

# Solutions

## Chapter 1

### Distance, Time and Speed

#### Page 11

- $\bar{v} = \frac{d}{t} = \frac{320 \text{ km}}{3.6 \text{ h}} = 89 \text{ km/h}$
- $t = \frac{d}{v} = \frac{65 \text{ km}}{85 \frac{\text{km}}{\text{h}}} = 0.76 \text{ h (46 min)}$
- $d = \bar{v}t = (92 \text{ km/h})(5.0 \text{ h}) = 4.6 \times 10^2 \text{ km}$
- (a) Total  $d = 84 \frac{\text{km}}{\text{h}} \times \frac{45}{60} \text{ h} + 96 \frac{\text{km}}{\text{h}} \times \frac{20}{60} \text{ h} = 95 \text{ km}$   
 (b)  $\bar{v} = \frac{\text{total } d}{\text{total } t} = \frac{95 \text{ km}}{65 \text{ min}} \times \frac{60 \text{ min}}{\text{h}} = 88 \text{ km/h}$
- (a)  $v = \bar{v}$  at  $t = 0.50 \text{ s}$   
 (b)  $v_f = 2\bar{v} = 28 \text{ m/s}$
- $d = ct$   
 (a)  $3.0 \times 10^5 \text{ km/s} \times 60 \text{ s} = 1.80 \times 10^7 \text{ km}$   
 (b)  $3.0 \times 10^5 \text{ km/s} \times 3600 \text{ s} = 1.08 \times 10^9 \text{ km}$   
 (c)  $1.08 \times 10^9 \text{ km} \times 24 = 2.59 \times 10^{10} \text{ km}$   
 (d)  $2.59 \times 10^{10} \text{ km} \times 365 = 9.46 \times 10^{12} \text{ km}$

#### Page 15

- $\frac{12.678 \text{ mm}}{0.25 \text{ mm}} = 12.928$   
 $12.928 \text{ mm} = 12.93 \text{ mm}$
- $\frac{45.987 \text{ m}^3}{2.1 \text{ m}^3} = 21.9$   
 $48.087 \text{ m}^3 = 48.1 \text{ m}^3$
- $\frac{12.345 \text{ mL}}{0.34 \text{ mL}} = 36.3$   
 $12.005 \text{ mL} = 12.01 \text{ mL}$
- $\frac{1.0001 \text{ mm}}{0.1 \text{ mm}} = 10.001$   
 $0.9001 \text{ mm} = 0.9 \text{ mm}$
- $\frac{12.5 \text{ g}}{0.0005 \text{ g}} = 25000$   
 $12.5005 \text{ g} = 12.5 \text{ g}$
- $\frac{16.768 \text{ kg}}{0.001 \text{ kg}} = 16768$   
 $16.767 \text{ kg} = 16.767 \text{ kg}$

#### Page 16

- $(1.25 \text{ m})(0.25 \text{ m}) = 0.31 \text{ m}^2$
- $(3.987654 \text{ cm})(1.3 \text{ cm}) = 5.2 \text{ cm}^2$
- $14.0 \text{ cm}^2 \div 2.1 \text{ cm} = 6.7 \text{ cm}$
- $(5.646 \text{ mL})(13.6 \text{ g/mL}) = 76.8 \text{ g}$

$$5. \frac{(98.45 \frac{\text{g}}{\text{mL}})(5.762 \text{ mL})}{1.4 \text{ mL}} = 4.1 \times 10^2 \text{ g/mL}$$

#### Page 18

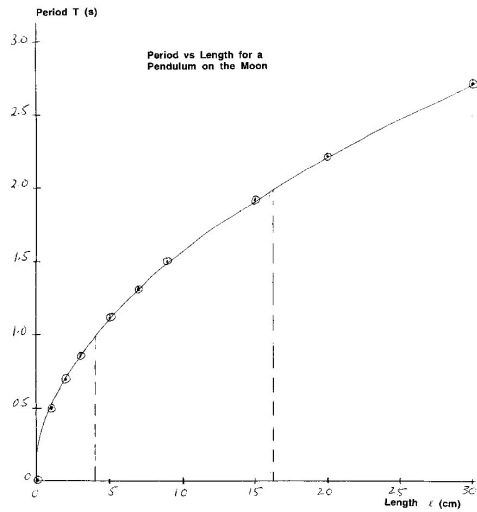
- (a)  $0.00572 \text{ kg} = 5.72 \times 10^{-3} \text{ kg}$   
 (b)  $520 \text{ 000 000 000 km} = 5.2 \times 10^{11} \text{ km}$   
 (c)  $300 \text{ 000 000 m/s} = 3.0 \times 10^8 \text{ m/s}$   
 (d)  $0.00000000000000000016 \text{ C} = 1.6 \times 10^{-19} \text{ C}$   
 (e)  $118.70004 \text{ g} = 1.1870004 \times 10^2 \text{ g}$
- (a)  $10^{3+7+12} = 10^{22}$   
 (b)  $10^{23-5} = 10^{18}$   
 (c)  $10^{12+(-13)} = 10^{-1}$   
 (d)  $10^{-8+(-12)} = 10^{-20}$   
 (e)  $10^{5-(-7)} = 10^{12}$   
 (f)  $10^{-2-(-9)} = 10^7$
- (a)  $2.5 \times 10^{-10}$   
 (b)  $6.2 \times 10^9$   
 (c)  $4.69 \times 10^7$   
 (d)  $4.501 \times 10^{-3}$
- $358 \text{ m}^3 = 3.58 \times 10^2 \text{ m}^3$
- Density =  $\frac{\text{mass}}{\text{volume}} = \frac{1.10 \text{ g}}{0.10 \text{ mL}} = 11 \text{ g/mL}$

#### Page 19 Chapter Review Questions

- (a) Period =  $\frac{28.4 \text{ s}}{10.0} = 2.84 \text{ s}$   
 (b) Frequency =  $\frac{10.0}{28.4 \text{ s}} = 0.352 \text{ s}^{-1} = 0.352 \text{ Hz}$
- Since  $T \propto \sqrt{\ell}$ , if length becomes  $\frac{1}{4} \ell$ , period  $T$  will be  $\frac{1}{2} \times 2.00 \text{ s}$ , or  $1.00 \text{ s}$ .  
 $f = 1/T = 1.00 \text{ s}^{-1} = 1.00 \text{ Hz}$ .
- $\bar{v} = \frac{d}{t} = \frac{568 \text{ km}}{7.2 \text{ h}} = 79 \frac{\text{km}}{\text{h}}$
- $d = \bar{v} t = 12.0 \frac{\text{km}}{\text{h}} \times 3.2 \text{ min} \times \frac{1 \text{ h}}{60 \text{ min}} = 0.64 \text{ km}$
- $t = \frac{d}{v} = \frac{1.8 \times 10^3 \text{ km}}{8.0 \times 10^2 \text{ km/h}} = 2.3 \text{ h}$
- (a) Total  $d = 4.56 \text{ m} + 3.4 \text{ m} + 12.8 \text{ m} = 27.76 \text{ m} = 20.8 \text{ m}$   
 (b) Total  $t = 12 \text{ s} + 6.89 \text{ s} + 36.235 \text{ s} = 55.125 \text{ s} \approx 55 \text{ s}$   
 (c)  $\bar{v} = \frac{20.8 \text{ m}}{55 \text{ s}} = 0.38 \text{ m/s}$ , or  $38 \text{ cm/s}$
- $t = \frac{d}{c} = \frac{2 \times 3.84 \times 10^5 \text{ km}}{3.00 \times 10^5 \text{ km/s}} = 2.56 \text{ s}$
- % Difference =

$$\frac{24.85 \text{ cm} - 24.50 \text{ cm}}{24.85 \text{ cm}} \times 100\% = 1.4\%$$

9. (a)



- (b) (i)  $\approx 4.1 \text{ cm}$  (ii)  $\approx 16.5 \text{ cm}$   
 (c) 4 times as long  
 (d)  $\approx 2.48 \text{ s}$

## Chapter 2 Acceleration

### Page 23

1. (a)  $a = \frac{\Delta v}{\Delta t} = \frac{60.0 \text{ km/h} - 0}{3.00 \text{ s}} = 20.0 \text{ km/h/s}$   
 (b)  $a = \frac{\Delta v}{\Delta t} = \frac{9.00 \text{ m/s} - 0}{3.00 \text{ s}} = 3.00 \text{ m/s}^2$   
 2.  $a = \frac{\Delta v}{\Delta t} = \frac{60.0 \text{ km/h} - 45.0 \text{ km/h}}{7.50 \text{ s}} = -2.00 \text{ km/h/s}$   
 3.  $a = \frac{\Delta v}{\Delta t} = \frac{60.0 \text{ km/h} - 120 \text{ km/h}}{4.0 \text{ s}} = -15 \text{ km/h/s}$

(Car is decelerating, so  $a < 0$ .)

### Page 31

1. Slope =  $\frac{76.0 \text{ m/s} - 20.0 \text{ m/s}}{4.00 \text{ s} - 0} = 14.0 \text{ m/s}^2$   
 (a) Equation is:  $v_f = 20.0 \text{ m/s} + 14.0 \text{ m/s}^2 t$   
 (b)  $v_f = 14.0 \text{ m/s}^2 t$   
 (c)  $a = \text{Slope} = 14.0 \text{ m/s}^2$   
 (d)  $a = 14.0 \text{ m/s}^2$   
 (e) Observers were at different locations. The aircraft was already moving when observer (a) recorded data.  
 2. (a)  $a = \frac{30.0 \text{ m/s} - 0}{3.0 \text{ s}} = 10. \text{ m/s}^2$   
 (b)  $a = 0$   
 (c)  $a = \frac{0 - 30.0 \text{ m/s}}{10.0 \text{ s} - 6.0 \text{ s}} = -7.5 \text{ m/s}^2$

### Page 34

1. (a) 15.0 m/s

(b)  $k = \frac{55.0 \text{ m/s} - 15.0 \text{ m/s}}{10.0 \text{ s}} = 4.00 \text{ m/s}^2$

(c) acceleration

(d)  $v_f = 15.0 \text{ m/s} + (4.00 \text{ m/s}^2)t$

2. (a) 5.0 m/s  
 (b)  $9.8 \text{ m/s}^2$   
 (c)  $v_f = v_o + at$   
 $v_f = 5.0 \text{ m/s} + (9.8 \text{ m/s}^2)(1.2 \text{ s}) = 17 \text{ m/s}$   
 3. (a) 5.5 m/s  
 (b)  $a = \frac{\Delta v}{\Delta t} = \frac{0 - 5.5 \text{ m/s}}{0.70 \text{ s} - 0} = -7.9 \text{ m/s}^2$   
 (c)  $v_f = 5.5 \text{ m/s} - (7.90 \text{ m/s}^2)t$   
 4. (a) 6.6 m/s  
 (b)  $-2.2 \text{ m/s}^2$   
 (c) 3.0 s

### Page 38

1. (a)  $v_f = v_o + at$   
 $v_f = 0 + (0.80 \text{ m/s}^2)(5.0 \text{ s}) = 4.0 \text{ m/s}$   
 (b)  $d = v_o t + \frac{1}{2}at^2$   
 $d = 0 + \frac{1}{2}(0.80 \text{ m/s}^2)(5.0 \text{ s})(5.0 \text{ s}) = 10. \text{ m}$   
 2. (a)  $v_f = v_o + at$   
 $v_f = 16.7 \text{ m/s} + (2.22 \text{ m/s}^2)(4.00 \text{ s}) = 25.6 \text{ m/s}$   
 (b)  $d = v_o t + \frac{1}{2}at^2$   
 $= (16.7 \text{ m/s})(4.00 \text{ s}) + \frac{1}{2}(2.22 \text{ m/s}^2)(4.00 \text{ s})(4.00 \text{ s})$   
 $= 66.8 \text{ m} + 17.76 \text{ m} = 84.6 \text{ m}$   
 3.  $v_f^2 = v_o^2 + 2ad$   
 $0 = (18.0 \text{ m/s})(18.0 \text{ m/s}) + 2a(4.5 \text{ m})$   
 $a = -\frac{(18.0 \text{ m/s})(18.0 \text{ m/s})}{2(4.5 \text{ m})} = -36 \text{ m/s}^2$   
 4.  $a = \frac{\Delta v}{\Delta t} = \frac{6.0 \text{ m/s} - 0}{1.2 \text{ s} - 0} = 5.0 \text{ m/s}^2$   
 $v_f = v_o + at$   
 $15.0 \text{ m/s} = 0 + (5.0 \text{ m/s}^2)t$   
 $t = 3.0 \text{ s}$   
 5. (a)  $a = \frac{\Delta v}{\Delta t} = \frac{36.0 \text{ m/s} - 0}{12.0 \text{ s} - 0} = 3.00 \text{ m/s}^2$   
 (b)  $v_f = at = (3.00 \text{ m/s}^2)(15.0 \text{ s}) = 45.0 \text{ m/s}$   
 (c)  $d = \frac{1}{2}at^2 = \frac{1}{2}(3.00 \text{ m/s}^2)(15.0 \text{ s})(15.0 \text{ s})$   
 $= 3.38 \times 10^2 \text{ m}$   
 6.  $d = \frac{1}{2}at^2$ ;  
 $a = \frac{2d}{t^2} = \frac{2(0.80 \text{ m})}{(2.00 \text{ s})(2.00 \text{ s})} = 0.40 \text{ m/s}^2$   
 7.  $a = \frac{8.0 \text{ m/s} - 12.0 \text{ m/s}}{3.25 \text{ s}} = -1.2 \text{ m/s}^2$   
 8. (a)  $d_1 = \frac{1}{2}gt^2 = \frac{1}{2}(9.8 \text{ m/s}^2)(1.0 \text{ s})^2 = 4.9 \text{ m}$   
 (b)  $d_2 = \frac{1}{2}(9.8 \text{ m/s}^2)(2.0 \text{ s})^2 = 19.6 \text{ m}$   
 During the second second,  
 $d_2 - d_1 = 19.6 \text{ m} - 4.9 \text{ m} = 14.7 \text{ m}$   
 9. (a)  $a = \frac{39.2 \text{ m/s} - 0}{0.20 \text{ s} - 0} = 196 \text{ m/s}^2$   
 (b)  $a = \frac{-39.2 \text{ m/s} - 39.2 \text{ m/s}}{8.20 \text{ s} - 0.20 \text{ s}} = -9.8 \text{ m/s}^2$   
 (c)  $a = \frac{0 - (-39.2 \text{ m/s})}{8.40 \text{ s} - 8.20 \text{ s}} = 196 \text{ m/s}^2$

(d) At B, because  $v_y = 0$  at peak of the flight.

(e) As soon as the ball leaves the pitcher's hand, the only force is gravity, which means  $a = g = -9.8 \text{ m/s}^2$ .

(f) *Direction is important, as well as speed.*

(g)  $d = \bar{v}t = \frac{1}{2}(39.2 \text{ m/s})(4.20 \text{ s}) = 82.3 \text{ m}$

(h)  $d = 82.3 \text{ m}$

(i) Average *velocity* = **Displacement**/time = 0! (Ball returns to its original place!)

#### Page 40 Chapter Review Questions

4. When no change in direction occurs.

$$5. (a) a = \frac{60.0 \text{ m/s} - 20.0 \text{ m/s}}{5.0 \text{ s} - 0} = 8.00 \text{ m/s}^2$$

$$(b) \bar{v} = \frac{20.0 \text{ m/s} + 60.0 \text{ m/s}}{2} = 40.0 \text{ m/s}$$

$$(c) d = \bar{v}t = (40.0 \text{ m/s})(5.00 \text{ s}) = 2.00 \times 10^2 \text{ m}$$

$$(d) v_f = 20.0 \text{ m/s} + (8.0 \text{ m/s}^2)t$$

$$6. v_f = 0 + (7.0 \text{ m/s}^2)(10.0 \text{ s}) = 70. \text{ m/s}$$

$$70. \text{ m/s} = \frac{0.070 \text{ km}}{\text{s}} \times \frac{3600 \text{ s}}{\text{h}} = 2.5 \times 10^2 \text{ km/h}$$

$$7. (a) a = \frac{0 - 60.0 \text{ m/s}}{5.0 \text{ s} - 0} = -12.0 \text{ m/s}^2$$

$$(b) v_f = 60.0 \text{ m/s} - (12.0 \text{ m/s}^2)t$$

$$(c) \bar{v} = \frac{60.0 \text{ m/s} + 0}{2} = 30.0 \text{ m/s}$$

$$(d) d = \bar{v}t = (30.0 \text{ m/s})(5.0 \text{ s}) = 1.5 \times 10^2 \text{ m}$$

$$(e) \text{Area} = \frac{1}{2} \text{height} \times \text{base} \\ = \frac{1}{2}(60.0 \text{ m/s})(5.0 \text{ s}) = 1.5 \times 10^2 \text{ m}$$

Note!  $\frac{1}{2}$  height  $\times$  base = average speed  $\times$  time (Same as (d)!)

$$8. v_f^2 = v_o^2 + 2ad \\ = (1.4 \text{ m/s})(1.4 \text{ m/s}) + 2(2.8 \text{ m/s}^2)(2.5 \text{ m})$$

$$v_f^2 = 16 \text{ m}^2/\text{s}^2.$$

$$v_f = \sqrt{16 \text{ m}^2/\text{s}^2} = 4.0 \text{ m/s}$$

$$9. v_f = v_o + at$$

$$1.52 \times 10^3 \text{ m/s} = 7.58 \times 10^3 \text{ m/s} + (-78.4 \text{ m/s}^2)t \quad t = -$$

$$\frac{7.58 \times 10^3 \text{ m/s} + 1.52 \times 10^3 \text{ m/s}}{-78.4 \text{ m/s}^2} = 77.3 \text{ s}$$

10. The truck decelerates from 80.0 km/h to 20.0 km/h, so  $\Delta v = 60.0 \text{ km/h}$ . It would take a time of  $t = 12 \text{ s}$  if the acceleration is  $-5.0 \text{ km/h/s}$ .

$$d = \bar{v}t = \frac{80.0 \text{ km/h} + 20.0 \text{ km/h}}{2} \times 12 \text{ s}$$

$$d = 50.0 \frac{\text{km}}{\text{h}} \times \frac{12 \text{ s}}{3600 \frac{\text{s}}{\text{h}}} = 0.167 \text{ km}$$

$$d \approx 167 \text{ m} \text{ or } 1.7 \times 10^2 \text{ m}$$

$$11. d = \frac{1}{2}at^2, \text{ so } t^2 = 2d/g \\ t^2 = 2 \times 5.3 \times 10^2 \text{ m}/9.8 \text{ m/s}^2 = 108 \text{ s}^2$$

$$t = \sqrt{108 \text{ s}^2} = 1.0 \times 10^1 \text{ s}$$

$$12. v_f^2 = 2ad$$

$$a = \frac{v_f^2}{2d} = \frac{(3.00 \times 10^7 \frac{\text{m}}{\text{s}})(3.00 \times 10^7 \frac{\text{m}}{\text{s}})}{2 \times 5.0 \times 10^{-2} \text{ m}} \\ = 9.0 \times 10^{15} \text{ m/s}^2$$

$$13. v_f = v_o + at$$

$$v_f = 40.0 \text{ m/s} + \frac{1}{2}(9.81 \text{ m/s}^2)(5.2 \text{ s}) = 66 \text{ m/s}$$

$$14. \Delta t = \frac{\Delta v}{a} = \frac{(60 \text{ km/h} - 80 \text{ km/h})}{-8.0 \text{ km/h/s}} = 2.5 \text{ s}$$

$$\Delta d = \bar{v} \Delta t = \frac{(60 \text{ km/h} + 80 \text{ km/h})}{2} \times \frac{2.5 \text{ s}}{3600 \text{ s/h}}$$

$$\Delta d = 49 \text{ m}$$

$$15. (a) v_f^2 = v_o^2 + 2ad$$

$$v_f^2 = (0.50 \text{ m/s})^2 + 2(2.3 \text{ m/s}^2)(56 \text{ m})$$

$$v_f^2 = 258.25 \text{ m}^2/\text{s}^2$$

$$v_f = 16 \text{ m/s}$$

$$(b) t = \frac{v_f - v_o}{a} = \frac{16 \text{ m/s} - 0.50 \text{ m/s}}{2.3 \text{ m/s}^2}$$

$$t = 6.7 \text{ s}$$

$$(c) t^2 = 2d/g = 400 \text{ m}/9.81 \text{ m/s}^2 = 40.8 \text{ s}^2$$

$$t = \sqrt{40.8 \text{ s}^2} = 6.4 \text{ s}$$

$$16. d_1 = 20.0 \text{ m}$$

$$t_1 = \sqrt{\frac{2d_1}{g}} = \sqrt{\frac{2 \times 20.0 \text{ m}}{9.81 \text{ m/s}^2}} = 2.02 \text{ s}$$

$$d_2 = 22.0 \text{ m}$$

$$t_2 = \sqrt{\frac{2d_2}{g}} = \sqrt{\frac{2 \times 22.0 \text{ m}}{9.81 \text{ m/s}^2}} = 2.12 \text{ s}$$

$$\Delta t = t_2 - t_1 = 0.10 \text{ s} \text{ to pass the window.}$$

17. (a) Graph of  $d$  vs  $t$  is a parabola.

(b) Graph of  $d$  vs  $t^2$  is a straight line, with a slope of  $k = 2.5 \text{ cm/s}^2$ . So  $d = kt^2$ .

Since  $d = \frac{1}{2}at^2$ , the slope  $k$  must equal  $\frac{1}{2}a$ .

Therefore,  $a = 2k = 5.0 \text{ cm/s}^2$ .

### Chapter 3 Forces

#### Page 49

$$1. k = \frac{\Delta y}{\Delta F} = \frac{3.00 \text{ cm}}{4.00 \text{ N}} = 0.750 \text{ cm/N}$$

$$2. y = (0.750 \text{ cm/N})F$$

$$3. (a) y = (0.750 \text{ cm/N})(4.0 \text{ N}) = 3.0 \text{ cm}$$

$$(b) 2.0 \text{ cm} = (0.750 \text{ cm/N}) F;$$

$$F = \frac{2.0 \text{ cm}}{0.750 \text{ cm/N}} = 2.7 \text{ N}$$

$$4. k = 3.75 \text{ cm}/5.0 \text{ N} = 0.75 \text{ cm/N}$$

#### Page 56

1(a) steering, axles, chain, sprocket. Lubricants.

(b) brakes, tires/road

$$2. (a) \mu = \frac{F_f}{F_N}; \quad (b) \text{The units cancel.}$$

$$(c) \mu = \frac{120 \text{ N}}{250 \text{ N}} = 0.480$$

$$3. \mu = \frac{F_f}{F_N} = \frac{F_f}{F_g}$$

$$F_g = \frac{F_f}{\mu} = \frac{24.5 \text{ N}}{0.0100} = 2.45 \times 10^3 \text{ N}$$

4. Friction force is independent of surface area of contact. The force remains the same.

### Page 62 Chapter Review Questions

1. electrical and magnetic forces.

2. The graph of  $F$  vs  $x$  is a straight line.

$$(a) \text{ Slope} = \frac{\Delta F}{\Delta x} = \frac{8.30 \text{ N}}{2.00 \text{ cm}} = 4.15 \text{ N/cm}$$

$$F_g = (4.15 \text{ N/cm})x$$

$$(b) F_g = (4.15 \text{ N/cm})(1.50 \text{ cm}) = 6.23 \text{ N}$$

$$(c) 6.50 \text{ N} = (4.15 \text{ N/cm})x$$

$$x = \frac{6.50 \text{ N}}{4.15 \text{ N/cm}} = 1.57 \text{ cm} (\approx 1.6 \text{ cm})$$

$$3. F_f = 0.525, \quad F_g = 5.00 \text{ N}$$

$$\mu = F_f/F_g = 0.525 \text{ N}/5.00 \text{ N} = 0.105$$

4.  $F_f = \mu F_N$ . If  $F_N$  (which in this case =  $F_g$ ) is doubled,  $F_f$  will double to 448 N. If side by side, the  $F_f$  is the same as stacked, since the friction force is independent of surface area of contact.

$$5. F_g = \frac{GMm}{R^2} \text{ If } R \text{ is changed to } (R + 4R) =$$

$5R$ , then  $F_g$  will be reduced by

$$\frac{1}{5^2} \times 2500 \text{ N, to } 100 \text{ N!}$$

$$6. (a) F_g = \frac{GMm}{d^2}$$

$$(i) 1/4 F_g \quad (ii) 1/9 F_g \quad (iii) 4F_g \quad (iv) 9 F_g$$

$$(b) (i) 2 F_g \quad (ii) 2 F_g \quad (iii) 4 F_g \quad (iv) F_g$$

$$(c) (i) F_g = \frac{GMm}{d^2}$$

$$6.67 \times 10^{-11} \text{ N} \frac{\text{m}^2}{\text{kg}^2} \times 10^2 \text{ kg} \times 5.98 \times 20^{24} \text{ kg}$$

$$= \frac{(6.38 \times 10^6 \text{ m})(6.38 \times 10^6 \text{ m})}{(6.38 \times 10^6 \text{ m})^2}$$

$$= 9.80 \times 10^2 \text{ N}$$

$$(ii) 1.62 \times 10^2 \text{ N}$$

$$(iii) 1.4 \times 10^{-11} \text{ N}$$

$$7. (a) k = 5.0 \text{ Nm}^2$$

$$(b) F_E = (5.0 \text{ Nm}^2) \frac{1}{d^2}$$

- (c)  $F_E$  is inversely proportional to the square of the distance between the two small spheres.

8. Water adheres to the rod.

9. Water coheres to the wet string.

## Chapter 4

### Newton's Laws of Motion

#### Page 75

$$1. F = ma = (5.0 \text{ kg})(5.0 \text{ m/s}^2) = 25 \text{ N}$$

$$2. (a) a = \frac{F}{m} = \frac{7.5 \times 10^4 \text{ N}}{3.0 \times 10^4 \text{ kg}} = 2.5 \text{ m/s}^2$$

$$(b) v_f = 5.0 \times 10^3 \text{ m/s} + (2.5 \text{ m/s}^2)(25 \text{ s}) = 5.1 \times 10^3 \text{ m/s}$$

$$3. m = \frac{F}{a} = \frac{2.4 \times 10^3 \text{ N}}{4.0 \times 10^1 \text{ m/s}^2} = 6.0 \times 10^1 \text{ kg}$$

$$4. (a) \bar{a} = \frac{\Delta v}{\Delta t} = \frac{60.0 \text{ m/s} - 0}{1.2 \text{ s}} = 5.0 \times 10^1 \text{ m/s}^2$$

$$(b) F = ma = (0.12 \text{ kg})(5.0 \times 10^1 \text{ m/s}^2) = 6.0 \text{ N}$$

$$(c) \text{Thrust} = F_g + \text{net upward Force} = 7.2 \text{ N}$$

$$5. (a) \text{net Force } F = \text{Thrust} - F_g$$

$$F = 3.3 \times 10^7 \text{ N} - 2.9 \times 10^7 \text{ N} = 4.0 \times 10^6 \text{ N}$$

$$a = \frac{F}{m} = \frac{4.0 \times 10^6 \text{ N}}{3.0 \times 10^6 \text{ kg}} = 1.3 \text{ m/s}^2$$

- (b) As fuel is expelled, mass decreases, so acceleration will increase. Also, gravitational field strength  $g$  decreases with altitude.

6. Net force is due to friction.  $F = F_f = ma$

$$a = \frac{\Delta v}{\Delta t} = \frac{0 - 5.5 \text{ m/s}}{5.0 \text{ s}} = -1.1 \text{ m/s}^2$$

$$|F| = F = m|a| = (60.0 \text{ kg})(1.1 \text{ m/s}^2) = 66 \text{ N}$$

$$\mu = \frac{F_f}{F_N} = \frac{F_f}{F_g} = \frac{66 \text{ N}}{590 \text{ N}} = 0.11$$

#### Page 77

$$1. F_g = mg = 1.0 \times 10^{-3} \text{ kg} \times 9.8 \text{ N/kg} = 9.8 \times 10^{-3} \text{ N}$$

$$2. g = \frac{F}{m} = \frac{143.62 \text{ N}}{14.67 \text{ kg}} = 9.790 \text{ N/kg}$$

$$3. m = \frac{F}{g} = \frac{789.5 \text{ N}}{9.80 \frac{\text{N}}{\text{kg}}} = 80.6 \text{ kg}$$

$$4. a = g = \frac{F}{m} = \frac{18.05 \text{ N}}{5.0 \text{ kg}} = 3.6 \text{ N/kg or } 3.6 \text{ m/s}^2$$

$$\text{Fraction} = \frac{3.6 \text{ m/s}^2}{9.8 \text{ m/s}^2} = 0.37$$

5. (a) % Difference =

$$\frac{9.832 \frac{\text{N}}{\text{kg}} - 9.782 \frac{\text{N}}{\text{kg}}}{9.832 \frac{\text{N}}{\text{kg}}} \times 100\% = 0.510\%$$

$$(b) 600.0 \text{ N} + 0.51\% \text{ of } 600.0 \text{ N} = 603.0 \text{ N}$$

- (c) Mass does **not** change.

#### Page 83

$$1. p = mv = (0.075 \text{ kg})(2.6 \text{ m/s}) = 0.20 \text{ kgm/s}$$

$$2. \text{Impulse} = F \Delta t = (55 \text{ N})(1.0 \times 10^{-3} \text{ s}) = 5.5 \times 10^{-2} \text{ Ns}$$

$$3. p_o = p_f$$

$$0 = (0.060 \text{ kg})(6.0 \times 10^2 \text{ m/s}) + (3.0 \text{ kg})v$$

$$v = \frac{-36 \text{ kgm/s}}{3.0 \text{ kg}} = -12 \text{ m/s}$$

$$4. p_o = p_f$$

$$(55 \text{ kg})(1.6 \text{ m/s}) = (55 \text{ kg} + 45 \text{ kg})v$$

$$v = \frac{55 \text{ kg} \times 1.6 \text{ m/s}}{100 \text{ kg}} = 0.88 \text{ m/s}$$

$$5. F\Delta t = \Delta(mv) = m\Delta v$$

$$F\Delta t = (10.0 \text{ kg})(25.5 \text{ m/s} - 12.6 \text{ m/s}) = 129 \text{ kgm/s}$$

$$F = \frac{129 \text{ kgm/s}}{5.00 \text{ s}} = 25.8 \text{ N}$$

$$6. p_o = p_f$$

$$(1.5 \times 10^3 \text{ kg})(44 \text{ m/s}) + (1.0 \times 10^3 \text{ kg})(-22 \text{ m/s}) = (2.5 \times 10^3 \text{ kg})v$$

$$66 \times 10^3 \text{ kgm/s} - 22 \times 10^3 \text{ kgm/s} = (2.5 \times 10^3 \text{ kg})v$$

$$v = \frac{44 \times 10^3 \text{ kgm/s}}{2.5 \times 10^3 \text{ kg}} = 18 \text{ m/s}$$

$$7. (a) \text{ Impulse} = F\Delta t = m\Delta v$$

$$= 0.145 \text{ kg} (-50.0 \text{ m/s} - 40.0 \text{ m/s})$$

$$= -13.1 \text{ kgm/s, or } -13.1 \text{ Ns}$$

(Ball reverses direction.)

$$(b) F = \frac{\text{Impulse}}{\Delta t} = \frac{-13.1 \text{ Ns}}{1.00 \times 10^{-3} \text{ s}} = -1.31 \times 10^4 \text{ N}$$

### Page 84 Chapter Review Questions

1. If the car stops suddenly, and you are not 'attached' to it, your inertia will cause you to keep moving at the same speed and in the same direction, until you collide with the windshield and/or steering wheel. A seatbelt attaches you to the vehicle, and you accelerate at the same rate as the vehicle.

2. In an inertial frame of reference ( $\Sigma F = 0$ ), if there are no unbalanced forces acting on a mass, it will not accelerate. It will continue moving at the same speed and in the same direction. If  $F=0$ , then  $a=0$ .

$$3. F=ma=(2.0 \times 10^3 \text{ kg})(1.5 \text{ m/s}^2)=3.0 \times 10^3 \text{ N}$$

$$4. a = \frac{F}{m} = \frac{1.16 \times 10^2 \text{ N}}{5.8 \times 10^3 \text{ kg}} = 2.0 \times 10^{-2} \text{ m/s}^2$$

$$5. m = \frac{F}{a} = \frac{2.0 \times 10^2 \text{ N}}{0.40 \text{ m/s}^2} = 5.0 \times 10^2 \text{ kg}$$

$$6. a = \frac{\text{net } F}{m} = \frac{12.8 \text{ N} - 2.8 \text{ N}}{5.0 \text{ kg}} = 2.0 \text{ m/s}^2$$

$$7. (a) F_g = mg = (45.2 \text{ kg})(9.80 \text{ N/kg}) = 443 \text{ N}$$

$$(b) 9.80 \text{ m/s}^2$$

8. See text. (Weight is the force of gravity on a mass.)

9. Newton's Third Law tells you that the force exerted along the rope is 500 N. The rope will not break.

$$12. (b) \text{ Impulse} = F\Delta t = \Delta(mv)$$

$$= m\Delta v = (0.046 \text{ kg})(60.0 \text{ m/s})$$

$$= 2.8 \text{ kgm/s, or } 2.8 \text{ Ns}$$

$$(c) \text{ Force} = \frac{\text{Impulse}}{\Delta t} = \frac{2.8 \text{ Ns}}{0.50 \times 10^{-3} \text{ s}} = 5.6 \times 10^3 \text{ N}$$

$$13. p_o = p_f$$

$$(0.250 \text{ kg})(5.0 \text{ m/s}) + (0.300 \text{ kg})(2.0 \text{ m/s}) = (0.550 \text{ kg})v$$

$$1.25 \text{ kgm/s} + 0.60 \text{ kgm/s} = (0.550 \text{ kg})v$$

$$v = \frac{1.85 \text{ kgm/s}}{0.550 \text{ kg}} = 3.4 \text{ m/s}$$

14. Measure acceleration of baby when pulled by a steady force. Calculate mass from  $m = F/a$ .

15. The mutual force between the ground and the feet of the competitors is what wins the match.

16. The reaction force on the rifle accelerates it into one's shoulder.

$$17. p_o = p_f$$

$$0 = (4.2 \text{ kg})v_R + (0.050 \text{ kg})(3.00 \times 10^2 \text{ m/s})$$

$$v_R = \frac{-(0.050 \text{ kg})(3.00 \times 10^2 \text{ m/s})}{4.2 \text{ kg}} = -3.6 \text{ m/s}$$

$$18. p_o = p_f$$

$$(12\,000 \text{ kg})(6.0 \text{ m/s}) + 0 = (24\,000 \text{ kg})v_f$$

$$v_f = 3.0 \text{ m/s}$$

## Chapter 5 Vectors

### Page 90

1. (a) Total distance = arithmetic sum of all the distances, which is 503.0 m

(b) Total displacement is the vector sum of the displacements, which is the displacement from the tee to the hole, which is 290.0 m.

### Page 93

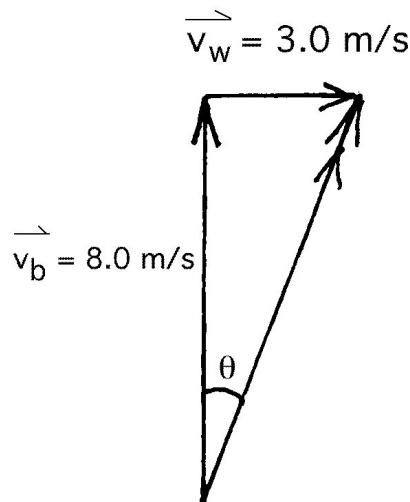
$$1. (a) y = v_y t = (4.0 \text{ m/s})(25 \text{ s}) = 1.0 \times 10^2 \text{ m}$$

$$(b) x = (3.0 \text{ m/s})(25 \text{ s}) = 7.5 \times 10^1 \text{ m}$$

$$(c) d = (5.0 \text{ m/s})(25 \text{ s}) = 1.3 \times 10^2 \text{ m}$$

$$2. (a) v_R^2 = (3.0 \text{ m/s})^2 + (8.0 \text{ m/s})^2 = 73 \text{ m}^2/\text{s}^2$$

$$v_R = 8.5 \text{ m/s}$$



$$\tan\theta = \frac{3.0 \text{ m/s}}{8.0 \text{ m/s}} = 0.375;$$

$$\theta = 21^\circ \text{ to the right}$$

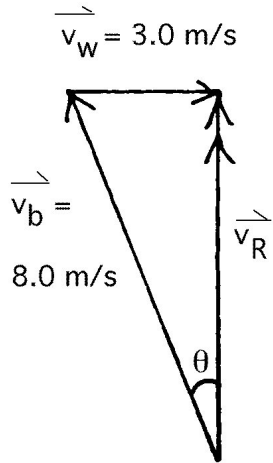
(This problem can be solved using just a scale diagram.)

$$(b) y = 1.0 \times 10^2 \text{ m}$$

$$t = \frac{y}{v_b} = \frac{1.0 \times 10^2 \text{ m}}{8.0 \times 10^0 \text{ m/s}} = 12.5 \text{ s} (\approx 13 \text{ s})$$

$$(c) x = v_w t = (3.0 \text{ m/s})(12.5 \text{ s}) = 38 \text{ m}$$

$$(d) d = (8.5 \text{ m/s})(12.5 \text{ s}) = 1.1 \times 10^2 \text{ m}$$



### Brain Buster

$$3. \sin\theta = \frac{3.0 \text{ m/s}}{8.0 \text{ m/s}} = 0.375;$$

$$\theta = 22^\circ$$

$$v_R = (8.0 \text{ m/s})(\cos 22^\circ) = (8.0 \text{ m/s})(0.927)$$

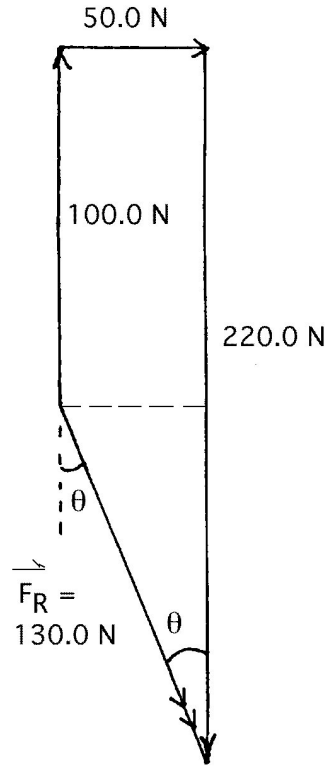
$$= 7.4 \text{ m/s directed upstream}$$

$$y = v_R t$$

$$100.0 \text{ m} = (7.4 \text{ m/s})t$$

$$t = 100.0 \text{ m} / 7.4 \text{ m/s} = 13.5 \text{ s} \approx 14 \text{ s}$$

### Page 94

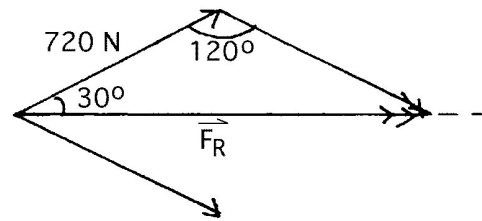


1. By scale or otherwise,  $F_R = 130.0 \text{ N}$

$$\tan\theta = \frac{50.0 \text{ N}}{120.0 \text{ N}} = 0.4167;$$

$$\theta = 22.6^\circ \text{ E of S.}$$

(A scale diagram can be used to solve this problem.)



2. (a)

$$\frac{F_R}{\sin 120^\circ} = \frac{720 \text{ N}}{\sin 30^\circ}$$

$$F_R = \sin 120^\circ \frac{720 \text{ N}}{\sin 30^\circ} = 1.25 \times 10^3 \text{ N}$$

$$(b) \frac{F_R}{\sin 150^\circ} = \frac{720 \text{ N}}{\sin 15^\circ}$$

$$F_R = \frac{\sin 150^\circ \times 720 \text{ N}}{\sin 15^\circ} = 1.39 \times 10^3 \text{ N}$$