p_2 = 0$

$p_1 = (60\ \text{kg})(26\ \text{m/s}) = 1.6\times10^{3}\ \text{kg}\cdot\text{m/s}$

$F\,\Delta t = \Delta p = p_2 - p_1$

$F = \dfrac{0 - 1.6\times10^{3}\ \text{kg}\cdot\text{m/s}}{0.20\ \text{s}}$

$= 8\times10^{3}$ N opposite to the direction of motion

b. $F_g = mg$

$m = \dfrac{F_g}{g} = \dfrac{8\times10^{3}\ \text{N}}{9.80\ \text{m/s}^2} = 800\ \text{kg}$

Such a mass is too heavy to lift. You cannot safely stop yourself with your arms.

7. $p_1 = p_2$

$(3.0\times10^{5}\ \text{kg})(2.2\ \text{m/s}) = (2)(3.0\times10^{5}\ \text{kg})(v)$

$v = 1.1\ \text{m/s}$

8. $p_{h1} + p_{g1} = p_{h2} + p_{g2}$

$m_h v_{h1} + m_g v_{g1} = m_h v_{h2} + m_g v_{g2}$

Since $v_{g1} = 0$, $m_h v_{h1} = (m_h + m_g)v_2$

where $v_2 = v_{h2} = v_{g2}$ is the common final speed of goalie and puck.

$v_2 = \dfrac{m_h v_{h1}}{(m_h + m_g)} = \dfrac{(0.105\ \text{kg})(24\ \text{m/s})}{(0.105\ \text{kg} + 75\ \text{kg})} = 0.034\ \text{m/s}$

9. $m_b v_{b1} + m_w v_{w1} = (m_b + m_w)v_2$

where v_2 is the common final velocity of bullet and wooden block.

Since $v_{w1} = 0$,

$v_{b1} = \dfrac{(m_b + m_w)v_2}{m_b}$

$= \dfrac{(0.0350\ \text{kg} + 5.0\ \text{kg})(8.6\ \text{m/s})}{(0.0350\ \text{kg})}$

$= 1.2\times10^{3}\ \text{m/s}$

10. $m_b v_{b1} + m_w v_{w1} = m_b v_{b2} + m_w v_{w2}$

with $v_{w1} = 0$

$v_{w2} = \dfrac{(m_b v_{b1} - m_b v_{b2})}{m_w} = \dfrac{m_b(v_{b1} - v_{b2})}{m_w}$

$= \dfrac{(0.0350\ \text{kg})(475\ \text{m/s} - 275\ \text{m/s})}{(2.5\ \text{kg})} = 2.8\ \text{m/s}$

11. $p_{A1} + p_{B1} = p_{A2} + p_{B2}$

so $p_{B2} = p_{B1} + p_{A1} - p_{A2}$

$m_B v_{B2} = m_B v_{B1} + m_A v_{A1} - m_A v_{A2}$

or $v_{B2} = \dfrac{m_B v_{B1} + m_A v_{A1} - m_A v_{A2}}{m_B}$

$= \dfrac{(0.710\ \text{kg})(+0.045\ \text{m/s}) + (0.355\ \text{kg})(+0.095\ \text{m/s})}{0.710\ \text{kg}} - \dfrac{(0.355\ \text{kg})(+0.035\ \text{m/s})}{0.710\ \text{kg}}$

$= 0.075$ m/s in the initial direction

12. $m_A v_{A1} + m_B v_{B1} = m_A v_{A2} + m_B v_{B2}$

so v_{B2}

$= \dfrac{m_A v_{A1} + m_B v_{B1} - m_A v_{A2}}{m_B}$

$= \dfrac{(0.50\ \text{kg})(6.0\ \text{m/s}) + (1.00\ \text{kg})(-12.0\ \text{m/s})}{1.00\ \text{kg}} - \dfrac{(0.50\ \text{kg})(-14\ \text{m/s})}{1.00\ \text{kg}}$

$= 2.0$ m/s, in opposite direction

13. $p_{r1} + p_{f1} = p_{r2} + p_{f2}$ where $p_{r1} + p_{f1} = 0$

If the initial mass of the rocket (including fuel) is $m_r = 4.00$ kg, then the final mass of the rocket is

$m_{r2} = 4.00\ \text{kg} - 0.0500\ \text{kg} = 3.95\ \text{kg}$

$0 = m_{r2}v_{r2} + m_f v_{f2}$

$v_{r2} = \dfrac{-m_f v_{f2}}{m_{r2}}$

$= \dfrac{-(0.0500\ \text{kg})(-625\ \text{m/s})}{(3.95\ \text{kg})} = 7.91\ \text{m/s}$

14. $p_{A1} + p_{B1} = p_{A2} + p_{B2}$ with $p_{A1} = p_{B1} = 0$

$m_B v_{B2} = -m_A v_{A2}$

so $v_{B2} = \dfrac{-m_A v_{A2}}{m_B} = \dfrac{-(1.5\ \text{kg})(-27\ \text{cm/s})}{(4.5\ \text{kg})}$

$= 9.0$ cm/s to the right

15. $p_{A1} + p_{B1} = p_{A2} + p_{B2}$ with $p_{A1} = p_{B1} = 0$

$m_A v_{A2} = -m_B v_{B2}$

so $v_{B2} = \dfrac{-m_A v_{A2}}{m_B} = \dfrac{-(80.0\ \text{kg})(4.0\ \text{m/s})}{(115\ \text{kg})}$

$= 2.8$ m/s in the opposite direction

16. a. Both the cannon and the ball fall to the ground in the same time from the same height. In that fall time, the ball moves 215 m, the cannon an unknown distance we will call x. Now

$t = \dfrac{d}{v}$

so $\dfrac{(215\ \text{m})}{v_{\text{ball}}} = \dfrac{x}{v_{\text{cannon}}}$

so $x = 215\ \text{m}\left[\dfrac{v_{\text{cannon}}}{v_{\text{ball}}}\right]$

Solutions for Practice Problems

related by conservation of momentum;

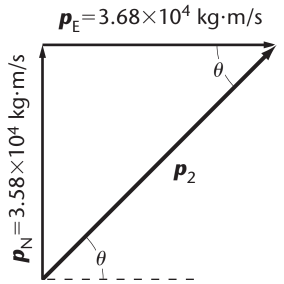
$$(4.5\text{ kg})v_{\text{ball}} = -(225\text{ kg})v_{\text{cannon}}$$

so $\left[\dfrac{-v_{\text{cannon}}}{v_{\text{ball}}}\right] = \dfrac{4.5\text{ kg}}{225\text{ kg}}$

Thus $x = -\left[\dfrac{4.5}{225}(215\text{ m})\right] = -4.3\text{ m}$

b. While on top, the cannon moves with no friction, and its velocity doesn't change, so it can take any amount of time to reach the back edge.

17.



$p_N + p_E = p_2$ (vector sum)

$p_N = m_N v_N = (1325\text{ kg})(27.0\text{ m/s})$
$= 3.58 \times 10^4\text{ kg}\cdot\text{m/s}$

$p_E = m_E v_E = (2165\text{ kg})(17.0\text{ m/s})$
$= 3.68 \times 10^4\text{ kg}\cdot\text{m/s}$

$\tan\theta = \dfrac{p_N}{p_E} = \dfrac{3.58 \times 10^4\text{ kg}\cdot\text{m/s}}{3.68 \times 10^4\text{ kg}\cdot\text{m/s}} = 0.973$

$\theta = 44.2°$ north of east

$(p_2)^2 = (p_N)^2 + (p_E)^2$

$= (3.58 \times 10^4\text{ kg}\cdot\text{m/s})^2 + (3.68 \times 10^4\text{ kg}\cdot\text{m/s})^2$

$= 2.64 \times 10^9\text{ kg}^2\text{ m}^2/\text{s}^2$

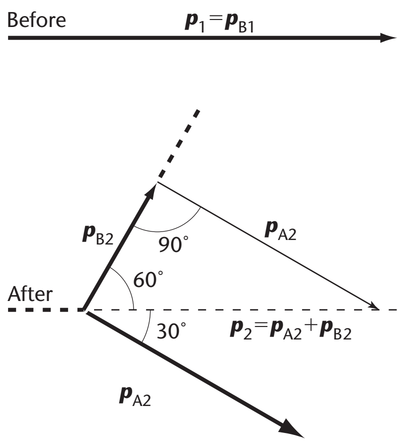
$p_2 = 5.13 \times 10^4\text{ kg}\cdot\text{m/s}$

$p_2 = m_2 v_2 = (m_N + m_E)v_2$

$v_2 = \dfrac{p_2}{(m_N + m_E)} = \dfrac{(5.13 \times 10^4\text{ kg}\cdot\text{m/s})}{(1325\text{ kg} + 2165\text{ kg})}$

$= 14.7\text{ m/s}$

18.



$p_{A1} + p_{B1} = p_{A2} + p_{B2}$ (vector sum) with $p_{A1} = 0$

$m_1 = m_2 = m = 0.17\text{ kg}$

$p_{B1} = m_{B1}v_{B1} = (0.17\text{ kg})(4.0\text{ m/s})$
$= 0.68\text{ kg}\cdot\text{m/s}$

$p_{A2} = p_{B1}\sin 60.0°$ $\qquad mv_{A2} = mv_{B1}\sin 60.0°$

$v_{A2} = v_{B1}\sin 60.0° = (4.0\text{ m/s})\sin 60.0°$
$= 3.5\text{ m/s}$, 30.0° to right

$p_{B2} = p_{B1}\cos 60.0°$ $\qquad mv_{B2} = mv_{B1}\cos 60.0°$

$v_{B2} = v_{B1}\cos 60.0° = (4.0\text{ m/s})\cos 60.0°$
$= 2.0\text{ m/s}$, 60.0° to left

Chapter 10

1. $W = Fd = (185\text{ N})(0.800\text{ m}) = 148$ joules

2. a. $W = Fd = (825\text{ N})(35\text{ m}) = 2.9 \times 10^4\text{ J}$

b. $W = Fd$
$= (2)(825\text{ N})(35\text{ m}) = 5.8 \times 10^4\text{ J}$

The amount of work doubles.

3. $F_g = mg = (0.180\text{ kg})(9.80\text{ m/s}^2) = 1.76\text{ N}$
$W = Fd = (1.76\text{ N})(2.5\text{ m}) = 4.4\text{ J}$

4. $W = Fd = mgd$

so $m = \dfrac{W}{gd} = \dfrac{7.0 \times 10^3\text{ J}}{(9.80\text{ m/s}^2)(1.2\text{ m})} = 6.0 \times 10^2\text{ kg}$

5. Both do the same amount of work. Only the height lifted and the vertical force exerted count.

6. Both the force and displacement are in the same direction, so

$W = Fd = (25\text{ N})(3.5\text{ m}) = 88\text{ J}$

7. a. Since gravity acts vertically, only the vertical displacement needs to be considered.

$W = Fd = (215\text{ N})(4.20\text{ m}) = 903\text{ J}$

b. Force is upward, but vertical displacement is downward, so

$W = Fd\cos\theta = Fd\cos 180°$
$= (215\text{ N})(4.20\text{ m})(\cos 180°) = -903\text{ J}$

8. $W = Fd\cos\theta = (628\text{ N})(15.0\text{ m})(\cos 46.0°)$

$= 6.54 \times 10^3\text{ J}$

9. $P = \dfrac{W}{t} = \dfrac{Fd}{t} = \dfrac{(575\text{ N})(20.0\text{ m})}{10.0\text{ s}}$
$= 1.15 \times 10^3\text{ W} = 1.15\text{ kW}$

10. a. $W = mgd = (7.5\text{ kg})(9.80\text{ m/s}^2)(8.2\text{ m})$
$= 6.0 \times 10^2\text{ J}$

b. $W = Fd + 6.0 \times 10^2$ J

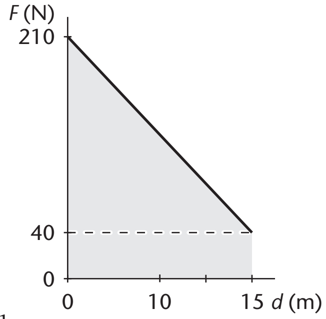
$= (645\text{ N})(8.2\text{ m}) + 6.0 \times 10^2\text{ J} = 5.9 \times 10^3\text{ J}$

c. $P = \dfrac{W}{t} = \dfrac{5.9 \times 10^3\text{ J}}{(30\text{ min})(60\text{ s/min})} = 3\text{ W}$

11. $P = \dfrac{W}{t}$ and $W = Fd$

so $F = \dfrac{Pt}{d} = \dfrac{(65 \times 10^3\text{ W})(35\text{ s})}{17.5\text{ m}} = 1.3 \times 10^5\text{ N}$

12. The work done is the area of the trapezoid under the solid line:



$W = \dfrac{1}{2}d(F_1 + F_2)$

$= \dfrac{1}{2}(15\text{ m})(210\text{ N} + 40\text{ N}) = 1.9 \times 10^3\text{ J}$

13. a. $IMA = \dfrac{d_e}{d_r} = \dfrac{2.0 \times 10^1\text{ cm}}{5.0\text{ cm}} = 4.0$

b. $MA = \dfrac{F_r}{F_e} = \dfrac{1.9 \times 10^4\text{ N}}{9.8 \times 10^3\text{ N}} = 1.9$

c. efficiency $= \left[\dfrac{MA}{IMA}\right] \times 100$

$= \left[\dfrac{1.9}{4.0}\right] \times 100 = 48\%$

14. a. $F_r = mg = (24.0\text{ kg})(9.80\text{ m/s}^2) = 235\text{ N}$

$MA = \dfrac{F_r}{F_e} = \dfrac{235\text{ N}}{129\text{ N}} = 1.82$

b. efficiency $= \left[\dfrac{MA}{IMA}\right] \times 100$ where

$IMA = \dfrac{d_e}{d_r} = \dfrac{33.0\text{ m}}{16.5\text{ m}} = 2.00$

so efficiency $= \dfrac{1.82}{2.00} \times 100 = 91.0\%$

15. efficiency $= \dfrac{W_o}{W_i} \times 100 = \dfrac{F_r d_r}{F_e d_e} \times 100$

so $d_e = \dfrac{F_r d_r(100)}{F_e(\text{efficiency})}$

$= \dfrac{(1.25 \times 10^3\text{ N})(0.13\text{ m})(100)}{(225\text{ N})(88.7\%)} = 0.81\text{ m}$

16. $IMA = \dfrac{8.00\text{ cm}}{35.6\text{ cm}} = 0.225$

$MA = (95.0\%)\dfrac{0.225}{100} = 0.214$

$F_r = (MA)(F_e) = (0.214)(155\text{ N}) = 33.2\text{ N}$

$d_e = (IMA)(d_r) = (0.225)(14.0\text{ cm}) = 3.15\text{ cm}$

All of the above quantities are doubled.

Chapter 11

1. a. $\dfrac{22.0\text{ m}}{\text{s}} \times \dfrac{3600\text{ s}}{1\text{ h}} \times \dfrac{1\text{ km}}{1000\text{ m}} = 79.2\text{ km/h}$

$\dfrac{44.0\text{ m}}{\text{s}} \times \dfrac{3600\text{ s}}{1\text{ h}} \times \dfrac{1\text{ km}}{1000\text{ m}} = 158\text{ km/h}$

b. $W = \Delta K = K_f - K_i$

$= 2.12 \times 10^5\text{ J} - 8.47 \times 10^5\text{ J}$

$= -6.35 \times 10^5\text{ J}$

c. $W = \Delta K = 0 - 8.47 \times 10^5\text{ J}$

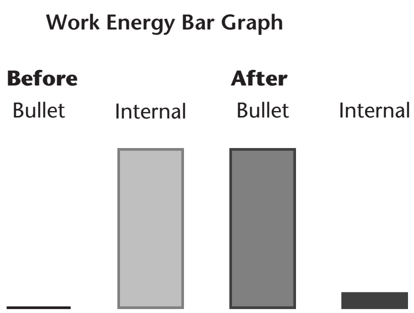
$= -8.47 \times 10^5\text{ J}$

d. $W = Fd$, so distance is proportional to work. The ratio is

$\dfrac{-6.35 \times 10^5\text{ J}}{-2.12 \times 10^5\text{ J}} = 3.00$

It takes three times the distance to slow the car to half its speed than it does to slow it to a complete stop.

2. a.



b. K=0

$K = \dfrac{1}{2}mv^2 = \dfrac{1}{2}(0.00420\text{ kg})(965\text{ m/s})^2$

$= 1.96 \times 10^3\text{ J}$

c. $W = \Delta K = 1.96 \times 10^3\text{ J}$

d. $W = Fd$

so $F = \dfrac{W}{d} = \dfrac{1.96 \times 10^3\text{ J}}{0.75\text{ m}} = 2.6 \times 10^3\text{ N}$

e. $F = \dfrac{W}{d} = \dfrac{\Delta K}{d} = \dfrac{1.96 \times 10^3\text{ J}}{0.015\text{ m}}$

$= 1.3 \times 10^5\text{ N, forward}$

3. a. $K = \frac{1}{2}mv^2$

$= \frac{1}{2}(7.85 \times 10^{11}\ \text{kg})(2.50 \times 10^4\ \text{m/s})^2$

$= 2.45 \times 10^{20}\ \text{J}$

b. $\dfrac{K_{\text{comet}}}{K_{\text{bomb}}} = \dfrac{2.45 \times 10^{20}\ \text{J}}{4.2 \times 10^{15}\ \text{J}} = 5.8 \times 10^4$
bombs would be required

4. a. Since $W_A = \Delta K = \frac{1}{2}mv_A^2$, then $v_A = \sqrt{\dfrac{2W_A}{m}}$

If $W_B = \frac{1}{2}W_A$,

$v_B = \sqrt{\dfrac{2W_B}{m}}$

$= \sqrt{2\left[\frac{1}{2}W_A\right]/m} = \sqrt{\frac{1}{2}}\,v_A$

$= (0.707)(1.0 \times 10^2\ \text{km/h}) = 71\ \text{km/h}$

b. If $W_C = 2W_A$,
$v_C = \sqrt{2}\,(1.0 \times 10^2\ \text{km/h}) = 140\ \text{km/h}$

5. a. $U_g = mgh$
$U_g = (2.00\ \text{kg})(9.80\ \text{m/s}^2)$
$(0.00\ \text{m} - 2.10\ \text{m} + 1.65\ \text{m})$
$U_g = -8.82\ \text{J}$

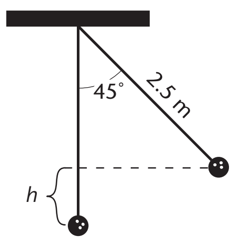
b. $U_g = mgh$
$U_g = (2.00\ \text{kg})(9.80\ \text{m/s}^2)(0.00\ \text{m} - 2.10\ \text{m})$
$U_g = -41.2\ \text{J}$

6. $U_g = mgh$
At the edge,
$U_g = (90\ \text{kg})(9.80\ \text{m/s}^2)(+45\ \text{m}) = 4 \times 10^4\ \text{J}$
At the bottom,
$U_g = (90\ \text{kg})(9.80\ \text{m/s}^2)(+45\ \text{m} - 85\ \text{m})$
$= -4 \times 10^4\ \text{J}$

7. a. $U_g = mgh = (50.0\ \text{kg})(9.80\ \text{m/s}^2)(425\ \text{m})$
$= 2.08 \times 10^5\ \text{J}$

b. $\Delta U_g = mgh_f - mgh_i = mg(h_f - h_i)$
$= (50.0\ \text{kg})(9.80\ \text{m/s}^2)(225\ \text{m} - 425\ \text{m})$
$= -9.80 \times 10^4\ \text{J}$

8.



a. $h = (2.5\ \text{m})(1 - \cos\theta) = 0.73\ \text{m}$
$U_g = mgh = (7.26\ \text{kg})(9.80\ \text{m/s}^2)(0.73\ \text{m}) = 52\ \text{J}$

b. the height of the ball when the rope was vertical

9. a. The system is the bike + rider + Earth. No external forces, so total energy is conserved.

b. $K = \frac{1}{2}mv^2$

$= \frac{1}{2}(85\ \text{kg})(8.5\ \text{m/s})^2 = 3.1 \times 10^3\ \text{J}$

c. $K_{\text{before}} + U_{\text{g before}} = K_{\text{after}} + U_{\text{g after}}$

$\frac{1}{2}mv^2 + 0 = 0 + mgh,$

$h = \dfrac{v^2}{2g} = \dfrac{(8.5\ \text{m/s})^2}{(2)(9.80\ \text{m/s}^2)} = 3.7\ \text{m}$

d. No. It cancels because both K and U_g are proportional to m.

10. a. $K_{\text{before}} + U_{\text{g before}} = K_{\text{after}} + U_{\text{g after}}$

$0 + mgh = \frac{1}{2}mv^2 + 0$

$v^2 = 2gh = 2(9.80\ \text{m/s}^2)(4.0\ \text{m}) = 78.4\ \text{m}^2/\text{s}^2$

$v = 8.9\ \text{m/s}$

b. No **c.** No

11. a. $K_{\text{before}} + U_{\text{g before}} = K_{\text{after}} + U_{\text{g after}}$

$0 + mgh = \frac{1}{2}mv^2 + 0$

$v^2 = 2gh = 2(9.80\ \text{m/s}^2)(45\ \text{m}) = 880\ \text{m}^2/\text{s}^2$

$v = 3.0 \times 10^1\ \text{m/s}$

b. $K_{\text{before}} + U_{\text{g before}} = K_{\text{after}} + U_{\text{g after}}$

$0 + mgh_i = \frac{1}{2}mv^2 + mgh_f$

$v^2 = 2g(h_i - h_f)$

$= 2(9.80\ \text{m/s}^2)(45\ \text{m} - 40\ \text{m}) = 98\ \text{m}^2/\text{s}^2$

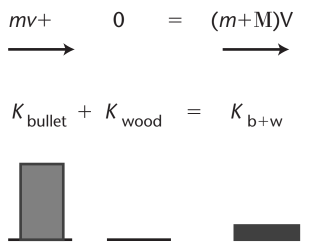
$v = 10\ \text{m/s}$

c. No

12. a. The system of Earth, bike, and rider remains the same, but now the energy involved is not mechanical energy alone. The rider must be considered as having stored energy, some of which is converted to mechanical energy.

b. Energy came from the chemical potential energy stored in the rider's body.

13. a.



b. From the conservation of momentum,

$$mv = (m + M)V$$

so $$V = \frac{mv}{m + M}$$

$$= \frac{(0.00200\text{ kg})(538\text{ m/s})}{0.00200\text{ kg} + 0.250\text{ kg}} = 4.27\text{ m/s}$$

c. $K = \frac{1}{2}mv^2 = \frac{1}{2}(0.00200\text{ kg})(538\text{ m/s})^2 = 289\text{ J}$

d. $K_f = \frac{1}{2}(m + M)V^2$

$$= \frac{1}{2}(0.00200\text{ kg} + 0.250\text{ kg})(4.27\text{ m/s})^2$$

$$= 2.30\text{ J}$$

e. $\%K\text{ lost} = \left(\frac{\Delta K}{K_i}\right) \times 100$

$$= \left(\frac{287\text{ J}}{289\text{ J}}\right) \times 100 = 99.3\%$$

14. Conservation of momentum $mv = (m + M)V$, or

$$v = \frac{(m + M)V}{m}$$

$$= \frac{(0.00800\text{ kg} + 9.00\text{ kg})(0.100\text{ m/s})}{0.00800\text{ kg}}$$

$$= 112.6\text{ m/s} = 113\text{ m/s}$$

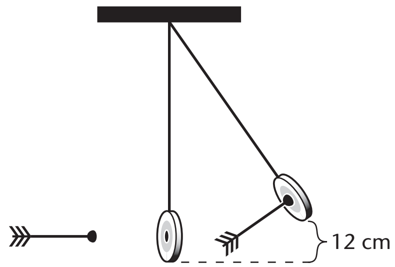
15. This is a conservation of momentum question.

$$mv_i + MV_i = mv_f + MV_f$$

where m, v_i, v_f refer to the bullet and M, V_i, V_f to Superman. The final momentum is the same as the initial momentum because the frictionless superfeet mean there are no external forces. The final momentum is that of Superman alone because the horizontal velocity of the bullet is zero. $V_i = 0$ m/s and $v_f = 0$ m/s which gives $mv_i = MV_f$

$$V_f = \frac{mv_i}{M} = \frac{(0.0042\text{ kg})(835\text{ m/s})}{104\text{ kg}} = 0.034\text{ m/s}$$

16. a.



b. Only momentum is conserved in the inelastic dart-target collision, so

$$mv_i + MV_i = (m + M)V_f$$

where $V_i = 0$ since the target is initially at rest and V_f is the common velocity just after impact. As the dart-target combination swings upward, energy is conserved so $\Delta U_g = \Delta K$ or, at the top of the swing,

$$(m + M)gh = \frac{1}{2}(m + M)V_f^2$$

c. Solving this for V_f and inserting into the momentum equation gives

$$v_i = (m + M)\,\frac{\sqrt{2gh_f}}{m}$$

$$= \frac{(0.025\text{ kg} + 0.73\text{ kg})\sqrt{2(9.8\text{ m/s}^2)(0.12\text{ m})}}{0.025\text{ kg}}$$

$$= 46\text{ m/s}$$

Chapter 12

1. a. $T_K = T_C + 273 = 0 + 273 = 273$ K

b. $T_C = T_K - 273 = 0 - 273 = -273$°C

c. $T_K = T_C + 273 = 273 + 273 = 546$ K

d. $T_C = T_K - 273 = 273 - 273 = 0$°C

2. a. $T_K = T_C + 273 = 27 + 273 = 3.00 \times 10^2$ K

b. $T_K = T_C + 273 = 150 + 273 = 4.23 \times 10^2$ K

c. $T_K = T_C + 273 = 560 + 273 = 8.33 \times 10^2$ K

d. $T_K = T_C + 273 = -50 + 273 = 2.23 \times 10^2$ K

e. $T_K = T_C + 273 = -184 + 273 = 89$ K

f. $T_K = T_C + 273 = -300 + 273 = -27$ K

impossible temperature—below absolute zero

3. a. $T_C = T_K - 273 = 110 - 273 = -163$ °C

b. $T_C = T_K - 273 = 70 - 273 = -203$ °C

c. $T_C = T_K - 273 = 22 - 273 = -251$°C

d. $T_C = T_K - 273 = 402 - 273 = 129$°C

e. $T_C = T_K - 273 = 323 - 273 = 5.0 \times 10^1\ °C$

f. $T_C = T_K - 273 = 212 - 273 = -61°C$

4. a. about 72°F is about 22°C, 295 K

b. about 40°F is about 4°C, 277 K

c. about 86°F is about 30°C, 303 K

d. about 0°F is about –18°C, 255 K

5. $Q = mC\Delta T$

$= (0.0600\ kg)(385\ J/kg \cdot °C)(80.0°C - 20.0°C)$

$= 1.39 \times 10^3\ J$

6. a. $Q = mC\Delta T$

$$\Delta T = \frac{Q}{mC} = \frac{836.0 \times 10^3\ J}{(20.0\ kg)(4180\ J/kg \cdot °C)} = 10.0°C$$

b. Using 1 L = 1000 cm^3, the mass of methanol required is

$m = \rho V = (0.80\ g/cm^3)(20.0\ L)(1000\ cm^3/L)$

$= 16\,000\ g$ or $16\ kg$

$$\Delta T = \frac{Q}{mC} = \frac{836.0 \times 10^3\ J}{(16\ kg)(2450\ J/kg \cdot °C)} = 21°C$$

c. Water is the better coolant since its temperature increase is less than half that of methanol when absorbing the same amount of heat.

7. $m_A C_A(T_f - T_{Ai}) + m_B C_B(T_f - T_{Bi}) = 0$

Since $m_A = m_B$ and $C_A = C_B$, there is cancellation in this particular case so that

$$T_f = \frac{(T_{Ai} + T_{Bi})}{2} = \frac{(80.0°C + 10.0°C)}{2} = 45.0°C$$

8. $m_A C_A(T_f - T_{Ai}) + m_W C_W(T_f - T_{Wi}) = 0$

Since, in this particular case, $m_A = m_W$, the masses cancel and

$$T_f = \frac{C_A T_{Ai} + C_W T_{Wi}}{C_A + C_W}$$

$$= \frac{(2450\ J/kg \cdot K)(16.0°C) + (4180\ J/kg \cdot K)(85.0°C)}{2450\ J/kg \cdot K + 4180\ J/kg \cdot K}$$

$= 59.5°C$

9. $m_B C_B(T_f - T_{Bi}) + m_W C_W(T_f - T_{Wi}) = 0$

$$T_f = \frac{m_B C_B T_{Bi} + m_W C_W T_{Wi}}{m_B C_B + m_W C_W}$$

$$= \frac{(0.100\ kg)(376\ J/kg \cdot K)(90.0°C)}{(0.100\ kg)(376\ J/kg \cdot K) + (0.200\ kg)(4180\ J/kg \cdot K)}$$

$$+ \frac{(0.200\ kg)(4180\ J/kg \cdot K)(20.0°C)}{(0.100\ kg)(376\ J/kg \cdot K) + (0.200\ kg)(4180\ J/kg \cdot K)}$$

$= 23.0°C$

10. $m_A C_A(T_f - T_{Ai}) + m_W C_W(T_f - T_{Wi}) = 0$

Since $m_A = m_W$, the masses cancel and

$$C_A = \frac{-C_W(T_f - T_{Wi})}{(T_f - T_{Ai})}$$

$$= \frac{-(4180\ J/kg \cdot K)(25.0°C - 10.0°C)}{(25.0°C - 100.0°C)}$$

$= 836\ J/kg \cdot K$

11. To warm the ice to 0.0°C:

$Q_W = mC\Delta T$

$= (0.100\ kg)(2060\ J/kg \cdot °C)(0.0° - (-20.0°C))$

$= 4120\ J = 0.41 \times 10^5\ J$

To melt the ice:

$Q_M = mH_f = (0.100\ kg)(3.34 \times 10^5\ J/kg)$

$= 3.34 \times 10^4\ J$

Total heat required:

$Q = Q_W + Q_M = 0.41 \times 10^4\ J + 3.34 \times 10^4\ J$

$= 3.75 \times 10^4\ J$

12. To heat the water from 60.0°C to 100.0°C:

$Q_1 = mC\Delta T$

$= (0.200\ kg)(4180\ J/kg \cdot °C)(40.0°C)$

$= 0.334 \times 10^5\ J$

To change the water to steam:

$Q_2 = mH_v = (0.200\ kg)(2.26 \times 10^6\ J/kg)$

$= 4.52 \times 10^5\ J$

To heat the steam from 100.0°C to 140.0°C:

$Q_3 = mC\Delta T$

$= (0.200\ kg)(2020\ J/kg \cdot °C)(40.0°C)$

$= 0.162 \times 10^5\ J$

$Q_{total} = Q_1 + Q_2 + Q_3 = 5.02 \times 10^5\ J$

13. Warm ice from –30.0°C to 0.0°C:

$Q_1 = mC\Delta T$

$= (0.300\ kg)(2060\ J/kg \cdot °C)(30.0°C)$

$= 0.185 \times 10^5\ J$

Melt ice:

$Q_2 = mH_f = (0.300\ kg)(3.34 \times 10^5\ J/kg)$

$= 1.00 \times 10^5\ J$

Heat water 0.0°C to 100.0°C:

$Q_3 = mC\Delta T$

$= (0.300\ kg)(4180\ J/kg \cdot °C)(100.0°C)$

$= 1.25 \times 10^5\ J$

Vaporize water:

$Q_4 = mH_v = (0.300\ kg)(2.26 \times 10^6\ J/kg)$

$= 6.78 \times 10^5\ J$

Heat steam 100.0°C to 130.0°C:

$Q_5 = mC\Delta T$

$= (0.300 \text{ kg})(2020 \text{ J/kg}\cdot°\text{C})(30.0°\text{C})$

$= 0.182 \times 10^5 \text{ J}$

$Q_{total} = Q_1 + Q_2 + Q_3 + Q_4 + Q_5 = 9.40 \times 10^5 \text{ J}$

14. a. To freeze, lead must absorb

$Q = -mH_f = -(0.175 \text{ kg})(2.04 \times 10^4 \text{ J/kg})$

$= -3.57 \times 10^3 \text{ J}$

This will heat the water

$$\Delta T = \frac{Q}{mC} = \frac{3.57 \times 10^3 \text{ J}}{(0.055 \text{ kg})(4180 \text{ J/kg}\cdot°\text{C})} = 16°\text{C}$$

$T = T_i + \Delta T = 20.0°\text{C} + 16°\text{C} = 36°\text{C}$

b. Now, $T_f = (m_A C_A T_{Ai} + m_B C_B T_{Bi})/(m_A C_A + m_B C_B)$

$$= \frac{(0.175 \text{ kg})(130 \text{ J/kg}\cdot\text{K})(327°\text{C})}{(0.175 \text{ kg})(130 \text{ J/kg}\cdot\text{K}) + (0.055 \text{ kg})(4180 \text{ J/kg}\cdot\text{K})}$$

$$+ \frac{(0.055 \text{ kg})(4180 \text{ J/kg}\cdot\text{K})(36.0°\text{C})}{(0.175 \text{ kg})(130 \text{ J/kg}\cdot\text{K}) + (0.055 \text{ kg})(4180 \text{ J/kg}\cdot\text{K})}$$

$= 62°\text{C}$

Chapter 13

1. $P = \dfrac{F}{A}$

so $F = PA = (1.0 \times 10^5 \text{ Pa})(1.52 \text{ m})(0.76 \text{ m})$

$= 1.2 \times 10^5 \text{ N}$

2. $F = mg$

$A = 4(l \times w)$

$$P = \frac{F}{A} = \frac{(925 \text{ kg})(9.80 \text{ m/s}^2)}{(4)(0.12 \text{ m})(0.18 \text{ m})}$$

$= 1.0 \times 10^5 \text{ N/m}^2 = 1.0 \times 10^5 \text{ Pa}$

3. $F_g = (11.8 \text{ g/cm}^3)(10^{-3} \text{ kg/g})(5.0 \text{ cm}) \times (10.0 \text{ cm})(20.0 \text{ cm})(9.80 \text{ m/s}^2)$

$= 116 \text{ N}$

$A = (0.050 \text{ m})(0.100 \text{ m}) = 0.0050 \text{ m}^2$

$$P = \frac{F}{A} = \frac{116 \text{ N}}{0.0050 \text{ m}^2} = 23 \text{ kPa}$$

4. $F_{net} = F_{outside} - F_{inside}$

$= (P_{outside} - P_{inside})A$

$= (0.85 \times 10^5 \text{ Pa} - 1.00 \times 10^5 \text{ Pa}) \times (1.82 \text{ m})(0.91 \text{ m})$

$= -2.5 \times 10^4 \text{ N}$ (toward the outside)

5. $\dfrac{F_1}{A_1} = \dfrac{F_2}{A_2}$

$$F_1 = \frac{F_2 A_1}{A_2} = \frac{(1600 \text{ N})(72 \text{ cm}^2)}{(1440 \text{ cm}^2)} = 8.0 \times 10^1 \text{ N}$$

6. $F_g = F_{buoyant} = \rho_{water} Vg$

$$V = \frac{F_g}{\rho_{water} g}$$

$$= \frac{600 \text{ N}}{(1000 \text{ kg/m}^3)(9.80 \text{ m/s}^2)} = 0.06 \text{ m}^3$$

This volume does not include that portion of her head that is above the water.

7. $F_T + F_{buoyant} = F_g$ where F_g is the air weight of the camera.

$F_T = F_g - F_{buoyant} = F_g - \rho_{water} Vg$

$= 1250 \text{ N} - (1000 \text{ kg/m}^3)(0.083 \text{ m}^3)(9.80 \text{ m/s}^2)$

$= 4.4 \times 10^2 \text{ N}$

8. $\Delta L = \alpha L_i \Delta T$

$= [25 \times 10^{-6}(°\text{C})^{-1}](3.66 \text{ m})(67°\text{C})$

$= 6.1 \times 10^{-3} \text{ m}$, or 6.1 mm

9. $L_2 = L_1 + \alpha L_1(T_2 - T_1)$

$= (11.5 \text{ m}) + [12 \times 10^{-6}(°\text{C})^{-1}](11.5 \text{ m}) \times (1221°\text{C} - 22°\text{C})$

$= 12 \text{ m}$

10. a. For water $\beta = 210 \times 10^{-6}(°\text{C})^{-1}$, so

$\Delta V = \beta V \Delta T$

$= [210 \times 10^{-6}(°\text{C})^{-1}](354 \text{ mL})(30.1°\text{C})$

$= 2.2 \text{ mL}$

$V = 354 \text{ mL} + 2.2 \text{ mL} = 356 \text{ mL}$

b. For Al $\beta = 75 \times 10^{-6}(°\text{C})^{-1}$, so

$\Delta V = \beta V \Delta T$

$= [75 \times 10^{-6}(°\text{C})^{-1}](354 \text{ mL})(30.1°\text{C})$

$= 0.80 \text{ mL}$

$V = 354 \text{ mL} + 0.80 \text{ mL} = 355 \text{ mL}$

c. The difference will spill,

$2.2 \text{ mL} - 0.80 \text{ mL} = 1.4 \text{ mL}$

11. a. $V_2 = V_1 + \beta V_1(T_2 - T_1)$

$= 45\,725 \text{ L} + [950 \times 10^{-6}(°\text{C})^{-1}] \times (45\,725 \text{ L})(-18.0°\text{C} - 32.0°\text{C})$

$= 43\,553 \text{ L} = 43\,600 \text{ L}$

b. Its volume has decreased because of a temperature decrease.

Chapter 14

1. a. $v = \dfrac{d}{t} = \dfrac{515 \text{ m}}{1.50 \text{ s}} = 343 \text{ m/s}$

b. $T = \dfrac{1}{f} = \dfrac{1}{436 \text{ Hz}} = 2.29 \text{ ms}$

c. $\lambda = \frac{v}{f} = \frac{d}{ft}$

$$\lambda = \frac{515 \text{ m}}{(436 \text{ Hz})(1.50 \text{ s})} = 0.787 \text{ m}$$

2. a. $v = \frac{d}{t} = \frac{685 \text{ m}}{2.00 \text{ s}} = 343 \text{ m/s}$

b. $v = \lambda f$

$$f = \frac{v}{\lambda} = \frac{343 \text{ m/s}}{0.750 \text{ m}} = 457 \text{ s}^{-1}, \text{ or } 457 \text{ Hz}$$

c. $T = \frac{1}{f} = \frac{1}{457 \text{ s}^{-1}} = 2.19 \times 10^{-3} \text{ s, or } 2.19 \text{ ms}$

3. at a lower frequency, because wavelength varies inversely with frequency

4. $v = \lambda f = (0.600 \text{ m})(2.50 \text{ Hz}) = 1.50 \text{ m/s}$

5. $\lambda = \frac{v}{f} = \frac{15.0 \text{ m/s}}{5.00 \text{ Hz}} = 3.00 \text{ m}$

6. $\frac{0.100 \text{ s}}{5 \text{ pulses}} = 0.0200 \text{ s/pulse, so } T = 0.0200 \text{ s}$

$$v = \frac{\lambda}{T} = \frac{1.20 \text{ cm}}{0.0200 \text{ s}} = 60.0 \text{ cm/s} = 0.600 \text{ m/s}$$

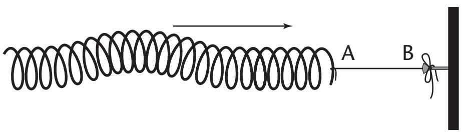
7. $v = \lambda f = (0.400 \text{ m})(20.0 \text{ Hz}) = 8.00 \text{ m/s}$

8. a. The pulse is partially reflected, partially transmitted.

b. erect, because reflection is from a less dense medium

c. It is almost totally reflected from the wall.

d. inverted, because reflection is from a more dense medium



9. Pulse inversion means rigid boundary; attached to wall.

10. a. The pulse is partially reflected, partially transmitted; it is almost totally reflected from the wall.

b. inverted, because reflection is from a more dense medium; inverted, because reflection is from a more dense medium

Chapter 15

1. $v = \lambda f$

so $f = \frac{v}{\lambda} = \frac{343 \text{ m/s}}{0.667 \text{ m}} = 514 \text{ Hz}$

2. From $v = \lambda f$ the largest wavelength is

$$\lambda = \frac{v}{f} = \frac{343 \text{ m/s}}{20 \text{ Hz}} = 17 \text{ m} = 20 \text{ m}$$

the smallest is

$$\lambda = \frac{v}{f} = \frac{343 \text{ m/s}}{16000 \text{ Hz}} = 0.021 \text{ m}$$

3. Assume that $v = 343$ m/s

$$2d = vt = (343 \text{ m/s})(0.20 \text{ s}) = 68.6 \text{ m}$$

$$d = \frac{68.6 \text{ m}}{2} = 34 \text{ m}$$

4. Woofer diameter 38 cm:

$$f = \frac{v}{\lambda} = \frac{343 \text{ m/s}}{0.38 \text{ m}} = 0.90 \text{ kHz}$$

Tweeter diameter 7.6 cm:

$$f = \frac{v}{\lambda} = \frac{343 \text{ m/s}}{0.076 \text{ m}} = 4.5 \text{ kHz}$$

5. Resonance spacing is $\frac{\lambda}{2}$ so using $v = \lambda f$ the resonance spacing is

$$\frac{\lambda}{2} = \frac{v}{2f} = \frac{343 \text{ m/s}}{2(440 \text{ Hz})} = 0.39 \text{ m}$$

6. Resonance spacing $= \frac{\lambda}{2} = 1.10$ m so

$\lambda = 2.20$ m

and $v = \lambda f = (2.20 \text{ m})(440 \text{ Hz}) = 970 \text{ m/s}$

7. From the previous Example Problem $v = 347$ m/s at 27°C and the resonance spacing gives

$$\frac{\lambda}{2} = 0.202 \text{ m}$$

or $\lambda = 0.404$ m

Using $v = \lambda f$,

$$f = \frac{v}{\lambda} = \frac{347 \text{ m/s}}{0.404 \text{ m}} = 859 \text{ Hz}$$

8. a. $\lambda_1 = 2L = 2(2.65 \text{ m}) = 5.30 \text{ m}$

so that the lowest frequency is

$$f_1 = \frac{v}{\lambda_1} = \frac{343 \text{ m/s}}{5.30 \text{ m}} = 64.7 \text{ Hz}$$

b. $f_2 = \frac{v}{\lambda_2} = \frac{v}{L} = \frac{343 \text{ m/s}}{2.65 \text{ m}} = 129 \text{ Hz}$

$$f_3 = \frac{v}{\lambda_3} = \frac{3v}{2L} = \frac{3(343 \text{ m/s})}{2(2.65 \text{ m})} = 194 \text{ Hz}$$

9. The lowest resonant frequency corresponds to the wavelength given by $\frac{\lambda}{2} = L$, the length of the pipe.

$\lambda = 2L = 2(0.65 \text{ m}) = 1.3 \text{ m}$

so $f = \frac{v}{\lambda} = \frac{343 \text{ m/s}}{1.3 \text{ m}} = 260 \text{ Hz}$

10. Beat frequency $= |f_2 - f_1|$

$= |333.0 \text{ Hz} - 330.0 \text{ Hz}| = 3.0 \text{ Hz}$

Chapter 16

1. $c = \lambda f$

so $f = \frac{c}{\lambda} = \frac{(3.00 \times 10^8\ \text{m/s})}{(556 \times 10^{-9}\ \text{m})} = 5.40 \times 10^{14}\ \text{Hz}$

2. $d = ct = (3.00 \times 10^8\ \text{m/s})(1.00 \times 10^{-9}\ \text{s}) \times (3.28\ \text{ft/1 m})$

$= 0.984\ \text{ft}$

3. a. $d = ct = (3.00 \times 10^8\ \text{m/s})(6.0 \times 10^{-15}\ \text{s})$

$= 1.8 \times 10^{-6}\ \text{m}$

b. Number of wavelengths $= \frac{\text{pulse length}}{\lambda_{\text{violet}}}$

$= \frac{1.8 \times 10^{-6}\ \text{m}}{4.0 \times 10^{-7}\ \text{m}}$

$= 4.5$

4. $d = ct = (299\ 792\ 458\ \text{m/s})\left(\frac{1}{2}\right)(2.562\ \text{s})$

$= 3.840 \times 10^8\ \text{m}$

5. $v = \frac{d}{t} = \frac{(3.0 \times 10^{11}\ \text{m})}{(16\ \text{min})(60\ \text{s/min})} = 3.1 \times 10^8\ \text{m/s}$

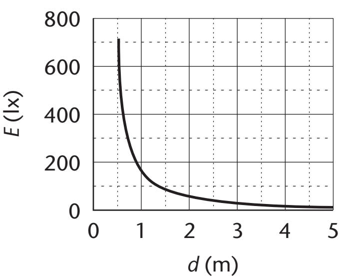
6. $\frac{E_{\text{after}}}{E_{\text{before}}} = \frac{P/4\pi d^2_{\text{after}}}{P/4\pi d^2_{\text{before}}} = \frac{d^2_{\text{before}}}{d^2_{\text{after}}} = \frac{(30\ \text{cm})^2}{(90\ \text{cm})^2} = \frac{1}{9}$

7. $E = \frac{P}{4\pi d^2} = \frac{2275\ \text{lm}}{4\pi(3.0\ \text{m})^2} = 2.0 \times 10^1\ \text{lx}$

8. Illuminance of a 150-watt bulb

$P = 2275,\ d = 0.5, 0.75, \ldots, 5$

$E(d) = \frac{P}{4\pi d^2}$



9. $P = 4\pi I = 4\pi(64\ \text{cd}) = 256\pi\ \text{lm}$

so $E = \frac{P}{4\pi d^2} = \frac{256\pi\ \text{lm}}{4\pi(3.0\ \text{m})^2} = 7.1\ \text{lx}$

10. From $E = \frac{P}{4\pi d^2}$

$P = 4\pi d^2 E = 4\pi(4.0\ \text{m})^2(2.0 \times 10^1\ \text{lx})$

$= 1280\pi\ \ \text{lm}$

so $I = \frac{P}{4\pi d^2} = \frac{1280\pi\ \text{lm}}{4\pi} = 3.2 \times 10^2\ \text{cd} = 320\ \text{cd}$

11. $E = \frac{P}{4\pi d^2}$

$P = 4\pi E d^2 = 4\pi(160\ \text{lm/m}^2)(2.0\ \text{m})^2$

$= 8.0 \times 10^3\ \text{lm}$

Chapter 17

1. The light is incident from air. From $n_{\text{i}} \sin \theta_{\text{i}} = n_{\text{r}} \sin \theta_{\text{r}}$,

$\sin \theta_{\text{r}} = \frac{n_{\text{i}} \sin \theta_{\text{i}}}{n_{\text{r}}} = \frac{(1.00) \sin 45.0°}{1.52}$

$= 0.465$, or $\theta_r = 27.7°$

2. $n_{\text{i}} \sin \theta_{\text{i}} = n_{\text{r}} \sin \theta_{\text{r}}$

so $\sin \theta_{\text{r}} = \frac{n_{\text{i}} \sin \theta_{\text{i}}}{n_{\text{r}}} = \frac{(1.00) \sin 30.0°}{1.33} = 0.376$

or $\theta_{\text{r}} = 22.1°$

3. a. Assume the light is incident from air.

$n_{\text{i}} \sin \theta_{\text{i}} = n_{\text{r}} \sin \theta_{\text{r}}$ gives

$\sin \theta_{\text{r}} = \frac{n_{\text{i}} \sin \theta_{\text{i}}}{n_{\text{r}}} = \frac{(1.00) \sin 45.0°}{2.42} = 0.292$

or $\theta_{\text{r}} = 17.0°$

b. Diamond bends the light more.

4. $n_1 \sin \theta_1 = n_2 \sin \theta_2$

so $n_2 = \frac{n_1 \sin \theta_1}{\sin \theta_2} = \frac{(1.33)(\sin 31°)}{\sin 27°} = 1.51$

5. a. $v_{\text{ethanol}} = \frac{c}{n_{\text{ethanol}}} = \frac{3.00 \times 10^8\ \text{m/s}}{1.36}$

$= 2.21 \times 10^8\ \text{m/s}$

b. $v_{\text{quartz}} = \frac{c}{n_{\text{quartz}}} = \frac{3.00 \times 10^8\ \text{m/s}}{1.54}$

$= 1.95 \times 10^8\ \text{m/s}$

c. $v_{\text{flint glass}} = \frac{c}{n_{\text{flint glass}}} = \frac{3.00 \times 10^8\ \text{m/s}}{1.61}$

$= 1.86 \times 10^8\ \text{m/s}$

6. $n = \frac{c}{v} = \frac{3.00 \times 10^8\ \text{m/s}}{2.00 \times 10^8\ \text{m/s}} = 1.50$

7. $n = 1.51$

so $v = \frac{c}{n} = \frac{3.00 \times 10^8\ \text{m/s}}{1.51} = 1.99 \times 10^8\ \text{m/s}$

8. $t = \frac{d}{v} = \frac{dn}{c}$

$\Delta t = \frac{d(n_{\text{air}} - n_{\text{vacuum}})}{c}$

$= \frac{d(1.0003 - 1.0000)}{3.00 \times 10^8\ \text{m/s}} = d(1.00 \times 10^{-12}\ \text{s/m})$

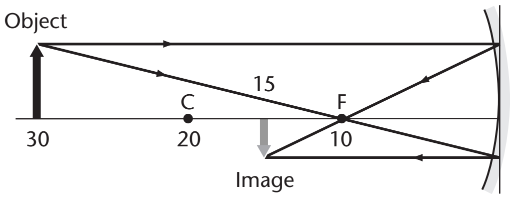
Solutions for Practice Problems

$$\text{Thus, } d = \frac{\Delta t}{1.00 \times 10^{-12}\text{ s/m}}$$
$$= \frac{1 \times 10^{-8}\text{ s}}{1.00 \times 10^{-12}\text{ s/m}} = 10^4\text{ m} = 10\text{ km}$$

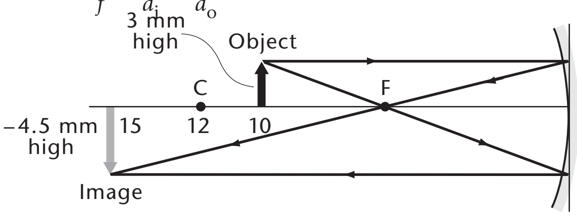
Chapter 18

1.

2. a.

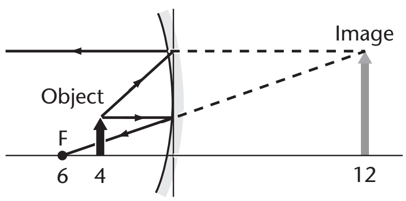


b. $\frac{1}{f} = \frac{1}{d_i} + \frac{1}{d_o}$



$$\frac{1}{6.0} = \frac{1}{d_i} + \frac{1}{10.0}$$
$$\frac{1}{d_i} = \frac{1}{6.0} - \frac{1}{10.0}$$
$$d_i = \frac{1}{\frac{1}{6.0} - \frac{1}{10.0}} = 15\text{ cm}$$
$$m = \frac{-d_i}{d_o} = \frac{-(15\text{ cm})}{10.0\text{ cm}} = -1.5$$
$$m = \frac{h_i}{h_o}$$
so $h_i = mh_o = (-1.5)(3.0\text{ mm}) = -4.5\text{ mm}$

3.



$$f = \frac{r}{2} = \frac{(12.0\text{ cm})}{2} = 6.00\text{ cm}$$
$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$$
so $d_i = \frac{fd_o}{d_o - f} = \frac{(6.00\text{ cm})(4.0\text{ cm})}{(4.0\text{ cm} - 6.00\text{ cm})} = -12\text{ cm}$

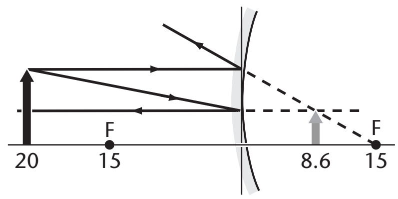
4. $\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$

so $d_i = \frac{fd_o}{d_o - f}$
$$= \frac{(16.0\text{ cm})(10.0\text{ cm})}{(10.0\text{ cm} - 16.0\text{ cm})} = -26.7\text{ cm}$$
$$m = \frac{h_i}{h_o} = -\frac{d_i}{d_o} = \frac{-(-26.7\text{ cm})}{(10.0\text{ cm})} = +2.67$$
so $h_i = mh_o = (2.67)(4.0\text{ cm}) = 11\text{ cm}$

5. $m = \frac{-d_i}{d_o} = 3.0$

so $d_i = -md_o = -3.0(25\text{ cm}) = -75\text{ cm}$
$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$
so $f = \frac{d_o d_i}{d_o + d_i} = \frac{(25\text{ cm})(-75\text{ cm})}{25\text{ cm} + (-75\text{ cm})}$
$= 37.5\text{ cm}$, and $r = 2f = 75\text{ cm}$

6. a.



b. $\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$

so $d_i = \frac{fd_o}{d_o - f}$
$$= \frac{(-15.0\text{ cm})(20.0\text{ cm})}{20.0\text{ cm} - (-15.0\text{ cm})} = -8.57\text{ cm}$$

7. $\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$

so $d_i = \frac{fd_o}{d_o - f}$
$$= \frac{(-12\text{ cm})(60.0\text{ cm})}{60.0\text{ cm} - (-12\text{ cm})} = -1.0 \times 10^1\text{ cm}$$
$$m = \frac{h_i}{h_o} = \frac{-d_i}{d_o} = \frac{-(-1.0 \times 10^1\text{ cm})}{60.0\text{ cm}} = +0.17$$
so $h_i = mh_o = (0.17)(6.0\text{ cm}) = 1.0\text{ cm}$

8. $\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$

so $f = \frac{d_o d_i}{d_o + d_i}$

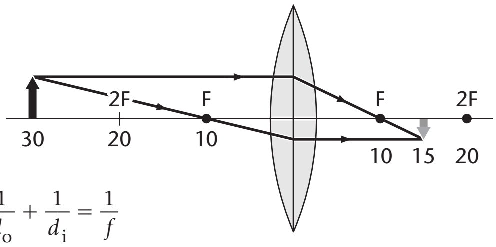
and $m = \frac{-d_i}{d_o}$ so $d_o = \frac{-d_i}{m}$

Since $d_i = -24$ cm and $m = 0.75$,

$$d_o = \frac{-(-24\text{ cm})}{0.75} = 32\text{ cm}$$

$$\text{and } f = \frac{(32\text{ cm})(-24\text{ cm})}{32\text{ cm} + (-24\text{ cm})} = -96\text{ cm}$$

9.



10. $\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$

$$\text{so } d_i = \frac{fd_o}{d_o - f} = \frac{(5.5\text{ cm})(8.5\text{ cm})}{8.5\text{ cm} - 5.5\text{ cm}} = 16\text{ cm}$$

$$h_i = \frac{-d_i h_o}{d_o} = \frac{-(16\text{ cm})(2.25\text{ mm})}{8.5\text{ cm}} = -4.2\text{ mm}$$

11. $\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$

with $d_o = d_i$ since

$$m = \frac{-d_i}{d_o} \quad \text{and} \quad m = -1$$

Therefore,

$$\frac{2}{d_i} = \frac{1}{f} \text{ and } \frac{2}{d_o} = \frac{1}{f}$$

$d_i = 2f = 5.0 \times 10^1$ mm and

$d_o = 2f = 5.0 \times 10^1$ mm

12. $\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$

$$\text{so } d_i = \frac{f\,d_o}{d_o - f} = \frac{(20.0\text{ cm})(6.0\text{ cm})}{6.0\text{ cm} - 20.0\text{ cm}} = -8.6\text{ cm}$$

13. $\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$

$$\text{so } d_i = \frac{fd_o}{d_o - f} = \frac{(12.0\text{ cm})(3.4\text{ cm})}{3.4\text{ cm} - 12.0\text{ cm}} = -4.7\text{ cm}$$

$$h_i = \frac{-h_o d_i}{d_o} = \frac{-(2.0\text{ cm})(-4.7\text{ cm})}{(3.4\text{ cm})} = 2.8\text{ cm}$$

14. $m = \frac{-d_i}{d_o}$

so $d_i = -md_o = -(4.0)(3.5\text{ cm}) = -14$ cm

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$

$$\text{so } f = \frac{d_o d_i}{d_o + d_i} = \frac{(3.5\text{ cm})(-14\text{ cm})}{3.5\text{ cm} + (-14\text{ cm})} = 4.7\text{ cm}$$

Chapter 19

1. $\lambda = \frac{xd}{L} = \frac{(13.2 \times 10^{-3}\text{ m})(1.90 \times 10^{-5}\text{ m})}{(0.600\text{ m})}$

$= 418$ nm

2. $x = \frac{\lambda L}{d} = \frac{(5.96 \times 10^{-7}\text{ m})(0.600\text{ m})}{(1.90 \times 10^{-5}\text{ m})} = 18.8$ mm

3. $d = \frac{\lambda L}{x} = \frac{(6.328 \times 10^{-7}\text{ m})(1.000\text{ m})}{(65.5 \times 10^{-3}\text{ m})} = 9.66\ \mu\text{m}$

4. $\lambda = \frac{xd}{L} = \frac{(55.8 \times 10^{-3}\text{ m})(15 \times 10^{-6}\text{ m})}{(1.6\text{ m})}$

$= 520$ nm

5. $x = \frac{\lambda L}{w} = \frac{(5.46 \times 10^{-7}\text{ m})(0.75\text{ m})}{(9.5 \times 10^{-5}\text{ m})} = 4.3$ mm

6. $w = \frac{\lambda L}{x} = \frac{(6.328 \times 10^{-7}\text{ m})(1.15\text{ m})}{(7.5 \times 10^{-3}\text{ m})} = 97\ \mu\text{m}$

7. $\lambda = \frac{wx}{L} = \frac{(2.95 \times 10^{-5}\text{ m})(1.20 \times 10^{-2}\text{ m})}{(6.00 \times 10^{-1}\text{ m})}$

$= 5.90 \times 10^2$ nm

8. a. Red, because central peak width is proportional to wavelength.

b. Width $= 2x = \frac{2\lambda L}{w}$

For blue,

$$2x = \frac{2(4.41 \times 10^{-7}\text{ m})(1.00\text{ m})}{(5.0 \times 10^{-5}\text{ m})} = 18\text{ mm}$$

For red,

$$2x = \frac{2(6.22 \times 10^{-7}\text{ m})(1.00\text{ m})}{(5.0 \times 10^{-5}\text{ m})} = 25\text{ mm}$$

Chapter 20

1. $F = \frac{Kq_A q_B}{d_{AB}{}^2}$

$$= \frac{(9.0 \times 10^9\text{ N}\cdot\text{m}^2/\text{C}^2)(2.0 \times 10^{-4}\text{ C})(8.0 \times 10^{-4}\text{ C})}{(0.30\text{ m})^2}$$

$= 1.6 \times 10^4$ N

2. $F = \frac{Kq_A q_B}{d_{AB}{}^2}$

$$q_B = \frac{Fd_{AB}{}^2}{Kq_A} = \frac{(65\text{ N})(0.050\text{ m})^2}{(9.0 \times 10^9\text{ N}\cdot\text{m}^2/\text{C}^2)(6.0 \times 10^{-6}\text{ C})}$$

$= 3.0 \times 10^{-6}$ C

3. $F = \frac{Kq_A q_B}{d_{AB}{}^2}$

$$= \frac{(9.0 \times 10^9\text{ N}\cdot\text{m}^2/\text{C}^2)(6.0 \times 10^{-6}\text{ C})(6.0 \times 10^{-6}\text{ C})}{(0.50\text{ m})^2}$$

$= 1.3$ N

4. At $d = 1.0$ cm,

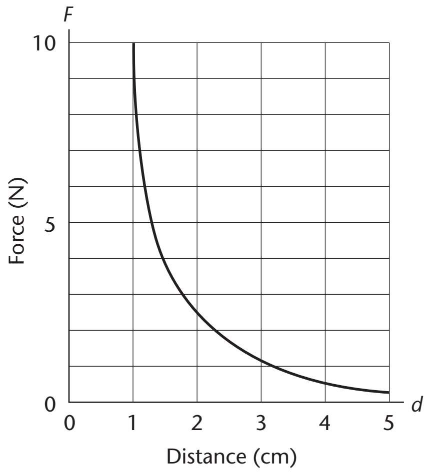
$F = \frac{Kq_A q_B}{d_{AB}{}^2}$

$$= \frac{(9.0 \times 10^9\text{ N}\cdot\text{m}^2/\text{C}^2)(7.5 \times 10^{-7}\text{ C})(1.5 \times 10^{-7}\text{ C})}{(1.0 \times 10^{-2}\text{ m})^2}$$

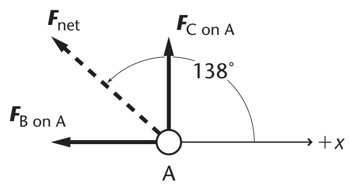
$= 1.0 \times 10^1$ N

Since force varies as distance squared, the force at $d = 5.0$ cm is $\frac{1}{25}$ the force at $d = 1.0$ cm, or 4.1×10^{-2} N.

The force varies as $\frac{1}{d^2}$, so the graph looks like



5. Magnitudes of all forces remain the same. The direction changes to 42° above the $-x$ axis, or 138°.



Chapter 21

1. $E = \frac{F}{q} = \frac{0.060\ \text{N}}{2.0 \times 10^{-8}\ \text{C}}$

$= 3.0 \times 10^6$ N/C directed to the left

2. $E = \frac{F}{q} = \frac{2.5 \times 10^{-4}\ \text{N}}{5.0 \times 10^{-4}\ \text{C}} = 0.50$ N/C

3. $\frac{F_2}{F_1} = \frac{(Kq_Aq_B/d_2^2)}{(Kq_Aq_B/d_1^2)} = \left(\frac{d_1}{d_2}\right)^2$ with $d_2 = 2d_1$

$F_2 = \left(\frac{d_1}{d_2}\right)^2 F_1 = \left(\frac{d_1}{2d_1}\right)^2 (2.5 \times 10^{-4}\ \text{N})$

$= 6.3 \times 10^{-5}$ N

4. a. No. The force on the 2.0 μC charge would be twice that on the 1.0 μC charge.

b. Yes. You would divide the force by the strength of the test charge, so the results would be the same.

5. $\Delta V = Ed = (8000\ \text{N/C})(0.05\ \text{m}) = 400$ J/C

$= 4 \times 10^2$ V

6. $\Delta V = Ed$

$E = \frac{\Delta V}{d} = \frac{500\ \text{V}}{0.020\ \text{m}} = 3 \times 10^4$ N/C

7. $\Delta V = Ed = (2.50 \times 10^3\ \text{N/C})(0.500\ \text{m})$

$= 1.25 \times 10^3$ V

8. $W = q\Delta V = (5.0\ \text{C})(1.5\ \text{V}) = 7.5$ J

9. a. Gravitational force (weight) downward, frictional force of air upward.

b. The two are equal in magnitude.

10. a. $F = Eq$

$q = \frac{F}{E} = \frac{1.9 \times 10^{-15}\ \text{N}}{6.0 \times 10^3\ \text{N/C}} = 3.2 \times 10^{-19}$ C

b. # electrons $= \frac{q}{q_e} = \frac{3.2 \times 10^{-19}\ \text{C}}{1.6 \times 10^{-19}\ \text{C/electron}}$

$= 2.0$ electrons

11. a. $F = Eq$

$q = \frac{F}{E} = \frac{6.4 \times 10^{-13}\ \text{N}}{4.0 \times 10^6\ \text{N/C}} = 1.6 \times 10^{-19}$ C

b. # electrons $= \frac{q}{1.6 \times 10^{-19}\ \text{C/electron}}$

$= 1.0$ electron

12. $E = \frac{F}{q} = \frac{6.4 \times 10^{-13}\ \text{N}}{(4)(1.6 \times 10^{-19}\ \text{C})} = 1.0 \times 10^6$ N/C

13. $q = C\Delta V = (27\ \mu\text{F})(25\ \text{V}) = 6.8 \times 10^{-4}$ C

14. $q = C\Delta V$, so the larger capacitor has a greater charge.

$q = (6.8 \times 10^{-6}\ \text{F})(15\ \text{V}) = 1.0 \times 10^{-4}$ C

15. $\Delta V = q/C$, so the smaller capacitor has the larger potential difference.

$\Delta V = \frac{(2.5 \times 10^{-4}\ \text{C})}{(3.3 \times 10^{-6}\ \text{F})} = 76$ V

16. $q = C\Delta V$ so $\Delta q = C(\Delta V_2 - \Delta V_1)$

$\Delta q = (2.2\ \mu\text{F})(15.0\ \text{V} - 6.0\ \text{V}) = 2.0 \times 10^{-5}$ C

Chapter 22

1. $P = VI = (120\ \text{V})(0.5\ \text{A}) = 60\ \text{J/s} = 60$ W

2. $P = VI = (12\ \text{V})(2.0\ \text{A}) = 24$ W

3. $P = VI$

$I = \frac{P}{V} = \frac{75\ \text{W}}{120\ \text{V}} = 0.63$ A

4. $P = VI = (12\ \text{V})(210\ \text{A}) = 2500$ W

In 10 s,

$E = Pt = (2500\ \text{J/s})(10\ \text{s})$

$= 25000\ \text{J} = 2.5 \times 10^4$ J

5. $I = \frac{V}{R} = \frac{12\ \text{V}}{30\ \Omega} = 0.4\ \text{A}$

6. $V = IR = (3.8\ \text{A})(32\ \Omega) = 1.2 \times 10^{2}\ \text{V}$

7. $R = \frac{V}{I} = \frac{3.0\ \text{V}}{2.0 \times 10^{-4}\ \text{A}} = 2.0 \times 10^{4}\ \Omega$

8. **a.** $R = \frac{V}{I} = \frac{120\ \text{V}}{0.50\ \text{A}} = 2.4 \times 10^{2}\ \Omega$

b. $P = VI = (120\ \text{V})(0.50\ \text{A}) = 6.0 \times 10^{1}\ \text{W}$

9. **a.** $I = \frac{P}{V} = \frac{75\ \text{W}}{120\ \text{V}} = 0.63\ \text{A}$

b. $R = \frac{V}{I} = \frac{120\ \text{V}}{0.63\ \text{A}} = 190\ \Omega$

10. **a.** The new value of the current is

$$\frac{0.63\ \text{A}}{2} = 0.315\ \text{A}$$

so $V = IR = (0.315\ \text{A})(190\ \Omega) = 6.0 \times 10^{1}\ \text{V}$

b. The total resistance of the circuit is now

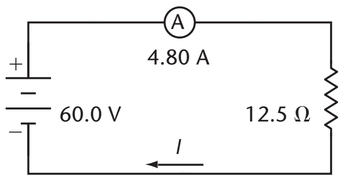
$$R_{\text{total}} = \frac{V}{I} = \frac{(120\ \text{V})}{(0.315\ \text{A})} = 380\ \Omega$$

Therefore,

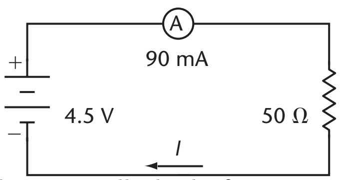
$$R_{\text{res}} = R_{\text{total}} - R_{\text{lamp}} = 380\ \Omega - 190\ \Omega = 190\ \Omega$$

c. $P = VI = (6.0 \times 10^{1}\ \text{V})(0.315\ \text{A}) = 19\ \text{W}$

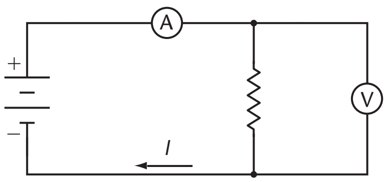
11. $I = \frac{V}{R} = \frac{60.0\ \text{V}}{12.5\ \Omega} = 4.80\ \text{A}$



12. $R = \frac{V}{I} = \frac{4.5\ \text{V}}{0.09\ \text{A}} = 50\ \Omega$



13. Both circuits will take the form



Since the ammeter resistance is assumed zero, the voltmeter readings will be

practice problem 11	6.0×10^{1} V
practice problem 12	4.5 V

14. **a.** $I = \frac{V}{R} = \frac{120\ \text{V}}{15\ \Omega} = 8.0\ \text{A}$

b. $E = I^2Rt = (8.0\ \text{A})^2(15\ \Omega)(30.0\ \text{s}) = 2.9 \times 10^{4}\ \text{J}$

c. 2.9×10^{4} J, since all electrical energy is converted to thermal energy.

15. **a.** $I = \frac{V}{R} = \frac{60\ \text{V}}{30\ \Omega} = 2\ \text{A}$

b. $E = I^2Rt = (2\ \text{A})^2(30\ \Omega)(5\ \text{min})(60\ \text{s/min})$

$= 4 \times 10^{4}\ \text{J}$

16. **a.** $E = (0.200)(100.0\ \text{J/s})(60.0\ \text{s}) = 1.20 \times 10^{3}\ \text{J}$

b. $E = (0.800)(100.0\ \text{J/s})(60.0\ \text{s}) = 4.80 \times 10^{3}\ \text{J}$

17. **a.** $I = \frac{V}{R} = \frac{220\ \text{V}}{11\ \Omega} = 2.0 \times 10^{1}\ \text{A}$

b. $E = I^2Rt = (2.0 \times 10^{1}\ \text{A})^2(11\ \Omega)(30.0\ \text{s}) = 1.3 \times 10^{5}\ \text{J}$

c. $Q = mC\Delta T$ with $Q = 0.70E$

$$\Delta T = \frac{0.70E}{mC} = \frac{(0.70)(1.3 \times 10^{5}\ \text{J})}{(1.20\ \text{kg})(4180\ \text{J/kg} \cdot \text{C°})} = 18\text{°C}$$

18. **a.** $P = IV = (15.0\ \text{A})(120\ \text{V}) = 1800\ \text{W} = 1.8\ \text{kW}$

b. $E = Pt = (1.8\ \text{kW})(5.0\ \text{h/day})(30\ \text{days})$

$= 270\ \text{kWh}$

c. Cost $= (0.11\ \$/\text{kWh})(270\ \text{kWh}) = \$30$

19. **a.** $I = \frac{V}{R} = \frac{115\ \text{V}}{12\,000\ \Omega} = 9.6 \times 10^{-3}\ \text{A}$

b. $P = VI = (115\ \text{V})(9.6 \times 10^{-3}\ \text{A}) = 1.1\ \text{W}$

c. Cost $= (1.1 \times 10^{-3}\ \text{kW})(\$0.09/\text{kWh}) \times (30\ \text{days})(24\ \text{h/day})$

$= \$0.07$

20. **a.** $I = \frac{P}{V} = \frac{1200\ \text{W}}{120\ \text{V}} = 1.0 \times 10^{1}\ \text{A}$

$R = \frac{V}{I} = \frac{120\ \text{V}}{1.0 \times 10^{1}\ \text{A}} = 12\ \Omega$

b. 1.0×10^{1} A

c. $P = IV = (1.0 \times 10^{1}\ \text{A})(120\ \text{V}) = 1200\ \text{W}$

$= 1.2 \times 10^{3}\ \text{J/s}$

d. $Q = mC\Delta T$

In one s,

$$\Delta T = \frac{Q}{mC} = \frac{1.2 \times 10^{3}\ \text{J/s}}{(0.500\ \text{kg})(4180\ \text{J/kg} \cdot \text{K})}$$

$= 0.57\text{°C/s}$

e. $\frac{120\ \text{V}}{2.00\ \text{m}} = 6.0 \times 10^{1}\ \text{V/m}$

f. $P = 1.2 \times 10^{3}\ \text{W} = 1.2\ \text{kW}$

Cost/3 min $= (1.2\ \text{kW})(\$0.10)\left(\frac{3\ \text{min}}{60\ \text{min/h}}\right)$

$= \$0.006$ or 0.6 cents

If only one slice is made, 0.6 cents; if four slices are made, 0.15 cents per slice.

Chapter 23

1. $R = R_1 + R_2 + R_3 = 20\ \Omega + 20\ \Omega + 20\ \Omega = 60\ \Omega$

$I = \frac{V}{R} = \frac{120\text{ V}}{60\ \Omega} = 2\text{A}$

2. $R = 10\ \Omega + 15\ \Omega + 5\ \Omega = 30\ \Omega$

$I = \frac{V}{R} = \frac{90\text{ V}}{30\ \Omega} = 3\text{ A}$

3. **a.** It will increase.

b. $I = \frac{V}{R}$, so it will decrease.

c. No. It does not depend on the resistance.

4. **a.** $R = \frac{V}{I} = \frac{120\text{ V}}{0.06\text{ A}} = 2000\ \Omega$

b. $\frac{2000\ \Omega}{10} = 200\ \Omega$

5. $V = IR = 3\text{ A}(10\ \Omega + 15\ \Omega + 5\ \Omega)$

$= 30\text{ V} + 45\text{ V} + 15\text{ V}$

$= 90\text{ V} =$ voltage of battery

6. **a.** $R = 20.0\ \Omega + 30.0\ \Omega = 50.0\ \Omega$

b. $I = \frac{V}{R} = \frac{120\text{ V}}{50.0\ \Omega} = 2.4\text{ A}$

c. $V = IR$

Across 20.0-Ω resistor,

$V = (2.4\text{ A})(20.0\ \Omega) = 48\text{ V}$

Across 30.0-Ω resistor,

$V = (2.4\text{ A})(30.0\ \Omega) = 72\text{ V}$

d. $V = 48\text{ V} + 72\text{ V} = 1.20 \times 10^2\text{ V}$

7. **a.** $R = 3.0\text{ k}\Omega + 5.0\text{ k}\Omega + 4.0\text{ k}\Omega = 12.0\text{ k}\Omega$

b. $I = \frac{V}{R} = \frac{12\text{ V}}{12.0\text{ k}\Omega} = 1.0\text{ mA} = 1.0 \times 10^{-3}\text{ A}$

c. $V = IR$

so $V = 3.0$ V, 5.0 V, and 4.0 V

d. $\text{V} = 3.0\text{ V} + 5.0\text{ V} + 4.0\text{ V} = 12.0\text{ V}$

8. **a.** $V_B = \frac{VR_B}{R_A + R_B} = \frac{(9.0\text{ V})(475\ \Omega)}{500\ \Omega + 475\ \Omega} = 4\text{ V}$

b. $V_B = \frac{VR_B}{R_A + R_B} = \frac{(9.0\text{ V})(4.0\text{ k}\Omega)}{0.5\text{ k}\Omega + 4.0\text{ k}\Omega} = 8\text{ V}$

c. $V_B = \frac{VR_B}{R_A + R_B} = \frac{(9.0\text{ V})(4.0 \times 10^5\ \Omega)}{0.005 \times 10^5\ \Omega + 4.0 \times 10^5\ \Omega}$

$= 9\text{ V}$

9. $V_2 = \frac{VR_2}{R_1 + R_2} = \frac{(45\text{ V})(235\text{ k}\Omega)}{475\text{ k}\Omega + 235\text{ k}\Omega} = 15\text{ V}$

10. **a.** $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} = \frac{3}{15\ \Omega}$

$R = 5.0\ \Omega$

b. $I = \frac{V}{R} = \frac{30\text{ V}}{5.0\ \Omega} = 6\text{ A}$

c. $I = \frac{V}{R} = \frac{30\text{ V}}{15.0\ \Omega} = 2\text{ A}$

11. **a.** $\frac{1}{R} = \frac{1}{120.0\ \Omega} + \frac{1}{60.0\ \Omega} + \frac{1}{40.0\ \Omega}$

$R = 20.0\ \Omega$

b. $I = \frac{V}{R} = \frac{12.0\text{ V}}{20.0\ \Omega} = 0.600\text{ A}$

c. $I_1 = \frac{V_1}{R_1} = \frac{12.0\text{ V}}{120.0\ \Omega} = 0.100\text{ A}$

$I_2 = \frac{V}{R_2} = \frac{12.0\text{ V}}{60.0\ \Omega} = 0.200\text{ A}$

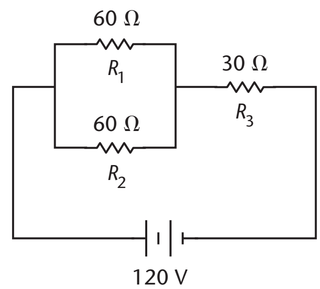
$I_3 = \frac{V}{R_3} = \frac{12.0\text{ V}}{40.0\ \Omega} = 0.300\text{ A}$

12. **a.** Yes. Smaller.

b. Yes. Gets larger.

c. No. It remains the same. Currents are independent.

13. **a.**



b. $\frac{1}{R} = \frac{1}{60\ \Omega} + \frac{1}{60\ \Omega} = \frac{2}{60\ \Omega}$

$R = \frac{60\ \Omega}{2} = 30\ \Omega$

c. $R_E = 30\ \Omega + 30\ \Omega = 60\ \Omega$

d. $I = \frac{V}{R} = \frac{120\text{ V}}{60\ \Omega} = 2\text{ A}$

e. $V_3 = IR_3 = (2\text{ A})(30\ \Omega) = 60\text{ V}$

f. $V = IR = (2\text{ A})(30\ \Omega) = 60\text{ V}$

g. $I = \frac{V}{R_1} = \frac{V}{R_2} = \frac{60\text{V}}{60\ \Omega} = 1\text{ A}$

Chapter 24

1. **a.** repulsive **b.** attractive

2. south, north, south, north

3. the bottom (the point)

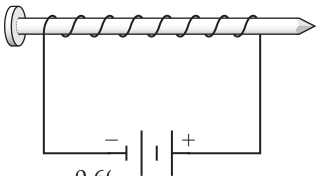
4. **a.** from south to north **b.** west

5. **a.** Since magnetic field strength varies inversely with the distance from the wire, it will be half as strong.

   b. It is one-third as strong.

6. the pointed end

7. $F = BIL = (0.40\ \text{N/A}\cdot\text{m})(8.0\ \text{A})(0.50\ \text{m}) = 1.6\ \text{N}$



8. $B = \dfrac{F}{IL} = \dfrac{0.60\ \text{N}}{(6.0\ \text{A})(0.75\ \text{m})} = 0.13\ \text{T}$

9. $F = BIL$, F = weight of wire.

   $B = \dfrac{F}{IL} = \dfrac{0.35\ \text{N}}{(6.0\ \text{A})(0.4\ \text{m})} = 0.1\ \text{T}$

10. $F = Bqv$

    $= (0.50\ \text{T})(1.6\times10^{-19}\ \text{C})(4.0\times10^{6}\ \text{m/s})$

    $= 3.2\times10^{-13}\ \text{N}$

11. $F = Bqv$

    $= (9.0\times10^{-2}\ \text{T})(2)(1.60\times10^{-19}\ \text{C}) \times (3.0\times10^{4}\ \text{m/s})$

    $= 8.6\times10^{-16}\ \text{N}$

12. $F = Bqv$

    $= (4.0\times10^{-2}\ \text{T})(3)(1.60\times10^{-19}\ \text{C}) \times (9.0\times10^{6}\ \text{m/s})$

    $= 1.7\times10^{-13}\ \text{N}$

13. $F = Bqv$

    $= (5.0\times10^{-2}\ \text{T})(2)(1.60\times10^{-19}\ \text{C}) \times (4.0\times10^{-2}\ \text{m/s})$

    $= 6.4\times10^{-22}\ \text{N}$

Chapter 25

1. **a.** $EMF = BLv$

   $= (0.4\ \text{N/A}\cdot\text{m})(0.5\ \text{m})(20\ \text{m/s}) = 4\ \text{V}$

   b. $I = \dfrac{V}{R} = \dfrac{4\ \text{V}}{6.0\ \Omega} = 0.7\ \text{A}$

2. $EMF = BLv$

   $= (5.0\times10^{-5}\ \text{T})(25\ \text{m})(125\ \text{m/s}) = 0.16\ \text{V}$

3. **a.** $EMF = BLv = (1.0\ \text{T})(30.0\ \text{m})(2.0\ \text{m/s})$

   $= 6.0\times10^{1}\ \text{V}$

   b. $I = \dfrac{V}{R} = \dfrac{BLv}{R}$

   $I = \dfrac{(1.0\ \text{T})(30.0\ \text{m})(2.0\ \text{m/s})}{15.0\ \Omega} = 4.0\ \text{A}$

4. Using the right-hand rule, the north pole is at the bottom.

5. **a.** $V_{eff} = (0.707)V_{max} = (0.707)(170\ \text{V}) = 120\ \text{V}$

   b. $I_{eff} = (0.707)I_{max} = (0.707)(0.70\ \text{A}) = 0.49\ \text{A}$

   c. $R = \dfrac{V_{eff}}{I_{eff}} = \dfrac{120\ \text{V}}{0.49\ \text{A}} = 240\ \Omega$

6. **a.** $V_{max} = \dfrac{V_{eff}}{0.707} = \dfrac{117\ \text{V}}{0.707} = 165\ \text{V}$

   b. $I_{max} = \dfrac{I_{eff}}{0.707} = \dfrac{5.5\ \text{A}}{0.707} = 7.8\ \text{A}$

7. **a.** $V_{eff} = (0.707)(425\ \text{V}) = 3.00\times10^{2}\ \text{V}$

   b. $I_{eff} = \dfrac{V_{eff}}{R} = \dfrac{3.00\times10^{2}\ \text{V}}{5.0\times10^{2}\ \Omega} = 0.60\ \text{A}$

8. $P = V_{eff}I_{eff}$

   $= (0.707\ V_{max})(0.707\ I_{max}) = \dfrac{1}{2}P_{max}$

   $P_{max} = 2P = 2(100\ \text{W}) = 200\ \text{W}$

9. **a.** $\dfrac{V_S}{V_P} = \dfrac{N_S}{N_P}$

   $V_S = \dfrac{V_P N_S}{N_P} = \dfrac{(7200\ \text{V})(125)}{7500} = 120\ \text{V}$

   b. $V_P I_P = V_S I_S$

   $I_P = \dfrac{V_S I_S}{V_P} = \dfrac{(120\ \text{V})(36\ \text{A})}{7200\ \text{V}} = 0.60\ \text{A}$

10. **a.** $\dfrac{V_P}{V_S} = \dfrac{N_P}{N_S}$

    $V_S = \dfrac{V_P N_S}{N_P} = \dfrac{(120\ \text{V})(15\ 000)}{500} = 3.6\times10^{3}\ \text{V}$

    b. $V_P I_P = V_S I_S$

    $I_P = \dfrac{V_S I_S}{V_P} = \dfrac{(3600\ \text{V})(3.0\ \text{A})}{120\ \text{V}} = 9.0\times10^{1}\ \text{A}$

    c. $V_P I_P = (120\ \text{V})(9.0\times10^{1}\ \text{A}) = 1.1\times10^{4}\ \text{W}$

    $V_S I_S = (3600\ \text{V})(3.0\ \text{A}) = 1.1\times10^{4}\ \text{W}$

11. **a.** $V_S = \dfrac{V_P N_S}{N_P} = \dfrac{(60.0\ \text{V})(90\ 000)}{300} = 1.80\times10^{4}\ \text{V}$

    b. $I_P = \dfrac{V_S I_S}{V_P} = \dfrac{(1.80\times10^{4}\ \text{V})(0.50\ \text{A})}{60.0\ \text{V}}$

    $= 1.5\times10^{2}\ \text{A}$

Chapter 26

1. $Bqv = Eq$

$$v = \frac{E}{B} = \frac{4.5 \times 10^3 \text{ N/C}}{0.60 \text{ T}} = 7.5 \times 10^3 \text{ m/s}$$

2. $Bqv = \frac{mv^2}{r}$

$$r = \frac{mv}{Bq} = \frac{(1.67 \times 10^{-27} \text{ kg})(7.5 \times 10^3 \text{ m/s})}{(0.60 \text{ T})(1.60 \times 10^{-19} \text{ C})}$$

$$= 1.3 \times 10^{-4} \text{ m}$$

3. $Bqv = Eq$

$$v = \frac{E}{B} = \frac{3.0 \times 10^3 \text{ N/C}}{6.0 \times 10^{-2} \text{ T}} = 5.0 \times 10^4 \text{ m/s}$$

4. $Bqv = \frac{mv^2}{r}$

$$r = \frac{mv}{Bq} = \frac{(9.11 \times 10^{-31} \text{ kg})(5.0 \times 10^4 \text{ m/s})}{(6.0 \times 10^{-2} \text{ T})(1.60 \times 10^{-19} \text{ C})}$$

$$= 4.7 \times 10^{-6} \text{ m}$$

5. a. $Bqv = Eq$

$$v = \frac{E}{B} = \frac{6.0 \times 10^2 \text{ N/C}}{1.5 \times 10^{-3} \text{ T}} = 4.0 \times 10^5 \text{ m/s}$$

b. $Bqv = \frac{mv^2}{r}$

$$m = \frac{Bqr}{v} = \frac{(0.18 \text{ T})(1.60 \times 10^{-19} \text{ C})(0.165 \text{ m})}{4.0 \times 10^5 \text{ m/s}}$$

$$= 1.2 \times 10^{-26} \text{ kg}$$

6. $m = \frac{B^2r^2q}{2V}$

$$= \frac{(5.0 \times 10^{-2} \text{ T})^2(0.106 \text{ m})^2(2)(1.60 \times 10^{-19} \text{ C})}{2(66.0 \text{ V})}$$

$$= 6.8 \times 10^{-26} \text{ kg}$$

7. $m = \frac{B^2r^2q}{2V}$

$$= \frac{(7.2 \times 10^{-2} \text{ T})^2(0.085 \text{ m})^2(1.60 \times 10^{-19} \text{ C})}{2(110 \text{ V})}$$

$$= 2.7 \times 10^{-26} \text{ kg}$$

8. Use $r = \frac{1}{B}\sqrt{\frac{2Vm}{q}}$ to find the ratio of radii of the two isotopes. If M represents the number of proton masses, then $\frac{r_{22}}{r_{20}} = \sqrt{\frac{M_{22}}{M_{20}}}$, so

$$r_{22} = r_{20}\left[\frac{22}{20}\right]^{1/2} = 0.056 \text{ m}$$

Separation then is

$$2(0.056 \text{ m} - 0.053 \text{ m}) = 6 \text{ mm}$$

Chapter 27

1. $K = -qV_0 = -(-1.60 \times 10^{-19} \text{ C})(3.2 \text{ J/C})$

$$= 5.1 \times 10^{-19} \text{ J}$$

2. $K = -qV_0 = \frac{-(-1.60 \times 10^{-19} \text{ C})(5.7 \text{ J/C})}{1.60 \times 10^{-19} \text{ J/eV}} = 5.7 \text{ eV}$

3. a. $c = f_0\lambda_0$

$$f_0 = \frac{c}{\lambda_0} = \frac{3.00 \times 10^8 \text{ m/s}}{310 \times 10^{-9} \text{ m}} = 9.7 \times 10^{14} \text{ Hz}$$

b. $W = hf_0 = (6.63 \times 10^{-34} \text{ J/Hz})(9.7 \times 10^{14} \text{ Hz})$

$$= (6.4 \times 10^{-19} \text{ J})\left[\frac{\text{eV}}{1.60 \times 10^{-19} \text{ J}}\right] = 4.0 \text{ eV}$$

c. $K_{max} = \frac{hc}{\lambda} - hf_0$

$$= \frac{\left[(6.63 \times 10^{-34} \text{ J/Hz})(3.00 \times 10^8 \text{ m/s})\left(\frac{\text{eV}}{1.60 \times 10^{-19} \text{ J}}\right)\right]}{(240 \times 10^{-9} \text{ m})} - 4.0 \text{ eV}$$

$$= 5.2 \text{ eV} - 4.0 \text{ eV} = 1.2 \text{ eV}$$

4. a. $W = \text{work function} = hf_0 = \frac{1240 \text{ eV} \cdot \text{nm}}{\lambda_0}$

where λ_0 has units of nm and W has units of eV.

$$\lambda_0 = \frac{1240 \text{ eV} \cdot \text{nm}}{W} = \frac{1240 \text{ eV} \cdot \text{nm}}{1.96 \text{ eV}} = 633 \text{ nm}$$

b. $K_{max} = hf - hf_0 = E_{photon} - hf_0$

$$= \frac{1240 \text{ eV} \cdot \text{nm}}{\lambda} - hf_0$$

$$= \frac{1240 \text{ eV} \cdot \text{nm}}{425 \text{ nm}} - 1.96 \text{ eV}$$

$$= 2.92 \text{ eV} - 1.96 \text{ eV} = 0.96 \text{ eV}$$

5. a. $\frac{1}{2}mv^2 = qV_0$

$$v^2 = \frac{2qV}{m} = \frac{2(1.60 \times 10^{-19} \text{ C})(250 \text{ J/C})}{9.11 \times 10^{-31} \text{ kg}}$$

$$= 8.8 \times 10^{13} \text{ m}^2/\text{s}^2$$

$$v = 9.4 \times 10^6 \text{ m/s}$$

b. $\lambda = \frac{h}{mv}$

$$= \frac{6.63 \times 10^{-34} \text{ J} \cdot \text{s}}{(9.11 \times 10^{-31} \text{ kg})(9.4 \times 10^6 \text{ m/s})}$$

$$= 7.7 \times 10^{-11} \text{ m}$$

6. a. $\lambda = \frac{h}{mv} = \frac{6.63 \times 10^{-34} \text{ J} \cdot \text{s}}{(7.0 \text{ kg})(8.5 \text{ m/s})} = 1.1 \times 10^{-35} \text{ m}$

b. The wavelength is too small to show observable effects.

7. a. $p = \frac{h}{\lambda} = \frac{6.63 \times 10^{-34} \text{ J} \cdot \text{s}}{5.0 \times 10^{-12} \text{ m}}$

$$= 1.3 \times 10^{-22} \text{ kg} \cdot \text{m/s}$$

b. Its momentum is too small to affect objects of

Appendix C

ordinary size.

Chapter 28

1. Four times as large since orbit radius is proportional to n^2, where n is the integer labeling the level.

2. $r_n = n^2k$, where $k = 5.30 \times 10^{-11}$ m

$r_2 = (2)^2(5.30 \times 10^{-11}\ \text{m}) = 2.12 \times 10^{-10}$ m

$r_3 = (3)^2(5.30 \times 10^{-11}\ \text{m}) = 4.77 \times 10^{-10}$ m

$r_4 = (4)^2(5.30 \times 10^{-11}\ \text{m}) = 8.48 \times 10^{-10}$ m

3. $E_n = \dfrac{-13.6\ \text{eV}}{n^2}$

$E_2 = \dfrac{-13.6\ \text{eV}}{(2)^2} = -3.40$ eV

$E_3 = \dfrac{-13.6\ \text{eV}}{(3)^2} = -1.51$ eV

$E_4 = \dfrac{-13.6\ \text{eV}}{(4)^2} = -0.850$ eV

4. Using the results of Practice Problem 3,

$E_3 - E_2 = (-1.51\ \text{eV}) - (-3.40\ \text{eV}) = 1.89$ eV

$$\lambda = \frac{hc}{\Delta E} = \frac{(6.63 \times 10^{-34}\ \text{J}\cdot\text{s})(3.00 \times 10^8\ \text{m/s})}{(1.89\ \text{eV})(1.61 \times 10^{-19}\ \text{J/eV})}$$

$= 6.54 \times 10^{-7}$ m $= 654$ nm

5. $\dfrac{x}{0.075\ \text{cm}} = \dfrac{5 \times 10^{-9}\ \text{m}}{2.5 \times 10^{-15}\ \text{m}}$

$x = 200\ 000$ m or 200 km

6. **a.** $\Delta E = 8.82\ \text{eV} - 6.67\ \text{eV} = 2.15$ eV

b. $\Delta E = hf = 2.15\ \text{eV}\left[\dfrac{1.60 \times 10^{-19}\ \text{J}}{\text{eV}}\right]$

$= 3.44 \times 10^{-19}$ J

so $f = \dfrac{\Delta E}{h} = \dfrac{3.44 \times 10^{-19}\ \text{J}}{6.63 \times 10^{-34}\ \text{J}\cdot\text{s}} = 5.19 \times 10^{14}$ Hz

c. $c = f\lambda$, so

$\lambda = \dfrac{c}{f} = \dfrac{3.00 \times 10^8\ \text{m/s}}{5.19 \times 10^{14}/\text{s}}$

$= 5.78 \times 10^{-7}$ m, or 578 nm

Chapter 29

1. $\dfrac{\text{free e}^-}{\text{cm}^3}$

$$= \frac{(2\ \text{e}^-/\text{atom})(6.02 \times 10^{23}\ \text{atoms/mol})(7.13\ \text{g/cm}^3)}{65.37\ \text{g/mol}}$$

$= 1.31 \times 10^{23}$ free e$^-$/cm^3

2. atoms/cm^3

$$= \frac{(6.02 \times 10^{23}\ \text{atoms/mol})(5.23\ \text{g/cm}^3)}{72.6\ \text{g/mol}}$$

$= 4.34 \times 10^{22}$ atoms/cm^3

free e$^-$/atom $= \dfrac{(2 \times 10^{16}\ \text{free e}^-/\text{cm}^3)}{(4.34 \times 10^{22}\ \text{atoms/cm}^3)}$

$= 5 \times 10^{-7}$

3. There were 5×10^{-7} free e$^-$/Ge atom, so we need 5×10^3 as many As dopant atoms, or 3×10^{-3} As atom/Ge atom.

4. At $I = 2.5$ mA, $V_d = 0.7$ V, so

$V = V_d + IR = 0.7\ \text{V} + (2.5 \times 10^{-3}\ \text{A})(470\ \Omega)$

$= 1.9$ V

5. $V = V_d + IR = 0.4\ \text{V} + (1.2 \times 10^{-2}\ \text{A})(470\ \Omega)$

$= 6.0$ V

Chapter 30

1. $A - Z$ = neutrons

$234 - 92 = 142$ neutrons

$235 - 92 = 143$ neutrons

$238 - 92 = 146$ neutrons

2. $A - Z = 15 - 8 = 7$ neutrons

3. $A - Z = 200 - 80 = 120$ neutrons

4. ${}^1_1\text{H}, {}^2_1\text{H}, {}^3_1\text{H}$

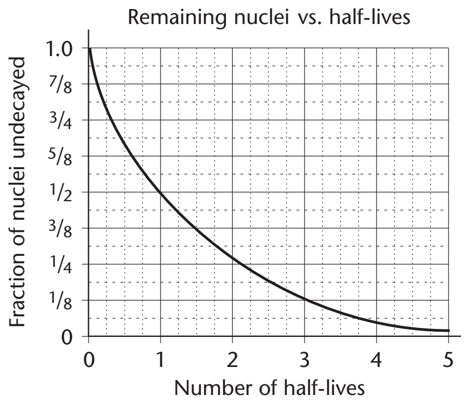
5. ${}^{234}_{92}\text{U} \rightarrow {}^{230}_{90}\text{Th} + {}^4_2\text{He}$

6. ${}^{230}_{90}\text{Th} \rightarrow {}^{226}_{88}\text{Ra} + {}^4_2\text{He}$

7. ${}^{226}_{88}\text{Ra} \rightarrow {}^{222}_{86}\text{Rn} + {}^4_2\text{He}$

8. ${}^{214}_{82}\text{Pb} \rightarrow {}^{214}_{83}\text{Bi} + {}^{0}_{-1}\text{e} + {}^0_0\bar{\nu}$

9.



24.6 years = 2(12.3 years)

which is 2 half-lives. Since $\frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$ there will be

$$(1.0\text{ g})\left[\frac{1}{4}\right] = 0.25\text{ g remaining}$$

10. Amount remaining = (original amount) $\left[\frac{1}{2}\right]^N$ where N is the number of half-lives elapsed. Since

$$N = \frac{8\text{ days}}{2.0\text{ days}} = 4$$

$$\text{Amount remaining} = (4.0\text{ g})\left[\frac{1}{2}\right]^4 = 0.25\text{ g}$$

11. The half-life of $^{210}_{84}$Po is 138 days.

There are 273 days or about 2 half-lives between September 1 and June 1. So the activity

$$= \left[2 \times 10^6 \frac{\text{decays}}{\text{s}}\right]\left[\frac{1}{2}\right]\left[\frac{1}{2}\right] = 5 \times 10^5\text{ Bq}$$

12. From **Table 30–1,** 6 years is approximately 0.5 half-life for tritium. Since **Figure 30–5** indicates that approximately $\frac{11}{16}$ of the original nuclei remain after 0.5 half-life, the brightness will be about $\frac{11}{16}$ of the original.

13. a. $E = mc^2 = (1.67 \times 10^{-27}\text{ kg})(3.00 \times 10^8\text{ m/s})^2$

$= 1.50 \times 10^{-10}$ J

b. $E = \dfrac{1.50 \times 10^{-10}\text{ J}}{1.60 \times 10^{-19}\text{ J/eV}} = 9.38 \times 10^8$ eV

$= 938$ MeV

c. The energy will be

(2)(938 MeV) = 1.88 GeV

Chapter 31

1. a.

6 protons = (6)(1.007825 u)	=	6.046950	u
6 neutrons = (6)(1.008665 u)	=	6.051990	u
total		12.098940	u
mass of carbon nucleus		−12.000000	u
mass defect		−0.098940	u

b. −(0.098940 u)(931.49 MeV/u) = −92.162 MeV

2. a. What is its mass defect?

1 proton	=	1.007825	u
1 neutron	=	1.008665	u
total		2.016490	u
mass of deuterium nucleus	=	−2.014102	u
mass defect		−0.002388	u

b. −(0.002388 u)(931.49 MeV/u) = −2.222 MeV

3. a.

7 protons = 7(1.007825 u)	=	7.054775	u
8 neutrons = 8(1.008665 u)	=	8.069320	u
total		15.124095	u
mass of nitrogen nucleus	=	−15.00011	u
mass defect of nitrogen nucleus	=	−0.12399	u

b. −(0.12399 u)(931.49 MeV/u) = −115.50 MeV

4. a.

8 protons = (8)(1.007825 u)	=	8.062600	u
8 neutrons = (8)(1.008665 u)	=	8.069320	u
total		16.131920	u
mass of oxygen nucleus		−15.99491	u
mass defect		−0.13701	u

b. −(0.13701 u)(931.49 MeV/u)

= −127.62 MeV

5. a. $^{14}_{6}\text{C} \rightarrow {}^{14}_{7}\text{N} + {}^{0}_{-1}\text{e}$

b. $^{55}_{24}\text{Cr} \rightarrow {}^{55}_{25}\text{Mn} + {}^{0}_{-1}\text{e}$

6. $^{238}_{92}\text{U} \rightarrow {}^{234}_{90}\text{Th} + {}^{4}_{2}\text{He}$

7. $^{214}_{84}\text{Po} \rightarrow {}^{210}_{82}\text{Pb} + {}^{4}_{2}\text{He}$

8. a. $^{210}_{82}\text{Pb} \rightarrow {}^{210}_{83}\text{Bi} + {}^{0}_{-1}\text{e}$

b. $^{210}_{83}\text{Bi} \rightarrow {}^{210}_{84}\text{Po} + {}^{0}_{-1}\text{e}$

c. $^{234}_{90}\text{Th} \rightarrow {}^{234}_{91}\text{Pa} + {}^{0}_{-1}\text{e}$

d. $^{239}_{93}\text{Np} \rightarrow {}^{239}_{94}\text{Pu} + {}^{0}_{-1}\text{e}$

9. Input masses
2.014102 u + 3.016049 u = 5.030151 u

Output masses
4.002603 u + 1.008665 u = 5.011268 u

Difference is –0.018883 u

Mass defect is –0.018883 u

Energy equivalent = –(0.018883 u)(931.49 meV/u)
= –17.589 MeV

10. Positron mass

$$= (9.109 \times 10^{-31}\ \text{kg}) \left[\frac{1\ \text{u}}{1.6605 \times 10^{-27}\ \text{kg}}\right]$$
$$= 0.0005486\ \text{u}$$

Input mass: 4 protons = 4(1.007825 u)
= 4.031300 u

Output mass: ${}^{4}_{2}\text{He}$ + 2 positrons
= 4.002603 u + 2(0.0005486 u)
= 4.003700

Mass difference = 0.027600 u

Energy released = (0.027600 u)(931.49 MeV/u)
= 25.709 MeV

Solutions for Practice Problems