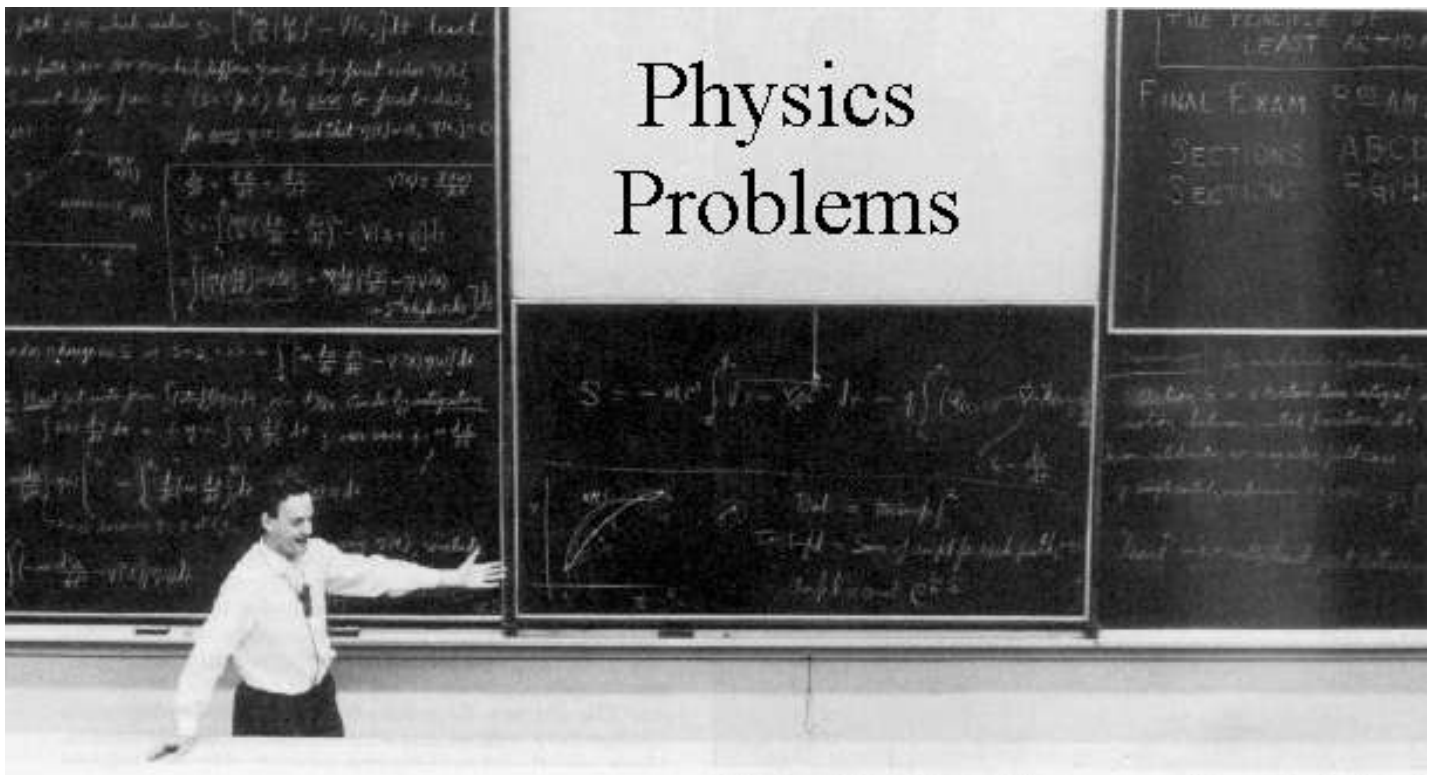




# James M. Hill

## Physics 112 Problem Set

### 2012 - 2013



Mr. P. MacDonald



## Solving Equations Review

**Part I.** Solve.

1.  $17 = m + 8$

2.  $z + 18 = 40$

3.  $8 - y = -24$

4.  $k + \frac{5}{6} = \frac{5}{18}$

5.  $-\frac{3}{4} = w - \frac{11}{12}$

6.  $\frac{9}{2}n = 36$

7.  $\frac{5}{4} = -\frac{15}{4}a$

8.  $0.03 = 3.5c - 1.02$

9.  $\frac{k}{6} - 11 = -20$

10.  $5x + 56 = 16$

11.  $4r + 4 = \frac{2}{3}$

12.  $\frac{7}{3} = 4 + \frac{5c}{2}$

13.  $-14 = -(31 + p)$

14.  $10(3r + 8) = 45$

15.  $68 = -4(m + 9)$

16.  $-10\left(\frac{2}{5} - f\right) = 86$

17.  $-45 = 10(n + 3)$

18.  $4(y + 8) = 7(y + 2)$

19.  $5(3k - 6) = 6(2k - 3)$

20.  $6(4 - 3j) = -2(3j - 5)$

21.  $2(3x - 5) + 4 = 15 - (9x - 4)$

22.  $7p - 2(3 - 4p) = 12p - (p + 4)$

23.  $\frac{3}{10}y = 19 - \frac{1}{5}y$

24.  $6a + 3 = \frac{5(4a + 1)}{3}$

25.  $12c + 2.6 = 6.8c$

26.  $0.55y - 4.5 = 0.05y + 5.5$

27.  $-\frac{1}{2}(4w + 6) = \frac{1}{3}(9 - 3w)$

28.  $7 + 3[4(2x - 3) - 8x] = 3x - 8$

29.  $r + 4 = 4[2(8r - 7) + 5r] - 3r$

**Part II.** Solve for the indicated variable.

30.  $C = K + 273$  ; for  $K$

31.  $V = Bh$  ; for  $B$

32.  $F = ma$  ; for  $a$

33.  $V = IR$  ; for  $I$

34.  $I = Prt$  ; for  $r$

35.  $i = \frac{1}{2}r^2w$  ; for  $w$

36.  $R = \frac{k\ell}{d^2}$  ; for  $\ell$

37.  $F = \frac{gm_1m_2}{d^2}$  ; for  $m_1$

38.  $C = \frac{mv^2}{r}$  ; for  $r$

39.  $2c - 3d = 11$  ; for  $d$

40.  $3by - 2 = 2by + 1$  ; for  $y$

41.  $v = V + gt$  ; for  $t$

42.  $E = Ir + IR$  ; for  $r$

43.  $F = \frac{9}{5}C + 32$  ; for  $C$

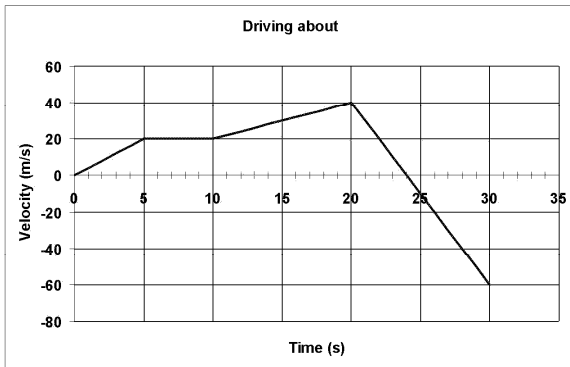
44.  $t = \frac{n}{2}(a + 50)$  ; for  $a$

45.  $A = 2\pi r(r + h)$  ; for  $h$

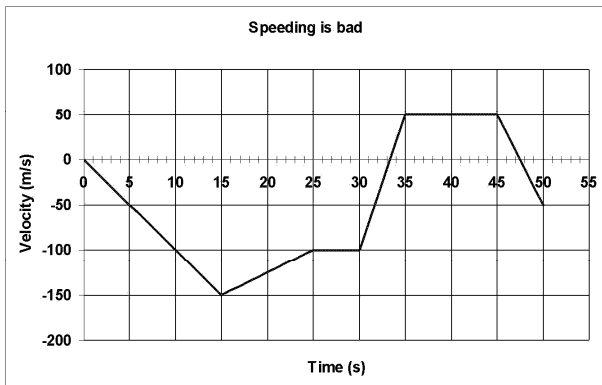
**Answer List**

- |                           |                         |                                 |
|---------------------------|-------------------------|---------------------------------|
| 1. 9                      | 2. 22                   | 3. 32                           |
| 4. $-\frac{5}{9}$         | 5. $\frac{1}{6}$        | 6. 8                            |
| 7. $-\frac{1}{3}$         | 8. 0.3                  | 9. -54                          |
| 10. -8                    | 11. $-\frac{5}{6}$      | 12. $-\frac{2}{3}$              |
| 13. -17                   | 14. $-\frac{7}{6}$      | 15. -26                         |
| 16. 9                     | 17. $-\frac{15}{2}$     | 18. 6                           |
| 19. 4                     | 20. $\frac{7}{6}$       | 21. $\frac{5}{3}$               |
| 22. $\frac{1}{2}$         | 23. 38                  | 24. 2                           |
| 25. -0.5                  | 26. 20                  | 27. -6                          |
| 28. -7                    | 29. $\frac{3}{4}$       | 30. $C - 273$                   |
| 31. $\frac{V}{h}$         | 32. $\frac{F}{m}$       | 33. $\frac{V}{R}$               |
| 34. $\frac{I}{Pt}$        | 35. $\frac{2i}{r^2}$    | 36. $\frac{Rd^2}{k}$            |
| 37. $\frac{Fd^2}{gm_2}$   | 38. $\frac{mv^2}{C}$    | 39. $\frac{2c-11}{3}$           |
| 40. $\frac{3}{b}$         | 41. $\frac{v-V}{g}$     | 42. $\frac{E-IR}{I}$            |
| 43. $\frac{5}{9}(F - 32)$ | 44. $\frac{2t}{n} - 50$ | 45. $\frac{A-2\pi r^2}{2\pi r}$ |

Physics 112  
Change in Velocity



1. Refer to the above image for the following v-t graph questions. **a)** What was the acceleration during the first five seconds? **b)** At what time(s) was there a change in direction? **c)** What was the displacement and distance for the entire 30 s? **d)** What was the average speed and velocity for the entire trip?



2. Refer to the above image for the following v-t graph questions. **a)** What was the magnitude of the greatest acceleration? **b)** What distance was traveled between 10 and 30 seconds? **c)** Calculate the average speed and velocity for the full 50 s.
3. A ball is thrown straight up with an initial velocity of 5.6 m/s. How long did it take to reach maximum height? Calculate the maximum height.
4. A car is traveling 30 m/s [E] when the brakes are applied creating an acceleration of 2.6 m/s<sup>2</sup> [W]. If the braking lasted for 7.6 seconds, what was the final velocity of the car? Calculate the distance traveled in that time. Assuming the acceleration remains constant, what distance is needed to stop the car?
5. A glider is flying 11 m/s [E] when a head wind provides an acceleration of 1.5 m/s<sup>2</sup> [W]. What is the glider's new heading if the wind remains constant for 25 seconds? Calculate the distance and displacement of the glider at the end of the 25 seconds.

**Answer List**

1. a)  $a = 4.0 \text{ m/s}^2$  b)  $t = 24 \text{ s}$  c)  $disp = 350 \text{ m}$ ,  $dist = 710 \text{ m}$  d)  $Speed = 24 \text{ m/s}$ ,  $v_{avg} = 11.7 \text{ m/s}$
2. a)  $30 \text{ m/s}^2$  b)  $dist = 2375 \text{ m}$  c)  $speed = 74 \text{ m/s}$ ,  $v_{avg} = -50 \text{ m/s}$
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Physics 112

1D Motion Equations

1. A car undergoes a constant acceleration from rest to 28 m/s in 9.5 s. What distance was covered in that time?
2. Not noticing a red light a drivers slams on the brakes squeeling to a halt in 3.75 s. Just before hitting the brakes the car was traveling 17 m/s and was 30 m from the light. **a)** What was the average acceleration of the car? **b)** Determine if the driver able to stop before reaching the traffic light by finding the distance required to stop.
3. An airplane lands with a speed of 70 m/s. After 3.5 s the airplane is traveling 17.5 m/s. **a)** What was the average acceleration of the airplane? **b)** What distance does the airplane need to stop?
4. During take off a Boeing 747 airplane accelerates at a constant  $10.8 \text{ m/s}^2$ . The airplane accelerated, from rest, for 7.8 s before it left the ground. **a)** With what speed did the airplane leave the ground? **b)** What distance was required for take-off?
5. A ball is thrown upwards, on the Earth ( $a_{gravity} = -9.81 \text{ m/s}^2$ , with an initial speed of 17 m/s. **a)** How long will the ball be traveling upwards? **b)** How high up will the ball travel?
6. A loonie dropped from the observation deck on the CN Tower in Toronto takes 8.35 s to hit the ground. **a)** Assuming no air resistance, with what speed is the loonie striking the ground? **b)** How high is the observation deck from the ground? (take  $a_{gravity} = -9.81 \text{ m/s}^2$ )
7. During its fall to Earth, hail stones from cumulonimbus clouds reach a terminal velocity (a constant speed) because of air resistance. **a)** Calculate at what speed a hail stone would strike the Earth if it continued to accelerate at  $a_{gravity} = -9.8 \text{ m/s}^2$  during its 20.2 s fall to the ground.
8. A ball is thrown straight up (assume no air resistance) at the surface of the Earth with  $v_o = 25 \text{ m/s}$ . How long will the ball be in the air?
9. The upward velocity of a cannon ball is initially 142 m/s. How long after the cannon ball is fired will it be 51.0 m above the ground?
10. What is the instantaneous velocity of a ball (launched upwards) that has a displacement of 21 m above the ground if the initial velocity was 32 m/s?
11. Use  $\Delta x = v_o t + \frac{1}{2} a t^2$  and  $a = \frac{v_f - v_o}{t}$  to derived  $v_f^2 = v_o^2 + 2a\Delta x$

**Answer List**

1.  $d=133$  m
2. **a)**  $a_{avg} = -4.5 \text{ m/s}^2$ , **b)** No, the driver needed 32 m to stop so the car ended up 2 m into the intersection.
3. **a)**  $a_{avg} = -15 \text{ m/s}^2$  **b)**  $d = 163$  m
4. **a)**  $v_f = 84 \text{ m/s}$  **b)**  $d = 330$  m
5. **a)**  $t = 1.73$  s; **b)**  $d = 15$  m
6. **a)**  $v_f = -82 \text{ m/s}$ ; **b)**  $d = 342$  m
7. **a)**  $v_f = -198 \text{ m/s}$ ;
8.  $t = 5.1$  s
9.  $t = 0.364$  and 28.6 seconds
10.  $v = +25 \text{ m/s}$  or  $-25 \text{ m/s}$
11. **a)**  $v_f = -198 \text{ m/s}$ ;



## Resultant Vectors Worksheet

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Part I - Find the resultant,  $\vec{R}$ , graphically for each of the following:

1. From home a car drives 16 km [E], and then 24 km [S].
2. A person runs 2.0 m/s [N] then 4.0 m/s [E30.°N].
3. A ball is kicked 25 m [W20.0°S] then kicked again 35 m [W60.0°N].
4. A basketball is passed 15 m due West, then 20. m due North, and finally 8.0 m due East.
5. A police car drives 70. km due North, then 80. km [E40.°N], and finally 50. km [E50.0°S].
6. A laser beam travels 1500 km [W30.°S], 2100 km [E20.°S], and finally 2700 km [W10.°S].

Part II - Find the resultant,  $\vec{R}$ , analytically for each of the following:

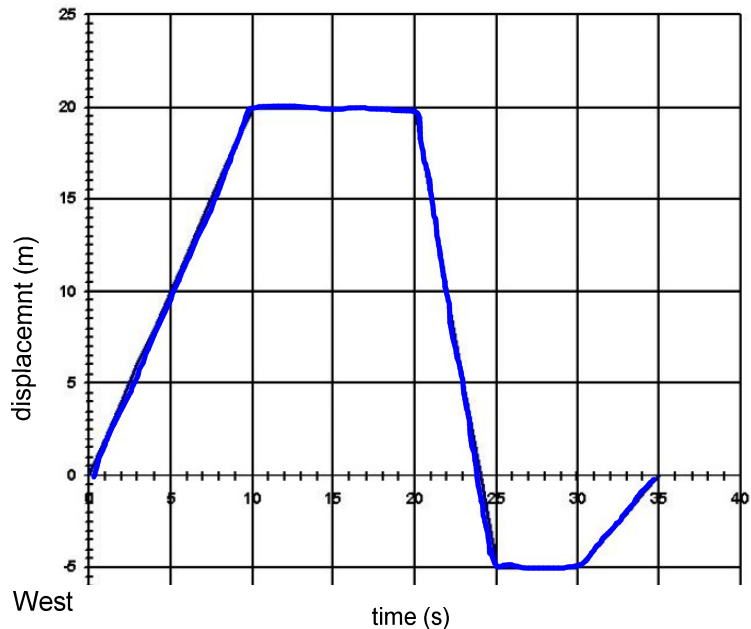
1. 33.5 km [E] and 48.9 km [N].
2. 103 m/s [S] and 76 m/s [E].
3. 1500 m [W] and 850 m [S].
4. 45 km [W], 95 km [E], and 105 km [N] (hint: determine resultant of East-West vectors first).
5. 25 m/s [S], 77 m/s [E], 81 m/s [W], and 12 m/s [N].
6. 38 km [E], 92 km [W], 75 km [E], 115 km [N], 67 km [S], and 33 km [N].

### More Practice & Review

1) Use a scale diagram to find the resultant of 90 km [W35°S], 60 km [E], and 70km [W75°N]

2) Calculate the resultant of 58 m [N], 12 m [S], 45 m [E], and 112 m [W].

3) East



(a) What was the instantaneous velocity at  $t = 7.25$  s?

(b) What was the displacement at  $t = 35$  s?

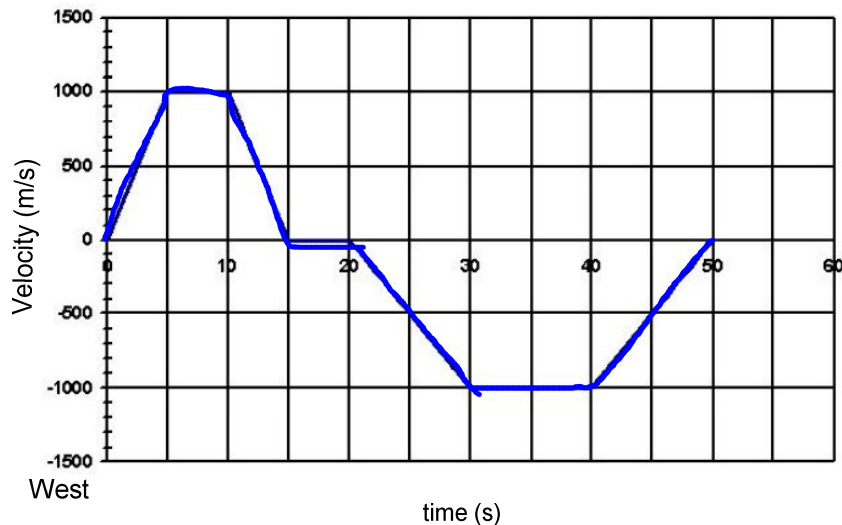
(c) What was the distance travelled during the 35 s trip?

(d) What was the average speed for the entire trip?  
Average velocity?

(e) What was the instantaneous velocity at  $t = 21.83$  s?

(f) What was the average velocity for the first 25 s?

4) East



(a) Determine the displacement and distance traveled.

(b) Determine the average speed and velocity.

(c) What was the instantaneous acceleration at  $t = 42.3$  s? at  $t = 24.8$  s?

5) A car accelerates from rest to 32 m/s [E] in 12.5 s. (a) Find the average acceleration. (b) What distance is does this car cover in that time?

6) A plane lands with a velocity of 47 m/s [E]. It takes 17 s to stop. (a) What was the average acceleration of the plane? (b) What distance was required to stop?

7) A police car initially at 100 km/h [E] accelerates at 5 km/h/s [E] (your speed increases by 5 km/h each second) for 8.9 s. (a) What is the final velocity of the car? (b) What distance was covered during the acceleration?

8) A car traveling at 25 m/s [E] accelerates to 10 m/s in 5.0 s. (a) What is the acceleration of the car? (b) What distance was covered in that time? (c) What distance is need to come to a stop? (hint: find the time needed to come to a stop first)

## Physics 112: Force Practice

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1. A 25 kg crate is pulled at a constant velocity with an applied force of 125 N.
  - a. Calculate the force of friction. (-125 N)
  - b. Calculate the normal force on the crate. (245 N)
  - c. Calculate the coefficient of kinetic friction. (0.51).
2. A sled has a weight of 75 N and is being pulled with a net force of 15 N. The coefficient of kinetic friction is 0.19.
  - a. What is the mass of the sled? (7.6 kg)
  - b. What is the force of friction? (14.25 N)
  - c. What is the applied force? (29.25 N)
3. A 55 kg box is moved with a net force of 28 N. The applied force necessary is 185 N.
  - a. What is the force of friction? (-157 N)
  - b. What is the normal force? (540 N)
  - c. What is the coefficient of kinetic friction? (0.29)
4. A box is being pulled across the floor at a constant velocity with an applied force of 184 N. The coefficient of kinetic friction is 0.26.
  - a. What is the force of friction? (-184 N)
  - b. What is the force of gravity on the box? (708 N)
  - c. What is the mass of the box? (72.2 kg)
5. A 46 kg object is being pulled with an applied force of 200 N. The coefficient of kinetic friction is 0.18.
  - a. What is the force of gravity on the object? (451 N)
  - b. What is the force of friction acting on the object? (81 N)
  - c. What is the net force acting on the object? (119 N)
6. A box is being pulled across the floor at a constant velocity with an applied force of 250 N. The coefficient of kinetic friction is 0.16. What is the mass of the box? (159 kg)
7. A 37 kg crate is pulled at a constant velocity with an applied force of 145 N. Calculate the coefficient of kinetic friction. (0.40)
8. A 39 kg object is being pulled with an applied force of 133 N. The coefficient of kinetic friction is 0.25. What is the net force acting on the object? (37 N)
9. A 42 kg box is moved with a net force of 52 N. The applied force necessary is 210 N. What is the coefficient of kinetic friction? (0.38)
10. A sled has a weight of 166 N and is being pulled with a net force of 27 N. The coefficient of kinetic friction is 0.24. What is the applied force? (67 N)

## Physics 112: Force Practice #2

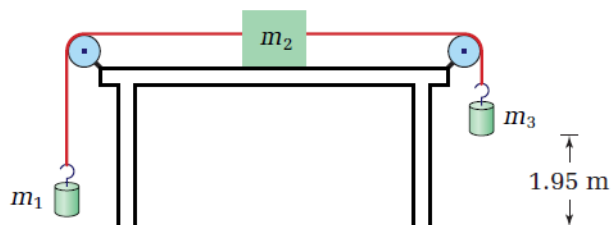
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1. A box is being pulled across the floor at a constant velocity with an applied force of 333 N. The coefficient of kinetic friction is 0.26. What is the mass of the box? (130 kg)
2. A 22 kg crate is pulled at a constant velocity with an applied force of 161 N. Calculate the coefficient of kinetic friction. (0.75)
3. A 28 kg object is being pulled with an applied force of 188 N. The coefficient of kinetic friction is 0.12. What is the net force acting on the object? (155 N)
4. A 31 kg box is moved with a net force of 32 N. The applied force necessary is 174 N. What is the coefficient of kinetic friction? (0.47)
5. A sled has a weight of 425 N and is being pulled with a net force of 17 N. The coefficient of kinetic friction is 0.16. What is the applied force? (85 N)

1. A towrope is used to pull a 1750 kg car across a flat surface, giving it an acceleration of  $1.35 \text{ m/s}^2$ . What force does the rope exert? ( $F = 2360 \text{ N}$ )
2. A racing car undergoes a uniform acceleration of  $4.00 \text{ m/s}^2$ . If the net force causing the acceleration is 3000 N, what is the mass of the car? ( $m = 750 \text{ kg}$ )
3. A 5.2 kg bowling ball is accelerated from rest to a velocity of 12 m/s as the bowler covers 5.0 m of approach before releasing the ball. What force is exerted on the ball during this time? ( $F = 75 \text{ N}$ )
4. A high jumper falling at a 4.0 m/s lands on foam pit and comes to rest compressing the pit 0.40 m. If the pit is able to exert an average force of 1200 N on the high jumper breaking the fall, what is the jumper's mass? ( $m = 60 \text{ kg}$ )
5. When a 20 kg child steps off a 3.0 kg (initially) stationary skateboard with an acceleration of  $0.50 \text{ m/s}^2$ , with what acceleration will the skateboard travel in the opposite direction? – hint: apply Newton's third law ( $a = 3.3 \text{ m/s}^2$ )
6. On Planet X, a 50 kg barbell can be lifted by only exerting a force of 180 N.
  - a. What is the acceleration of gravity on Planet X? ( $a = 3.6 \text{ m/s}^2$ )
  - b. What minimum force is needed to lift this barbell on Earth? ( $F = 490 \text{ N}$ )
7. An applied force of 20 N is needed to accelerate a 9.0 kg wagon at  $2.0 \text{ m/s}^2$  along a sidewalk.
  - a. How large is the frictional force? ( $F_f = 2.0 \text{ N}$ )
  - b. What is the coefficient of friction? ( $\mu = 0.023$ )
8. A 2.0 kg brick has a sliding coefficient of friction of 0.38. What force must be applied to the brick for it to move at a constant velocity? ( $F_a = 7.5 \text{ N}$ )
9. In bench pressing 100 kg, a weight lifter applies a force of 1040 N. How large is the upward acceleration of the weights during the lift? ( $a = 0.59 \text{ m/s}^2$ )
10. An elevator that weighs 3 000 N is accelerated upward at  $1.5 \text{ m/s}^2$ . What force does the cable apply to give this acceleration? ( $F_a = 3460 \text{ N}$ )
11. An 873 kg dragster, starting from rest, attains a speed of 26.3 m/s in 0.59 s.
  - a. Find the average acceleration of the dragster during this time interval. ( $a = 44.6 \text{ m/s}^2$ )
  - b. What is the size of the average force on the dragster during this time interval? ( $F = 38\,900 \text{ N}$ )
  - c. If the driver has a mass of 68 kg, what force does the seatbelt exert on the driver? ( $F = 3030 \text{ N}$ )
12. The downward acceleration of a karate chop is  $-6500 \text{ m/s}^2$ . If the mass of the forearm is 0.70 kg, what is the force exerted by the arm? ( $F = -4550 \text{ N}$ )

13. A car with a mass of 1550 kg is driving on track initially going 10 m/s. The driver accelerates to 30 m/s in 10 s. What is the average force acting on the car during that time? ( $F = 3100 \text{ N}$ )
14. A car has a mass of 710 Kg. It starts from rest and travels 40 m in 3.0 s. What is the average force acting on the car assuming a uniform acceleration? ( $F = 6300 \text{ N}$ )
15. A force of  $-9000 \text{ N}$  is used to stop a 1500 kg car traveling 20 m/s. What breaking distance is needed to bring the car to a halt? ( $d = 33 \text{ m}$ )
16. A 65 kg diver jumps of a 10 m high platform.
- d. Find the swimmer's velocity the instant he reaches the water. ( $v = -14 \text{ m/s}$ )
  - e. The swimmer comes to a stop 2.0 m below the surface of the water. Calculate the net stopping force exerted by the water. ( $F = 3200 \text{ N}$ )
17. A 5.0 kg remote controlled car is used in an experiment to determine the coefficient of friction between the car's tires and the floor. The car is driven at a uniform velocity and then the tires are locked. The car comes to rest in 3.2 m in a time of 1.7 s. Assuming the only force stopping the car is friction; calculate the coefficient of friction between the tires and the floor. ( $\mu = 0.23$ )

19. An Atwood machine consists of masses of 3.8 kg and 4.2 kg. What is the acceleration of the masses? What is the tension in the rope?
20. The smaller mass on an Atwood machine is 5.2 kg. If the masses accelerate at  $4.6 \text{ m/s}^2$ , what is the mass of the second object? What is the tension in the rope?
21. The smaller mass on an Atwood machine is 45 kg. If the tension in the rope is 512 N, what is the mass of the second object? What is the acceleration of the objects?
22. A 3.0 kg counterweight is connected to a 4.5 kg window that freely slides vertically in its frame. How much force must you exert to start the window opening with an acceleration of  $0.25 \text{ m/s}^2$ ?
23. Two gymnasts of identical 37 kg mass dangle from opposite sides of a rope that passes over a frictionless, weightless pulley. If one of the gymnasts starts to pull herself up the rope with an acceleration of  $1.0 \text{ m/s}^2$ , what happens to her? What happens to the other gymnast?
24. A Fletcher's trolley apparatus consists of a 1.90 kg cart on a level track attached to a light string passing over a pulley and holding a 0.500 kg mass suspended in the air. Neglecting friction, calculate
- the tension in the string when the suspended mass is released
  - the acceleration of the trolley
25. A 40.0 g glider on an air track is connected to a 25.0 g mass suspended by a string passing over a frictionless pulley. When the mass is released, how long will it take the glider to travel the 0.85 m to the other end of the track? (Assume the mass does not hit the floor, so there is constant acceleration during the experiment.)
26. The objects in the diagram have the following masses:  $m_1 = 228 \text{ g}$ ,  $m_2 = 615 \text{ g}$ , and  $m_3 = 455 \text{ g}$ . The coefficient of kinetic friction between the block and the table is 0.260. Mass  $m_3$  is 1.95 m above the floor. What will be the time interval between the instant that the masses start to move and the instant when mass  $m_3$  hits the floor?



**PRACTICE PROBLEMS**

MHR: Pg. 341 # 1-4.

1. A metronome beats 54 times over a 55 s time interval. Determine the frequency and period of its motion.
2. Most butterflies beat their wings between 450 and 650 times per minute. Calculate in hertz the range of typical wing-beating frequencies for butterflies.
3. A watch spring oscillates with a frequency of 3.58 Hz. How long does it take to make 100 vibrations?
4. A child swings back and forth on a swing 12 times in 30.0 s. Determine the frequency and period of the swinging.

**PRACTICE PROBLEMS**

Pg. 349 # 5 – 9.

5. A longitudinal wave in a 6.0 m long spring has a frequency of 10.0 Hz and a wavelength of 0.75 m. Calculate the speed of the wave and the time that it would take to travel the length of the spring.
7. Tsunamis are fast-moving ocean waves typically caused by underwater earthquakes. One particular tsunami travelled a distance of 3250 km in 4.6 h and its wavelength was determined to be 640 km. What was the frequency of this tsunami?
8. An earthquake wave has a wavelength of 523 m and travels with a speed of 4.60 km/s through a portion of Earth's crust.
  - (a) What is its frequency?
  - (b) If it travels into a different portion of Earth's crust, where its speed is 7.50 km/s, what is its new wavelength?
6. Interstellar hydrogen gas emits radio waves with a wavelength of 21 cm. Given that radio waves travel at  $3.00 \times 10^8$  m/s, what is the frequency of this interstellar source of radiation?
  - (c) What assumption(s) did you make to answer part (b)?
9. The speed of sound in air at room temperature is 343 m/s. The sound wave produced by striking middle C on a piano has a frequency of 256 Hz.
  - (a) Calculate the wavelength of this sound.
  - (b) Calculate the wavelength for the sound produced by high C, one octave higher than middle C, with a frequency of 512 Hz.

**Problems for Understanding Chapter Review Pg. 372 # 21 – 28.**

21. A pendulum takes 1.0 s to swing from the rest line to its highest point. What is the frequency of the pendulum?
22. By what factor will the wavelength change if the period of a wave is doubled?
23. A wave with an amplitude of 50.0 cm travels down a 8.0 m spring in 4.5 s. The person who creates the wave moves her hand through 4 cycles in 1 second. What is the wavelength?
24. A sound wave has a frequency of 60.0 Hz. What is its period? If the speed of sound in air is 343 m/s, what is the wavelength of the sound wave?
25. Water waves in a ripple tank are 2.6 cm long. The straight wave generator used to produce the waves sends out 60 wave crests in 42 s.
  - (a) Determine the frequency of the wave.
  - (b) Determine the speed of the wave.
26. A rope is 1.0 m long and the speed of a wave in the rope is 3.2 m/s. What is the frequency of the fundamental mode of vibration?
27. A tsunami travelled 3700 km in 5.2 h. If its frequency was  $2.9 \times 10^{-4}$  Hz, what was its wavelength?
28. A storm produces waves of length 3.5 m in the centre of a bay. The waves travel a distance of 0.50 km in 2.00 min.
  - (a) What is the frequency of the waves?
  - (b) What is the period of the waves?



**Part I.** Wave Problems. Take into account significant figures.

1. A woman jogger runs 25 complete laps in 5.0 min.  
a) What is her lap period in seconds? b) What is her frequency in Hertz?
2. A child on a swing completes 20.0 cycles in 25.0 s. Calculate a) the frequency and b) the period of the swing.
3. A stroboscope is flashing so that the time interval between flashes is  $1.18 \times 10^{-2}$  s. Calculate the frequency of the strobe lights flashes.
4. Calculate the frequency, in Hz, and the period, in seconds, of a tuning fork that vibrates  $2.4 \times 10^4$  times in 1.00 min.
5. Determine the frequency, in Hz, of each of the following:  
a) If 95 crests in a slinky pass a fixed point in 12.7 s.  
b) If the period of a tuning fork is 0.00462 s.
6. A swimmer notices that 30.0 waves strike a break water in 1.00 min. What is their period of the waves in seconds?
7. Determine the frequency of each of the following:  
a) A basketball player who scores 36 points in 24 min.  
b) A roadrunner who escapes a coyote 27 times in 9 min.  
c) A fan that turns 170.0 times in 15.0 s.
8. Determine the period of each of the following:  
a) The pulse from a human heartbeat that is heard 24 times in 15 s.  
b) A tuning fork that vibrates 2048 times in 8.0 s.  
c) The Moon, which travels around the Earth 6.00 times in 163.8 days.
9. Calculate the frequency, in Hz, of each of the following periods:  
a) 5.0 s  
b) 0.80 s  
c)  $2.50 \times 10^{-2}$  s  
d) 0.40 min
10. Calculate the period, in seconds, of each of the following frequencies:  
a) 10.0 Hz  
b) 500.0 Hz  
c) 0.25 Hz  
d) 102.1 MHz
11. A source with a frequency of 25 Hz produces water waves that have a wavelength of 3.0 cm. What is the speed of the waves in *cm/s*? *m/s*?
12. An FM radio station broadcasts with a frequency of  $f = 109.3$  MHz, the speed of the waves is  $3.00 \times 10^8$  m/s a) What is the period of the radio waves? b) What is the wavelength of the radio waves?
13. A pebble thrown in water creates waves with a wavelength,  $\lambda$ , of 14 cm and a frequency of 3.5 Hz. a) What is the velocity of the waves? b) How long will it take the waves to reach a shore 5.2 m away?
14. A hiker shouts towards a cliff 846 m away. He hears his echo 4.75 s later. What is the speed of sound in air?
15. A wave in a rope travels at a speed of 2.5 m/s. If the wavelength is 1.3 m, what is the period of the wave?
16. A sound wave travels at 350.0 m/s. What is the wavelength of a sound with a frequency of  $1.4 \times 10^3$  Hz?

17. The wavelength of a water wave is 8.0 m and its speed is 2.0 m/s. How many waves will pass a fixed point in the water in 1.00 min?
18. The tine of a tuning fork, when struck, has an amplitude of 0.13 cm. If the frequency of the tuning fork is 200 Hz, what total distance will the tine travel in 1.00 min?
19. Water waves with a wavelength of 6.0 m approach a lighthouse at 5.6 m/s. a) What is the frequency of the waves? b) What is the period of the waves?
20. Two people are fishing from small boats located 30 m apart. Waves pass through the water, and each person's boat bobs up and down 15 times in 1.0 min. At a time when one boat is on a crest, the other is in a trough, and there is one crest between the two boats. What is the speed of the waves in m/s?
21. The wavelength of a water wave is 3.7 m and its period is 1.5 s. Calculate:
  - a) The speed of the wave.
  - b) The time required for the wave to travel 100.0 m.
  - c) The distance traveled by the wave in 1.00 min.
22. A boat at anchor is rocked by waves whose crests are 30.0 m apart and whose speed is 8.0 m/s. What is the interval of time between crests striking the boat?
23. A television station broadcasts with a frequency of 90.0 MHz. If the speed of the electromagnetic wave emitted by the station tower is  $3.00 \times 10^8$  m/s, what is the wavelength of the waves?
24. What are the wavelengths in air of the lowest and the highest audible frequencies if the range of human hearing is 20.0 Hz to 20.0 kHz. Assume the speed of sound is 342 m/s.
25. A source vibrates a string with a frequency of 103.6 Hz. The wavelengths produced are 2.70 cm. If the frequency is reduced by a factor of four, then what is the speed and wavelengths of the waves if the tension remains the same?
26. Waves traveling on a piece of string encounter a second piece of string tied to the first. The original waves have a speed of 43.8 cm/s and a frequency of 7.35 Hz. In the second medium the waves have a speed of 17.2 cm/s.
  - a) What is the frequency of the waves in the second medium?
  - b) What is the wavelength of the waves in the second medium?
  - c) What is the orientation of the transmitted wave, erect or inverted?
  - d) What is the orientation of the reflected wave, erect or inverted?
27. A standing wave interference pattern is produced in a rope by a vibrator with a frequency of 28.0 Hz. a) If the wavelength is 25.5 cm, what is the distance between successive nodes? b) What is the velocity of the wave in m/s?
28. The distance between the second and fifth nodes in a standing wave is 93.0 cm. a) What is the wavelength of the waves? b) What is the velocity if the source has a frequency of 12.5 Hz?

29. A string is vibrated such that a standing wave is produced.
- What is the wavelength of a vibrating string if the distance between adjacent nodes is 8.5 cm?
  - What is the velocity of the waves if the frequency of the source is 21 Hz?
31. A standing wave pattern in a string is observed to have eight antinodes (with a node at the beginning and end of the pattern). The distance between the second and seventh node is 12.5 cm. The speed of the waves is 2125 cm/s. What frequency must the string be vibrated at to observe three antinodes?
33. A standing wave pattern in a string is observed to have five antinodes (with a node at the beginning and end of the pattern). The distance between the first and fifth node is 33.6 cm. The speed of the waves is 7756 cm/s. What frequency must the string be vibrated at to observe two antinodes?
30. Standing waves are produced in a string by two waves traveling in opposite directions at 6.0 m/s. The distance between the second and sixth node is 80.0 cm. Determine the wavelength and the frequency of the propagating waves.
32. A standing wave pattern in a string is observed to have 12 antinodes (with a node at the beginning and end of the pattern). The distance between the third and ninth node is 46.1 cm. The speed of the waves is 1577 cm/s. What frequency must the string be vibrated at to observe six antinodes?

## Part II. Sound Problems

34. What is the speed of sound on a hot summers day when the temperature is 35 °C?
36. What temperature, in °C, results in a speed of sound being  $v = 376$  m/s?
38. On a particular day the speed of sound is 321 m/s. Using the Kelvin temperature scale, What is the speed of sound if **a)** the temperature doubles. **b)** the temperature triples. **c)** the temperature drops by a factor of four.
40. A firetruck emits a frequency of  $7.85 \times 10^3$  Hz and travels at  $v_s = 80.50$  km/h. A car is traveling at  $v_o = 62.70$  km/h. The speed of sound is  $v = 346.0$  m/s. What frequency is heard by the car's driver if **a)** the vehicles are approaching each other? **b)** the vehicles are receding from each other?
42. The air temperature is 23 °C. What frequency will be heard by someone standing on a corner as a police car drives away at 135 km/h and emits a frequency of  $2.3 \times 10^3$  Hz?
35. What is the speed of sound on a cool 265 °K day?
37. What temperature, in °C, results in a speed of  $1.2 \times 10^3$  km/h?
39. What is the observed frequency of a  $6.50 \times 10^3$  Hz source moving **a)** towards a stationary observer at 95.0 m/s? **b)** away from a stationary observer at 95.0 m/s? Take the speed of sound to be  $v = 325$  m/s
41. What is the speed of truck, in km/h, if the driver hears a frequency of a police car to be  $f_o = 1.77 \times 10^4$  Hz? The police car is driving 139 km/h and its siren has a frequency of  $f_s = 1.4 \times 10^4$  Hz. The speed of sound is 334 m/s.
43. A fighter plane is traveling at half the speed of sound and emits a frequency of 614.0 Hz. A commercial aircraft is traveling at one-fifth the speed of sound. What frequency is detected by the commercial plane if **a)** the planes are approaching each other? **b)** the planes are receding from each other?

44. A stationary observer at an air show watches a fighter plane approach it at one-third the speed of sound. The plane emits a sound frequency of 15 Hz. What is the wavelength of the sound detected by the observer if the air temperature is  $27^{\circ}\text{C}$ ?
45. Joe and Dave have nothing better to do with their time so they run towards each other yelling as they go. Joe can run at an impressive 250 m/s and Dave can run at a slow 95 m/s. Joe yells at  $1.60 \times 10^3$  Hz and Dave shouts at 355 Hz. The air temperature is a cool  $265^{\circ}\text{K}$ . **a)** What frequency does Joe hear Dave shout at? **b)** What frequency does Dave hear Joe yell at?
46. How fast must a source be moving relative to a stationary observer such that the observer hears a frequency **a)** three times that of the source? **c)** one-fourth that of the source? Take the speed of sound to be 325 m/s.
47. What fraction of the speed of sound must a source be moving so that a stationary observer hears a frequency four times greater than the source frequency?
48. What fraction of the speed of sound must a source be moving so that a stationary observer hears a frequency two-thirds that of the source?
49. Two fighter planes approach each other, one traveling North and the other traveling South. The North bound plane is traveling at two-fifths the speed of sound. The south bound plane detects a frequency three times that of the source. What fraction of the speed of sound is the South bound plane traveling?
50. A Saskatoon firetruck races towards a fire at 117 km/h while its sirens roar at  $1.250 \times 10^4$  Hz. A stationary observer along the way hears a frequency of  $1.395 \times 10^4$  Hz. What month is the fire occurring?

**Part III.** Wave Phenomena. Answer in complete sentences.

51. Suppose you and your lab partner were asked to measure the speed of a transverse wave in a giant slinky. How could you do it? List the equipment you would need.
52. You are creating waves in a rope by shaking your hand back and forth. Without changing the distance your hand moves, you begin to shake it faster and faster. What happens to the amplitude, frequency, period, and velocity of the wave?
53. If you pull on one end of a Slinky, does the pulse reach the other end instantaneously? What if you pull on a rope? Hit the end of a metal rod?
54. A pulse is sent along a spring. The spring is attached to a light thread that is tied to a wall. Sketch the problem, label the point where the spring and string are attached **A** and label the point where the string attaches to the wall point **B**. **a)** What happens when the pulse reaches point **A**? **b)** Is the pulse reflected from **A** erect or inverted? **c)** What happens when the transmitted pulse reaches **B**? **d)** Is the pulse reflected from **B** erect or inverted?
55. A long spring runs across the floor of a room and out the door. A pulse is sent along the spring. After a few seconds, an inverted pulse returns. Is the spring attached to the wall in the next room or is it lying loose on the floor?
56. If you want to increase the wavelength of waves in a rope, should you shake it at a higher or lower frequency?

57. Rhonda sends a pulse along a rope. How does the position of a point on the rope, before the pulse comes compare to the position after the pulse has passed?
59. Suppose you produce a wave by shaking one end of a spring back and forth. How does the frequency of your hand compare to that of the wave?
61. What is the amplitude of a wave and what does it represent?
63. What happens to the spring at nodes of a standing wave?
65. When a stone is dropped into water, the resulting ripples spread farther and farther out, getting smaller and smaller in amplitude. Why does the amplitude eventually decrease to zero?
67. You send a pulse down a string that is attached to a second string with unknown properties. The pulse returns to you inverted and with a smaller amplitude. Is the speed of the waves faster or slower in the second string? Explain your reasoning.
58. What is the difference between a pulse and a wave?
60. Waves are sent along a spring of fixed length. a) Can the speed of the waves be changed? Explain. b) Can the frequency of a wave in the spring be changed? Explain.
62. When a wave reaches the boundary of a new medium, part of the wave is reflected and part is transmitted. What determines the amount of reflection?
64. You repeatedly dip your finger into a sink full of water to make circular waves. What happens to the wavelength as you move your finger faster?
66. What happens when two billiard balls collide head on? How does this differ from two waves or pulses that collide head on?

**Answer List**

- |   |  |  |
|---|--|--|
| <p>1. a) <math>T = 12 \text{ s}</math></p> <p style="padding-left: 20px;">b) <math>f = 0.083 \text{ Hz}</math></p> <p>4. <math>f = 4.0 \times 10^2 \text{ Hz}</math>,<br/><math>T = 2.5 \times 10^{-3} \text{ s}</math></p> <p>7. a) 1.5 points/min</p> <p style="padding-left: 20px;">b) 3 escapes/min</p> <p style="padding-left: 20px;">c) 11.3 rotations/s</p> <p>10. a) 0.100 s</p> <p style="padding-left: 20px;">b) <math>2.000 \times 10^{-3} \text{ s}</math></p> <p style="padding-left: 20px;">c) 4.0 s</p> <p style="padding-left: 20px;">d) <math>9.794 \times 10^{-9} \text{ s}</math></p> <p>13. a) <math>v = 49 \text{ cm/s}</math></p> <p style="padding-left: 20px;">b) <math>t = 11 \text{ s}</math></p> <p>16. <math>\lambda = 0.25 \text{ m}</math></p> <p>19. a) 0.93 Hz</p> <p style="padding-left: 20px;">b) 1.1 s</p> <p>22. 3.8 s</p> <p>25. Speed remains the same.<br/><math>v = 280. \text{ cm/s}</math> Wavelength<br/>becomes increased by a factor<br/>of four, <math>\lambda = 10.8 \text{ cm}</math></p> <p>28. a) <math>\lambda = 62.0 \text{ cm}</math></p> <p style="padding-left: 20px;">b) <math>v = 775 \text{ cm/s}</math></p> <p>31. <math>f_3 = 159 \text{ Hz}</math></p> <p>34. <math>v = 352 \text{ m/s}</math></p> <p>37. <math>T = 3.8 \text{ }^\circ\text{C}</math></p> | <p>2. a) <math>f = 0.800 \text{ Hz}</math></p> <p style="padding-left: 20px;">b) <math>T = 1.25 \text{ s}</math></p> <p>5. a) 7.5 Hz</p> <p style="padding-left: 20px;">b) 216 Hz</p> <p>8. a) 0.63 s</p> <p style="padding-left: 20px;">b) <math>3.9 \times 10^{-3} \text{ s}</math></p> <p style="padding-left: 20px;">c) 27.3 days/lunar cycle</p> <p>11. <math>v = 75 \text{ cm/s}</math>, <math>0.75 \text{ m/s}</math></p> <p>14. <math>v = 356 \text{ m/s}</math></p> <p>17. 15 waves</p> <p>20. 5.0 m/s</p> <p>23. 3.33 m</p> <p>26. a) 7.35 Hz</p> <p style="padding-left: 20px;">b) 2.34 cm</p> <p style="padding-left: 20px;">c) erect</p> <p style="padding-left: 20px;">d) inverted</p> <p>29. a) 17 cm</p> <p style="padding-left: 20px;">b) 360 cm/s</p> <p>32. <math>f_6 = 51.3 \text{ Hz}</math></p> <p>35. <math>v = 326 \text{ m/s}</math></p> <p>38. a) <math>v = 454 \text{ m/s}</math> b) <math>v = 556 \text{ m/s}</math><br/>c) <math>v = 161 \text{ m/s}</math></p> | <p>3. <math>f = 84.7 \text{ Hz}</math></p> <p>6. 2.00 s</p> <p>9. a) 0.20 Hz</p> <p style="padding-left: 20px;">b) 1.2 Hz</p> <p style="padding-left: 20px;">c) 40.0 Hz</p> <p style="padding-left: 20px;">d) <math>4.2 \times 10^{-2} \text{ Hz}</math></p> <p>12. a) <math>T = 9.149 \times 10^{-9} \text{ s}</math></p> <p style="padding-left: 20px;">b) <math>\lambda = 2.74 \text{ m}</math></p> <p>15. <math>T = 0.52 \text{ s}</math></p> <p>18. 62 m</p> <p>21. a) 2.5 m/s</p> <p style="padding-left: 20px;">b) 41 s</p> <p style="padding-left: 20px;">c) <math>1.5 \times 10^2 \text{ m}</math></p> <p>24. 17 m to <math>1.7 \times 10^{-2} \text{ m}</math></p> <p>27. a) <i>node dist.</i> = 12.8 cm</p> <p style="padding-left: 20px;">b) <math>v = 7.14 \text{ m/s}</math></p> <p>30. <math>\lambda = 40.0 \text{ cm}</math> and <math>f = 15 \text{ Hz}</math></p> <p>33. <math>f_2 = 185 \text{ Hz}</math></p> <p>36. <math>T = 73.8 \text{ }^\circ\text{C}</math></p> <p>39. a) <math>f_o = 9.185 \times 10^3 \text{ Hz}</math> b)<br/><math>f_o = 5158 \text{ Hz}</math></p> |
|---|--|--|

40. a)  $f_o = 8.813 \times 10^3 \text{ Hz}$  b)  $f_o = 7.000 \times 10^3 \text{ Hz}$
41.  $v_o = 142 \text{ km/h}$
42.  $f_o = 2.0 \times 10^3 \text{ Hz}$
43. a)  $f_o = 1474 \text{ Hz}$  b)  $f_o = 327 \text{ Hz}$
44.  $\lambda_o = 15 \text{ m}$
45. a)  $f = 889 \text{ Hz}$  b)  $f = 8.86 \times 10^3 \text{ Hz}$
46. a) 216 m/s approaching the observer. b) 975 m/s receding from the observer.
47.  $\frac{v_s}{v} = \frac{3}{4}$
48.  $\frac{v_s}{v} = \frac{1}{2}$
49.  $\frac{v_o}{v} = \frac{4}{5}$
50. *Not going to make it that easy, check your answer with me.*
51. *short answer*
52. *short answer*
53. *short answer*
54. *short answer*
55. *short answer*
56. *Lower*
57. *Same position*
58. *short answer*
59. *Same frequency*
60. *short answer*
61. *The distance of maximum displacement fromt the equilibrium position. Represents the wave's energy*
62. *The difference in wave velocity of the new medium.*
63. *No motion*
64. *Wavelength get smaller*
65. *Short answer*
66. *short answer*
67. *Short answer*

### Catalog List

- |               |               |               |               |
|---------------|---------------|---------------|---------------|
| 1. 20P BA 1   | 2. 20P BA 5   | 3. 20P BA 7   | 4. 20P BA 8   |
| 5. 20P BA 20  | 6. 20P BA 22  | 7. 20P BA 23  | 8. 20P BA 24  |
| 9. 20P BA 25  | 10. 20P BA 26 | 11. 20P BA 9  | 12. 20P BA 2  |
| 13. 20P BA 3  | 14. 20P BA 4  | 15. 20P BA 10 | 16. 20P BA 12 |
| 17. 20P BA 29 | 18. 20P BA 28 | 19. 20P BA 35 | 20. 20P BA 38 |
| 21. 20P BA 39 | 22. 20P BA 41 | 23. 20P BA 44 | 24. 20P BA 46 |
| 25. 20P BA 48 | 26. 20P BA 49 | 27. 20P BA 16 | 28. 20P BA 17 |
| 29. 20P BA 52 | 30. 20P BA 57 | 31. 20P BA 58 | 32. 20P BA 59 |
| 33. 20P BA 60 | 34. 20P BA 61 | 35. 20P BA 62 | 36. 20P BA 63 |
| 37. 20P BA 64 | 38. 20P BA 65 | 39. 20P BA 66 | 40. 20P BA 67 |
| 41. 20P BA 68 | 42. 20P BA 69 | 43. 20P BA 70 | 44. 20P BA 71 |
| 45. 20P BA 72 | 46. 20P BA 73 | 47. 20P BA 74 | 48. 20P BA 75 |
| 49. 20P BA 76 | 50. 20P BA 77 | 51. 20P BB 1  | 52. 20P BB 2  |
| 53. 20P BB 3  | 54. 20P BB 6  | 55. 20P BB 7  | 56. 20P BB 8  |
| 57. 20P BB 10 | 58. 20P BB 11 | 59. 20P BB 13 | 60. 20P BB 14 |
| 61. 20P BB 15 | 62. 20P BB 16 | 63. 20P BB 19 | 64. 20P BB 21 |
| 65. 20P BB 37 | 66. 20P BB 39 | 67. 20P BB 40 |               |

**Part I.** Sources of light questions. Use complete sentences.

1. Sound doesn't travel through a vacuum; how do we know light does?
2. What is the wavelength, from shortest to longest, the human eye can detect?
3. What colour of light has the shortest wavelength?
4. What colour of light has the shortest frequency?
5. Distinguish between a luminous body and an illuminated body.
6. Explain how we can see ordinary nonluminous classroom objects.
7. What happens to the wavelength of light as the frequency increases?
8. To what is the illumination of a surface by a light source directly proportional? Inversely proportional?
9. A point source of light is 2.0 m from screen **A** and 4.0 m from screen **B**. How does the illumination of screen **B** compare with the illumination of screen **A**?
10. Convert 700.0 nm, the wavelength of red light, to metres.
11. The Sun is  $1.5 \times 10^8$  km from the Earth. How many minutes does it take for its light to reach us?
12. Radio stations are usually identified by their frequency. What is the radio wavelength  $\lambda$  of a station that broadcasts with a frequency of 99.0 MHz?
13. What is the wavelength of electromagnetic radiation that has a frequency of  $4.8 \times 10^{14}$  Hz? Convert your answer to nanometres.
14. How many minutes does it take light to travel  $3.30 \times 10^{12}$  m?
15. What is the wavelength of light that has a frequency of  $7.23 \times 10^{14}$  Hz? What is the colour of this light?
16. Assuming Jupiter is at its closest approach to Earth, how many minutes does it take a radio signal from Earth to reach Jupiter if Jupiter is 5.2 AU from the Sun? (AU is an astronomical unit, 1 AU is the distance between the Earth and the Sun.)



**Answer List**

1. *short answer*
2. *short answer*
3. violet
4. red light
5. *short answer*
6. *short answer*
7. wavelength decreases
8. Directly proportional to the luminous flux. Inversely proportional to the square of the distance from the source.
9. Screen **A** is four times brighter than screen **B**.
10.  $7.000 \times 10^{-7}$  m
11. 8.3 min
12. 3.03 m
13.  $6.3 \times 10^{-7}$ , or 630 nm
14. 183 min
15.  $\lambda = 415$  nm, it is violet/blue light.
16. 35 min

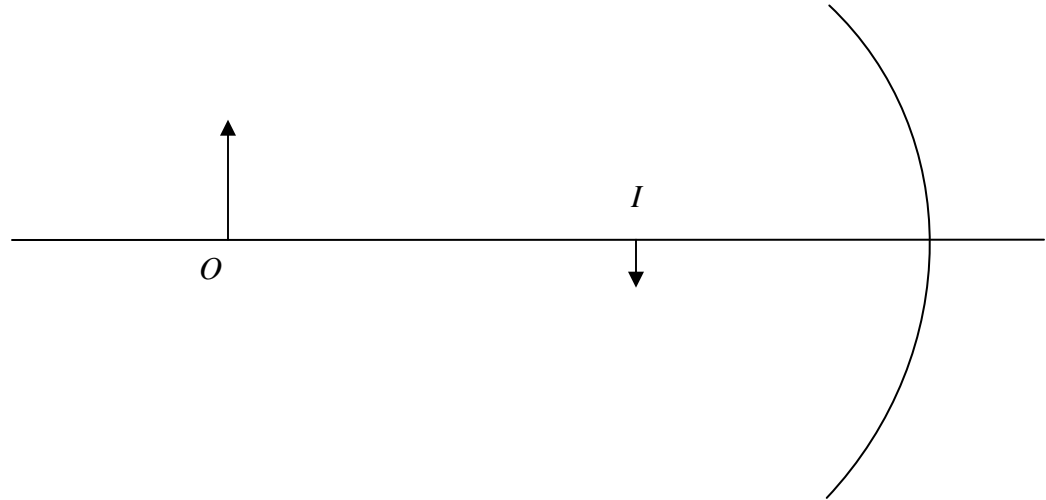
**Catalog List**

- |               |               |               |               |
|---------------|---------------|---------------|---------------|
| 1. 20P CA 1   | 2. 20P CA 2   | 3. 20P CA 3   | 4. 20P CA 4   |
| 5. 20P CA 5   | 6. 20P CA 6   | 7. 20P CA 7   | 8. 20P CA 8   |
| 9. 20P CA 9   | 10. 20P CA 11 | 11. 20P CA 13 | 12. 20P CA 14 |
| 13. 20P CA 16 | 14. 20P CA 17 | 15. 20P CA 18 | 16. 20P CA 19 |

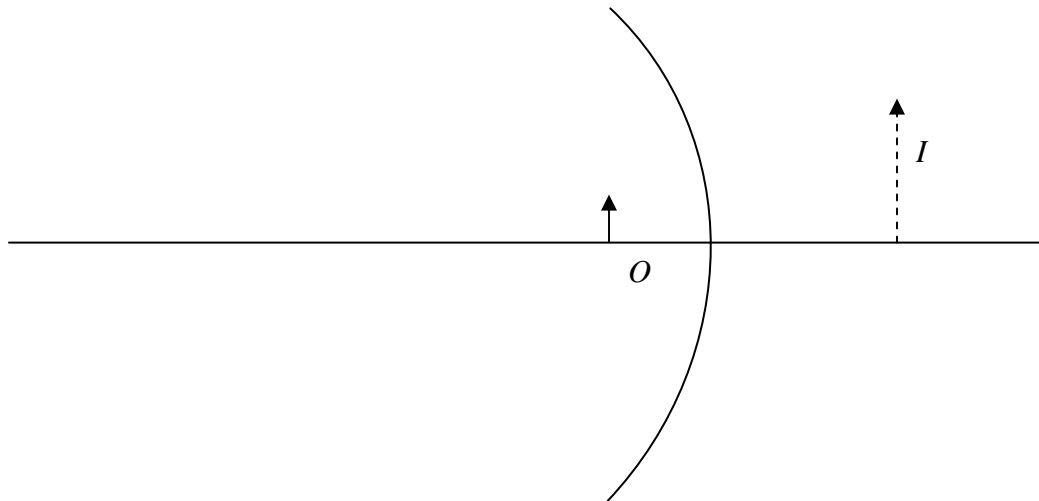
## Converging Mirror Problems

1. Locate the centre of curvature.

a.

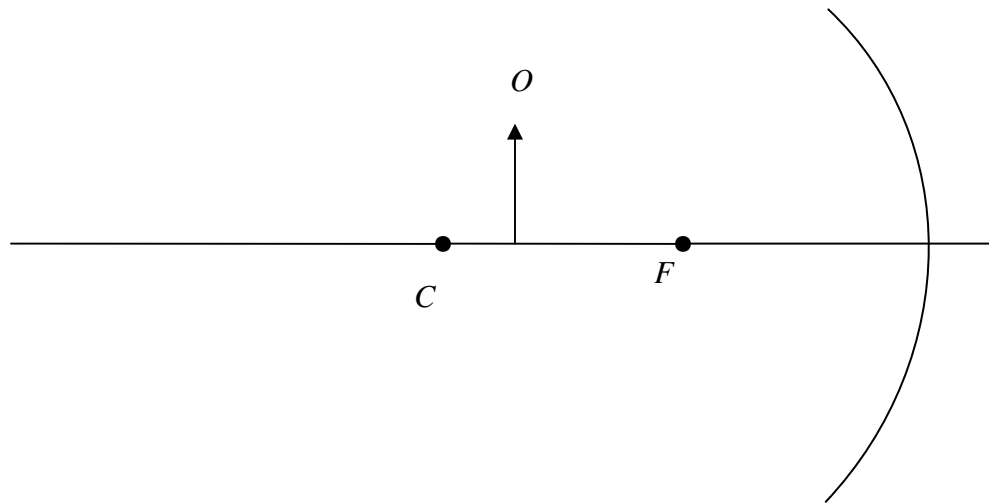


b.

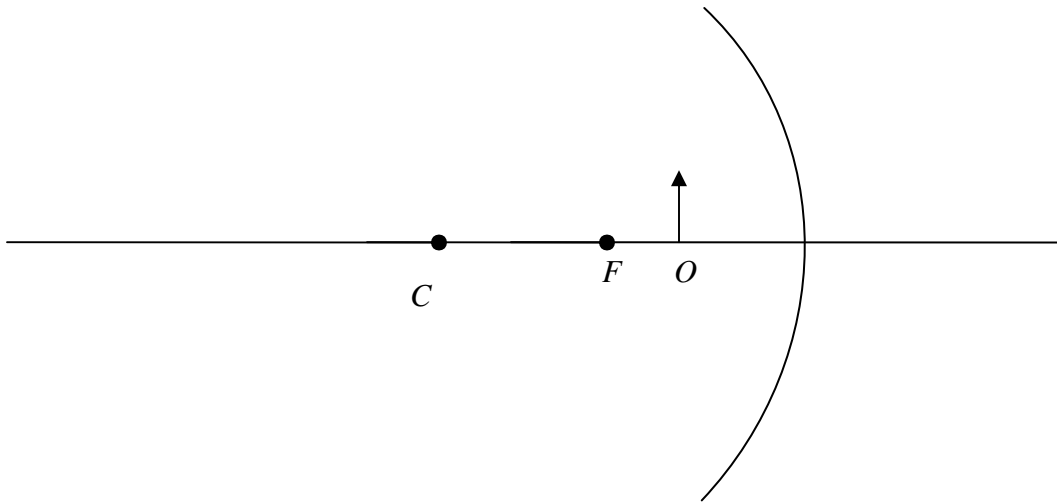


2. Locate the image of the object.

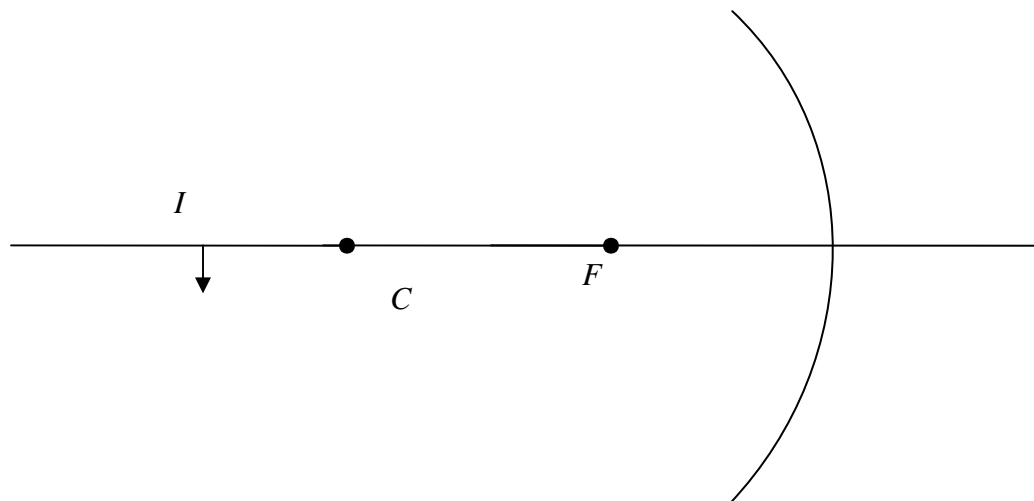
a.



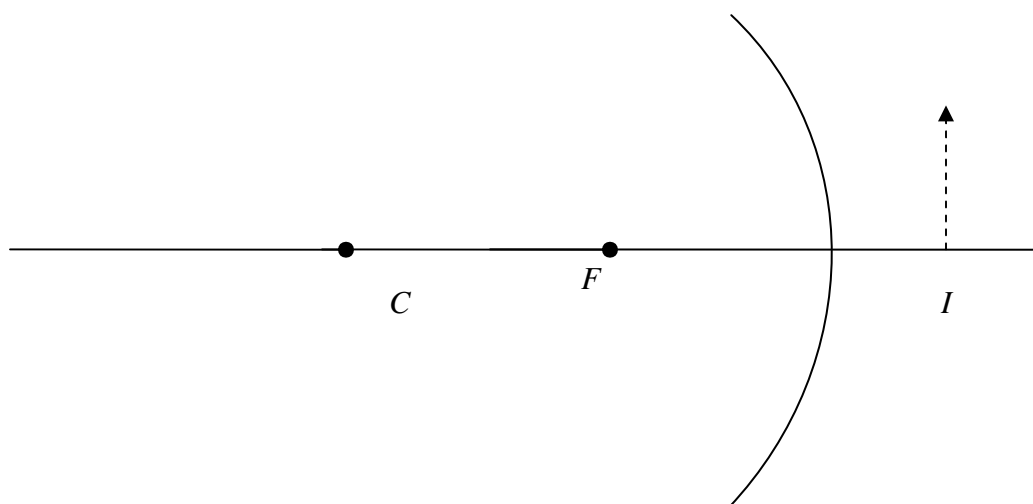
b.



3. Find the location and size of the object.  
a.

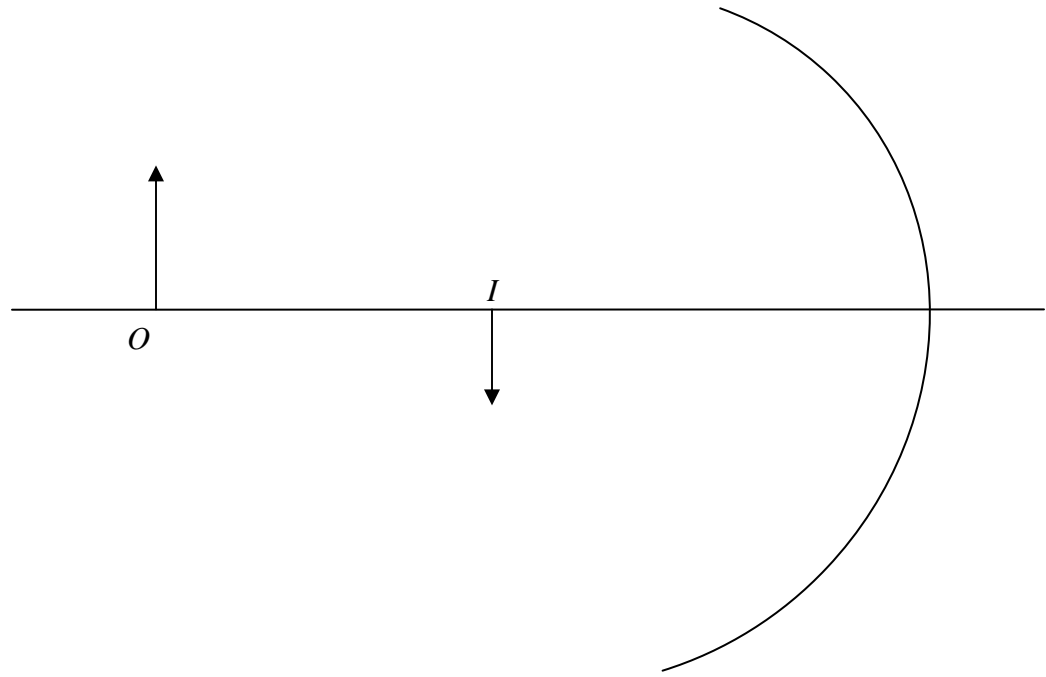


b.

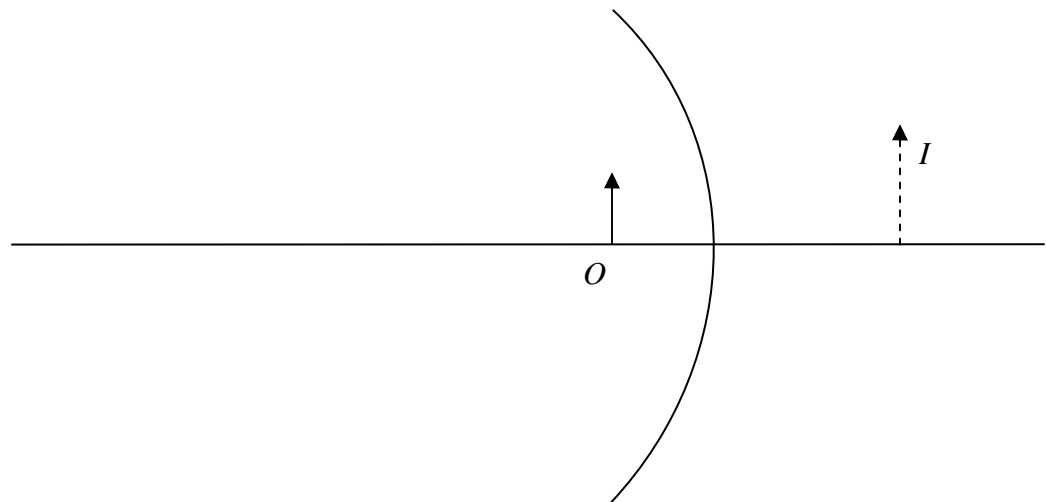


4. Determine the location of the principal focus.

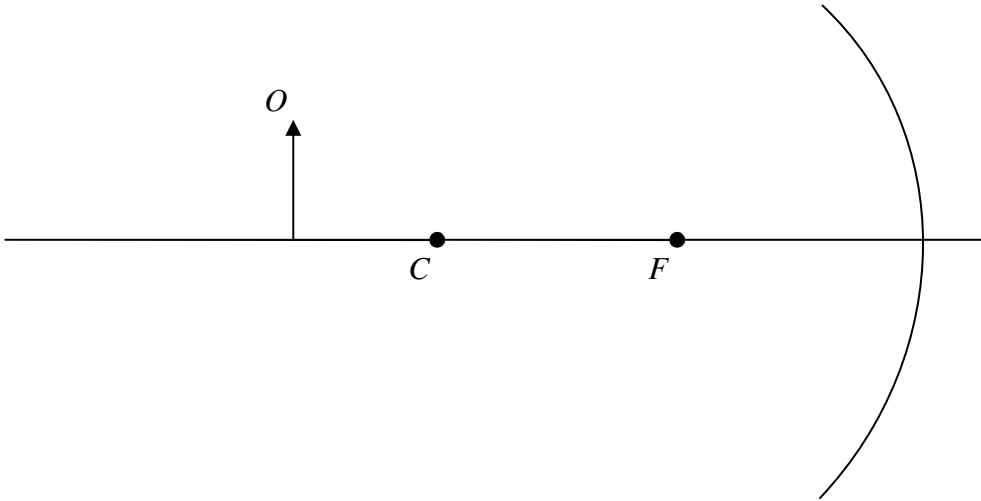
a.



b.



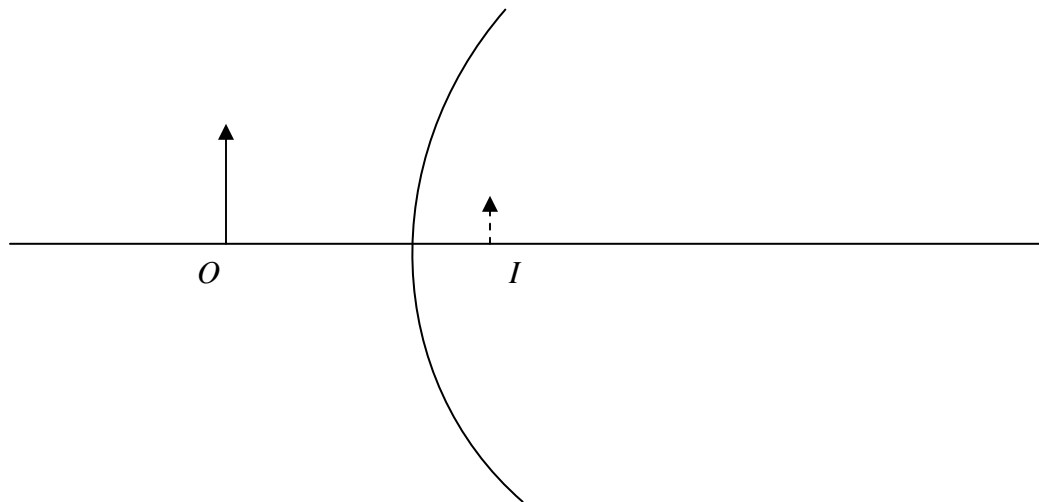
5. Locate the image in the following mirrors. List the characteristics of the image.



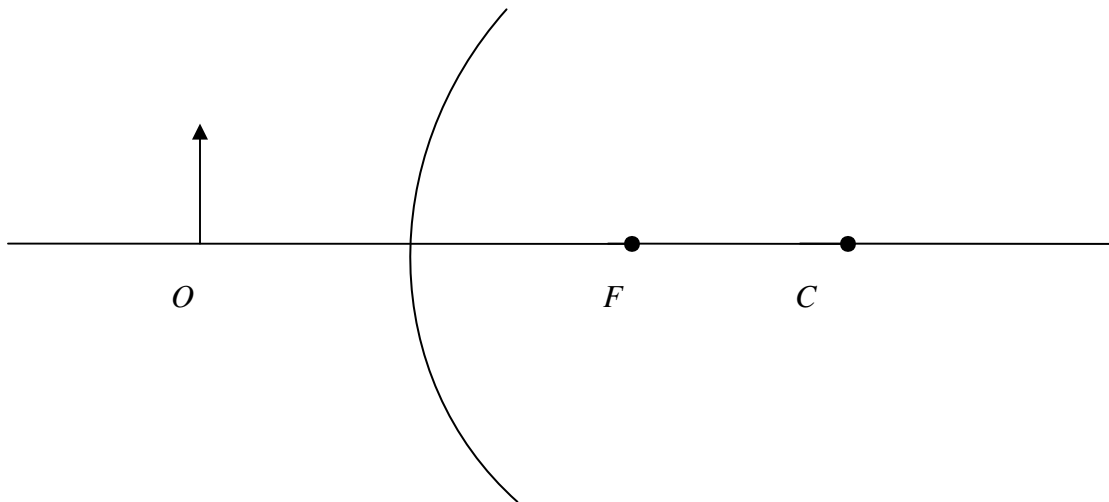
Characteristics:

### Diverging Mirror Problems

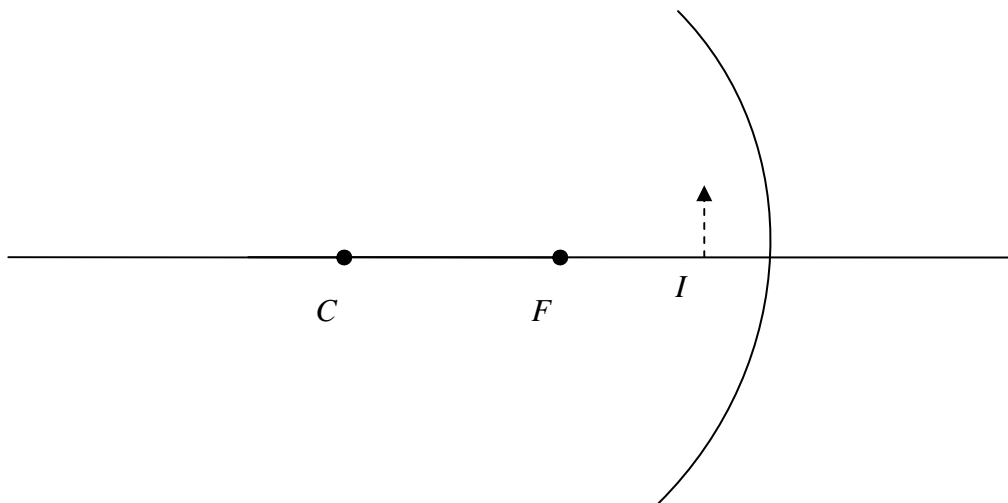
6. Locate the centre of curvature.



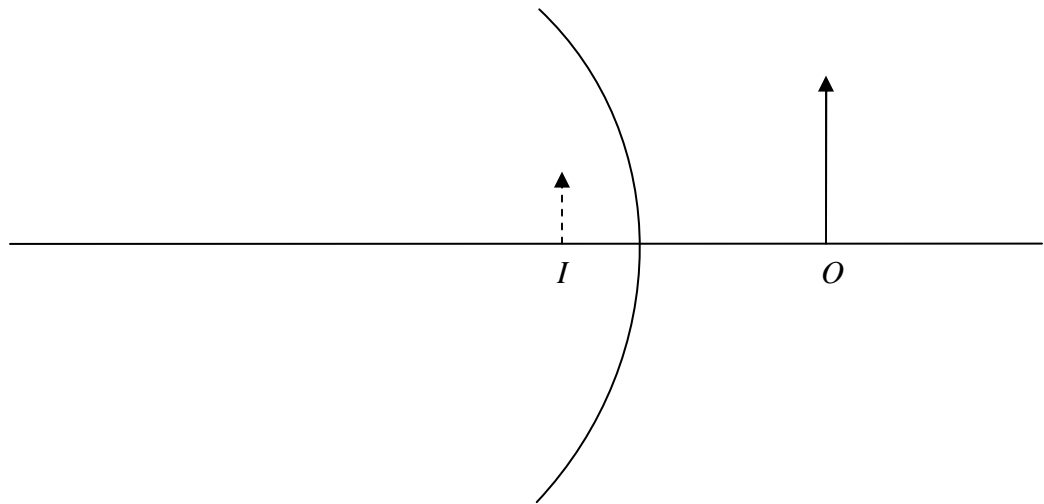
7. Locate the image of the object.



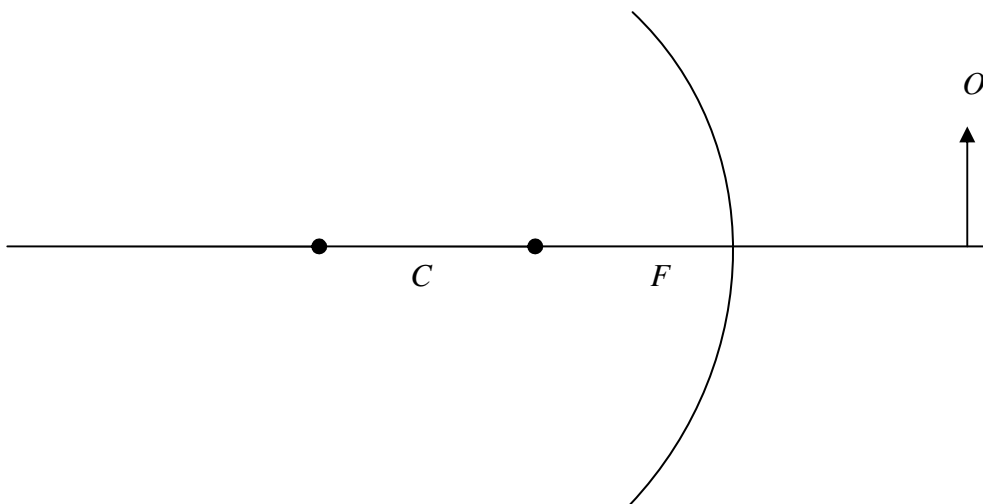
8. Find the location and size of the object.



9. Determine the location of the principal focus.



10. Locate the image in the diverging mirror.



Characteristics:



**Part I.** Mirrors and Reflection Problems.

1. A converging mirror has a focal length of 15.0 cm. a) Where is the image if the object is 58.0 cm from the vertex? b) What is the height of the image if the original object was 75.0 cm high?
2. A 2.5 m tall person stands 1.5 m in front of a large diverging mirror. a) What is the focal length of the mirror if the mirror has a magnification of  $M = +0.65$ ? b) What is the height of the image?
3. An image of a person's face is located a distance of  $d_i = -25.0$  cm from the vertex of a converging mirror. The person is 11.0 cm from the vertex. a) What is the focal length of the mirror? b) What is the magnification of the mirror? c) What is the height of the image if the face is 26.0 cm high?
4. How far from the vertex is an image in a diverging mirror if it has a focal length of  $f = -49.0$  cm and the object is 33.0 cm from the vertex?
5. Determine the image distance for a converging mirror with a focal length of  $f = 44$  cm if the object is placed 62 cm from the screen. What are the four characteristics of the image?
6. A 15 cm pencil is placed 35 cm from a diverging mirror. If the focal length is  $f = -25$  cm, find the image distance and height. What are the four characteristics of the image?
7. Determine the image distance in a converging mirror that has a focal length of 15.0 cm when the object is placed a) 40.0 cm from the mirror; and b) 10.0 cm from the mirror.
8. Determine the image distance in a diverging mirror that has a focal length of  $-20.0$  cm when the object is placed a) 10.0 cm from the mirror; and b) 30.0 cm from the mirror.
9. A candle 3.0 cm high is placed 30.0 cm from a converging mirror with a focal length of 20.0 cm. Find the location and height of the image. What are the images characteristics?
10. A woman looks at herself in a magnifying converging mirror whose focal length is 20.0 cm. If her face is 10.0 cm from the mirror, at what distance from the mirror is her image? what is the magnification of her face?
11. A 2.0 cm high candle is placed 15 cm in front of a converging mirror with a focal length of 30.0 cm. How far behind the mirror does the candle appear, and how large is it?
12. A dentist holds a converging mirror with a focal length of 20.0 mm a distance of 15 mm from a tooth. What is the magnification of a filling in the tooth?
13. A trucker sees the image of a car passing her truck in her diverging rear-view mirror whose focal length is  $-60.0$  cm. If the car is 1.5 m high and 6.0 m away, what is the size and location of the image?
14. Where is an image formed with a converging mirror of focal length 25 cm if the object is placed a) 45 cm from the vertex? b) 15 cm from the vertex?
15. A converging mirror has a focal length of 42 cm. Where should an object be placed to produce a *real* image one third the size of the object?
16. A converging mirror has a focal length of 42 cm. Where should an object be placed to produce a *virtual* image three times the size of the object?
17. Where is the centre of curvature of a diverging mirror that produces an image three quarters as high as the original object? The original object is 24.0 cm from the vertex of the mirror.
18. A converging mirror has a focal length of 30.0 cm. Where must an object be placed to produce a *real* image five times the size of the object?

19. A child looks at his reflection in a spherical Christmas tree ornament 8.0 cm in diameter, and sees that the image of his face is reduced by a factor of half. How far is his face from the ornament?
20. A converging mirror has a focal length of 15 cm. Where would you place an object in order to produce a virtual image two times as tall as the object?
21. A converging mirror has a focal length of 24 cm. Where would you place an object: a) to produce a real image one-third the size of the object? b) to produce a real image 3.00 times the size of the object? c) to produce a virtual image 3.00 times the size of the object?
22. A converging mirror has a focal length of  $f = 15.0$  cm. The distance between the object and its real, enlarged image is 40.0 cm. Determine the magnification.
23. A converging mirror has a focal length of  $f = 12.0$  cm. The distance between the object and its real, reduced image is 55.0 cm. Determine the magnification.
24. You are given either a converging or diverging mirror with a known focal length  $f$ . Using the mirror and magnification equations, show that to obtain a desired magnification  $M$ , the object should be placed a distance of,  $d_o = \frac{f(M - 1)}{M}$ .

**Answer List**

- |  |   |  |
|--|---|--|
| 1. a) $d_i = 20.2 \text{ cm}$<br>b) $h_i = -26.1 \text{ cm}$           | 2. a) $f = -2.8 \text{ m}$<br>b) $h_i = 1.6 \text{ m}$  | 3. a) $f = 19.6 \text{ cm}$<br>b) $M = 2.27$<br>c) $h_i = 59.1 \text{ cm}$   |
| 4. $d_i = -19.7 \text{ cm}$  | 5. $d_i = 1.5 \times 10^2 \text{ cm}$ . Image is real, inverted, beyond $C$ , and larger than the object. | 6. $d_i = -15 \text{ cm}$ ; $h_i = 6.3 \text{ cm}$ . Image is virtual, between $V$ and $F$ , smaller than the object, and erect. |
| 7. a) $d_i = 24.0 \text{ cm}$<br>b) $d_i = -30.0 \text{ cm}$           | 8. a) $d_i = -6.70 \text{ cm}$<br>b) $d_i = -12.0 \text{ cm}$   | 9. $d_i = 60.0 \text{ cm}$ ; $h_i = -6.0 \text{ cm}$ . The image is real, inverted, beyond $C$ , and larger than the object.     |
| 10. $d_i = -20.0 \text{ cm}$ ; $M = +2.0$                              | 11. $d_i = -30.0 \text{ cm}$ ; $h_i = 4.0 \text{ cm}$   | 12. $M = +4.0$   |
| 13. $h_i = 14 \text{ cm}$ ; $d_i = -0.55 \text{ m}$                    | 14. a) $d_i = 56 \text{ cm}$<br>b) $d_i = -38 \text{ cm}$   | 15. $d_o = 1.7 \times 10^2 \text{ cm}$   |
| 16. $d_o = 28 \text{ cm}$  | 17. $C = -144$  | 18. $d_o = 36 \text{ cm}$  |
| 19. $d_o = 2.0 \text{ cm}$   | 20. $d_o = 7.5 \text{ cm}$  | 21. a) $d_o = 96 \text{ cm}$<br>b) $d_o = 32 \text{ cm}$<br>c) $d_o = 16 \text{ cm}$   |
| 22. $d_o = 20.0 \text{ cm}$ , $d_i = 60.0 \text{ cm}$ ,<br>$M = -3.00$ | 23. $d_o = 69.5 \text{ cm}$ , $d_i = 14.5 \text{ cm}$ ,<br>$M = -0.209$                                   | 24. <i>proof</i>   |

**Catalog List**

- |               |               |               |               |
|---------------|---------------|---------------|---------------|
| 1. 20P CB 1   | 2. 20P CB 2   | 3. 20P CB 3   | 4. 20P CB 4   |
| 5. 20P CB 5   | 6. 20P CB 6   | 7. 20P CB 8   | 8. 20P CB 9   |
| 9. 20P CB 11  | 10. 20P CB 12 | 11. 20P CB 13 | 12. 20P CB 14 |
| 13. 20P CB 15 | 14. 20P CB 17 | 15. 20P CB 19 | 16. 20P CB 20 |
| 17. 20P CB 21 | 18. 20P CB 24 | 19. 20P CB 26 | 20. 20P CB 27 |
| 21. 20P CB 28 | 22. 20P CB 31 | 23. 20P CB 32 | 24. 20P CB 40 |

**Part I.** Review of trigonometric properties and right triangles.

1. Find  $\tan 40^\circ$  to three decimal places.
2. Find  $\sin 40^\circ$  to three decimal places.
3. Find  $\tan 80^\circ$  to four decimal places.
4. Find  $m\angle C$  to the nearest degree given  $\sin C = 0.5784$ .
5. Find  $m\angle A$  to the nearest degree given  $\tan A = 3.2452$ .
6. Find  $\angle A$  to the nearest tenth of a degree if  $\cos A = 0.906$ .
7. Find  $\angle P$  to the nearest tenth of a degree of  $\sin A = 0.457$ .
8. Find  $\angle \phi$  to the nearest degree given  $\sin \phi = 0.423$ .
9. Find  $\angle \theta$  to the nearest degree given  $\tan \theta = 9.094$ .
10. Find  $m\angle \beta$  to the nearest degree given  $\sin \beta = \frac{4}{7}$ .
11. Find  $\angle \beta$  to the nearest degree given  $\tan \beta = \frac{\sqrt{5}}{3}$ .

**Part II.** Refraction of light problems.

12. What is the speed of light in flint glass?
13. Light travels from air into ruby. What is the speed of light in ruby?
14. How long will it take light to travel through a piece of fused quartz 1.35 m thick?
15. How many times faster does light travel in glycerin than in zircon?
16. What is the index of refraction of a liquid in which the speed of light is  $2.50 \times 10^8$  m/s?
17. What is the speed of light in sodium chloride?
18. Zircon is often used as an imitation diamond in costume jewelry. Calculate how much the speed of light decreases when it passes from air into zircon.
19. What is the wavelength of blue light in ruby if it travels from a vacuum where its wavelength is  $\lambda = 455$  nm?
20. Someone claims to have invented a material with an index of refraction of  $n = 0.85$ . What is the speed of light in that material? What argument can you provide against such a material existing?
21. A piece of fused quartz of a length 25 cm is placed next to a 55 cm piece of zircon (there is no gap between the two). How long will it take light to travel through both materials? Be careful with the units.
22. How does the frequency of a radio wave,  $\lambda = 2.8$  m, traveling through air compare to the frequency of the radio wave after entering water? What is the wavelength and frequency of this radio wave in the water?
23. Light travels from air into flint glass. a) What is the speed of light in flint glass? b) If the incident angle is  $25^\circ$ , what is the angle of refraction?
24. Light is traveling from an unknown medium into diamond. The angle of incidence is  $42^\circ$  and the angle of refraction is  $28^\circ$ . What is the index of refraction of the unknown medium?
25. Light travels from Plexiglass into ruby. What is the angle of incidence if the angle of refraction is measured to be  $16.8^\circ$ ?
26. Light passes from air into diamond with an angle of incidence of  $60.0^\circ$ . What will be the angle of refraction?
27. A transparent substance has a refractive index of  $n = 1.30$ . What is the angle of incidence in air when the angle of refraction in the substance is  $45^\circ$ ?

28. What is the index of refraction of a material if the angle of incidence in air is  $50.0^\circ$  and the angle of refraction in the material is  $40.0^\circ$ ?
30. A ray of light in air strikes diamond and another strikes a piece of fused quartz, in each case at an angle of incidence of  $40.0^\circ$ . What is the difference between the angles of refraction?
32. The speed of light in a certain material is  $9.68 \times 10^7$  m/s. If light enters that material from crown glass with an angle of incidence of  $33.5^\circ$ , what will be the angle of refraction?
34. Light is traveling from water into crown glass. What is the largest possible angle of refraction?
36. A ray of light travels from diamond into Plexiglas. What is the critical angle in the diamond?
38. For each of the following light travels into water. Calculate the critical angle for (a) zircon (b) sodium chloride, and (c) ethyl alcohol.
40. What is the difference between the critical angle light traveling from ruby-to-air and the critical angle for light traveling from water-to-air?
42. In a certain medium, light will travel 1.75 m in 11.0 ns. What is the critical angle of the substance if light is traveling from that substance into air?
29. A ray of light passes from water into carbon disulphide,  $n_{CS_2} = 1.63$ , with an angle of incidence of  $30.0^\circ$ . What is the angle of refraction in the carbon disulfide?
31. Light travels from water into an unknown material. If the angle of incidence is  $35.5^\circ$  and the measured angle of refraction is  $17.4^\circ$ , what is the speed of light in the unknown material?
33. Light is traveling from air into glycerin. What is the largest possible angle of refraction?
35. What is the critical angle in crystal glass if light travels from it into air?
37. What is the critical angle in flint glass when light passes from flint glass into air?
39. The critical angle for a medium is  $40.5^\circ$ . What is the index of refraction for that medium if the light travels into air?
41. In a certain substance, light travels 3.15 m in 16.5 ns. What is the critical angle of the substance if light travels from that substance into ethyl alcohol?

**Answer List**

- |   |   |   |
|---|---|---|
| 1. 0.839  | 2. 0.643                                    | 3. 5.6713                                   |
| 4. $35^\circ$   | 5. $73^\circ$                               | 6. $25.0^\circ$                             |
| 7. $27.2^\circ$   | 8. $25^\circ$                               | 9. $83.7^\circ$                             |
| 10. $35^\circ$  | 11. $37^\circ$                              | 12. $v = 1.82 \times 10^8$ m/s              |
| 13. $v_{ruby} = 1.95 \times 10^8$ m/s   | 14. $t = 6.57$ ns                           | 15. $v_{glycerin} = 1.31v_{zircon}$         |
| 16. $n = 1.20$  | 17. $v_{s.chloride} = 1.96 \times 10^8$ m/s | 18. Light decreases $1.44 \times 10^8$ m/s. |
| 19. $\lambda_{ruby} = 295$ nm   | 20. $v_{material} = 3.53 \times 10^8$ m/s   | 21. $t = 4.74$ ns                           |
| 22. The wavelength decreases in water. The frequency is $f = 1.1 \times 10^8$ Hz and $\lambda = 2.11$ m in the water. | 23. a) $v = 1.82 \times 10^8$ m/s           | 24. $n_{unknown} = 1.7$                     |
|   | b) $\theta_R = 15^\circ$                    |   |
| 25. $\theta_i = 17.1^\circ$   | 26. $\theta_R = 21.0^\circ$                 | 27. $\theta_i = 67^\circ$                   |
| 28. $n = 1.19$  | 29. $\theta_R = 24.0^\circ$                 | 30. The difference is $11^\circ$ .          |
| 31. $v_{material} = 1.16 \times 10^8$ m/s   | 32. $\theta_R = 15.7^\circ$                 | 33. $42.9^\circ$                            |
| 34. $61.0^\circ$  | 35. $\theta_C = 40.5^\circ$                 | 36. $\theta_C = 38.6^\circ$                 |
| 37. $\theta_C = 37.3^\circ$   | 38. a) $\theta_C = 43.8^\circ$              | 39. $n = 1.54$                              |
|   | b) $\theta_C = 60.4^\circ$                  |   |
|   | c) $\theta_C = 77.9^\circ$                  |   |
| 40. The difference is $8.3^\circ$ .   | 41. $\theta_C = 59.5^\circ$                 | 42. $\theta_C = 31.9^\circ$                 |

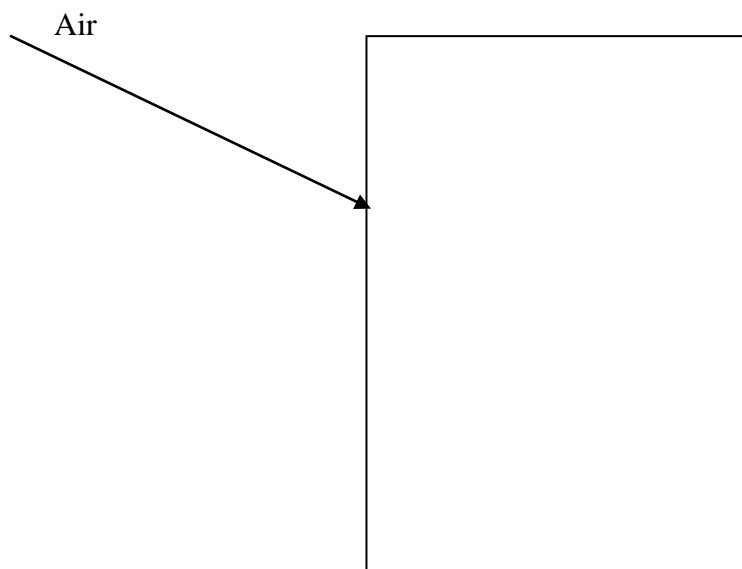
**Catalog List**

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|---------------|---------------|---------------|---------------|
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| 5. CM2 JA 90  | 6. CM2 JA 91  | 7. CM2 JA 92  | 8. CM2 JA 93  |
| 9. CM2 JA 94  | 10. CM2 JA 95 | 11. CM2 JA 96 | 12. 20P CC 1  |
| 13. 20P CC 2  | 14. 20P CC 5  | 15. 20P CC 6  | 16. 20P CC 9  |
| 17. 20P CC 10 | 18. 20P CC 11 | 19. 20P CC 13 | 20. 20P CC 15 |
| 21. 20P CC 16 | 22. 20P CC 17 | 23. 20P CC 19 | 24. 20P CC 20 |
| 25. 20P CC 22 | 26. 20P CC 23 | 27. 20P CC 24 | 28. 20P CC 25 |
| 29. 20P CC 27 | 30. 20P CC 29 | 31. 20P CC 30 | 32. 20P CC 33 |
| 33. 20P CC 47 | 34. 20P CC 48 | 35. 20P CC 34 | 36. 20P CC 35 |
| 37. 20P CC 38 | 38. 20P CC 39 | 39. 20P CC 40 | 40. 20P CC 42 |
| 41. 20P CC 43 | 42. 20P CC 45 |               |               |

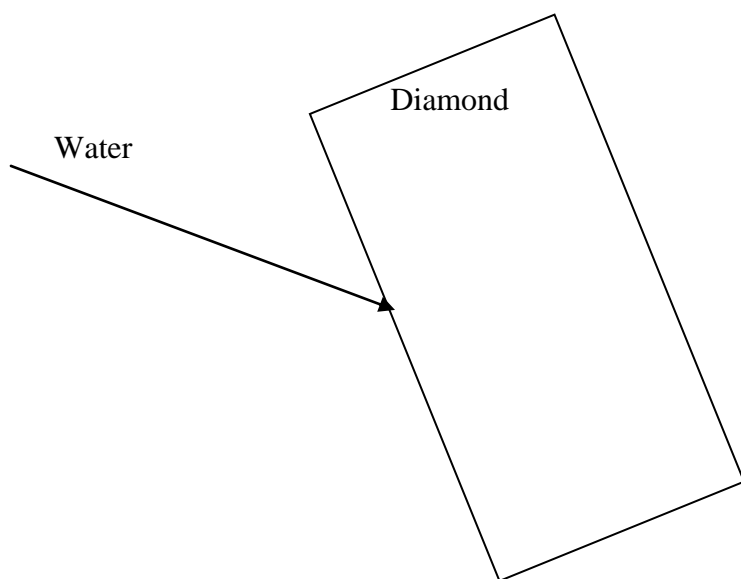
## Displacement & Deviation Practice

→ Use a protractor, ruler, and calculator to trace the path of light.

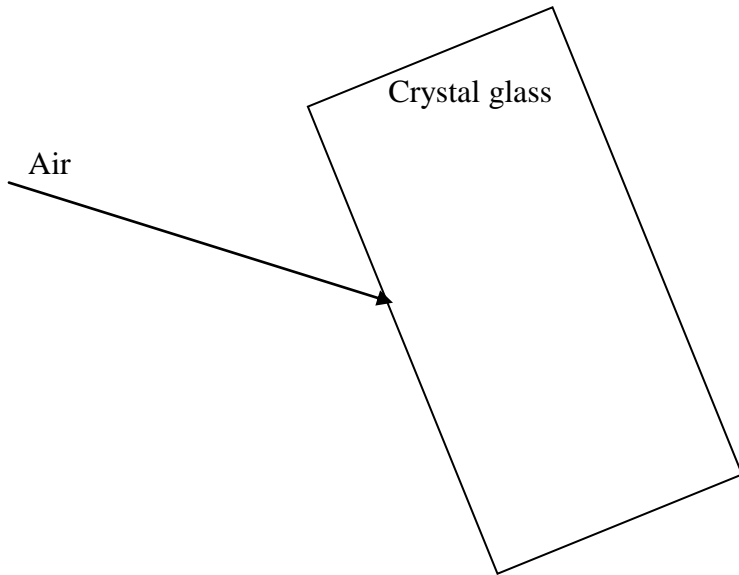
41. Find the lateral displacement in mm for the rectangular piece of crown glass.



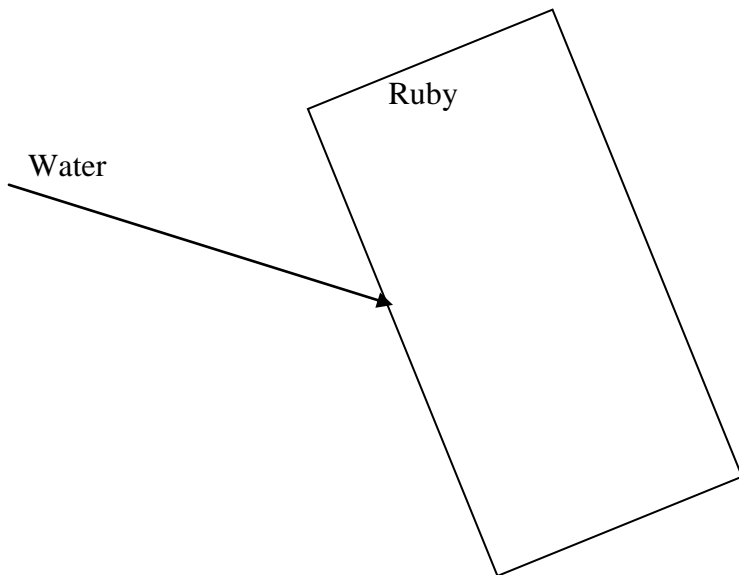
42. Find the lateral displacement in mm for light traveling from water into diamond.



43. Using a protractor, ruler, and calculator, calculate the lateral displacement in mm.

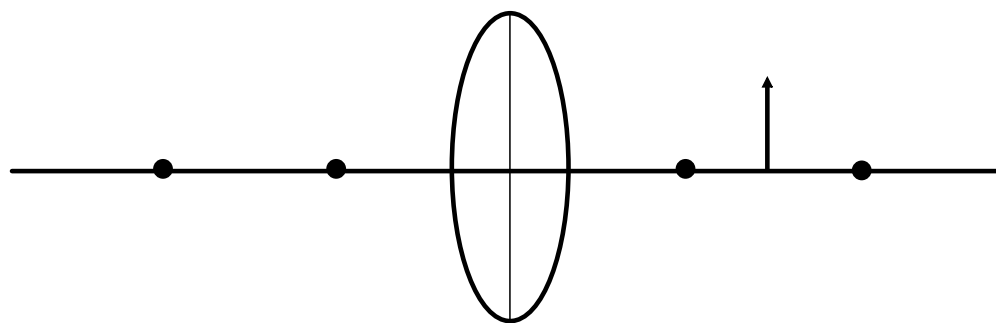
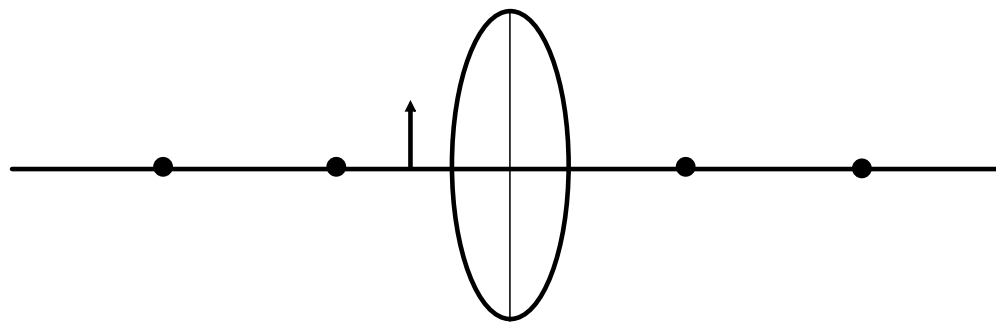
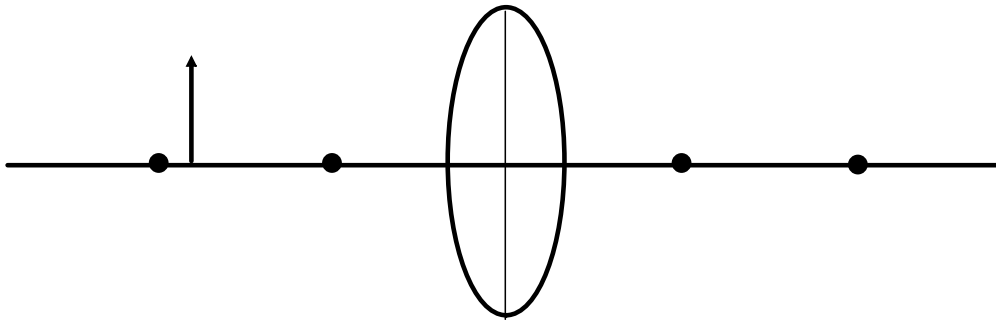
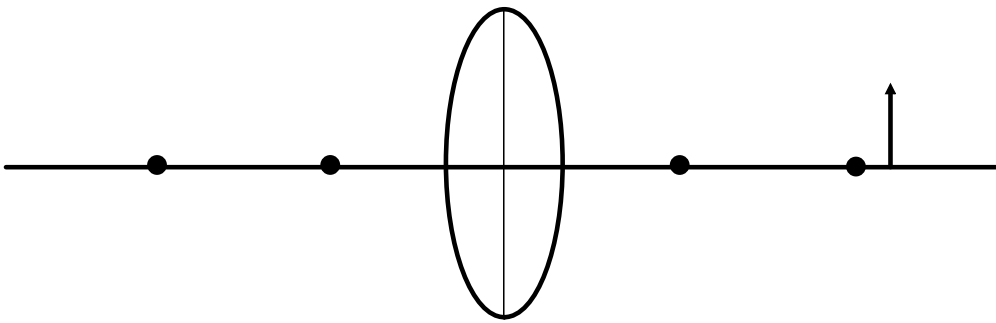
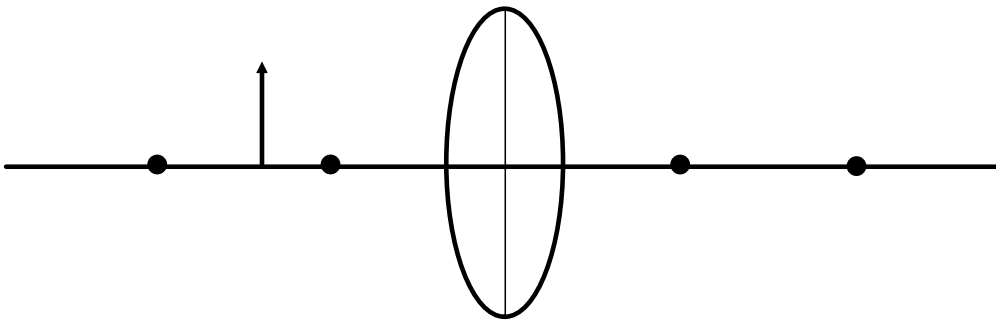


44. Find the lateral displacement in mm for light traveling from water into ruby.  
(Displacement  $\approx 6.5$  mm)

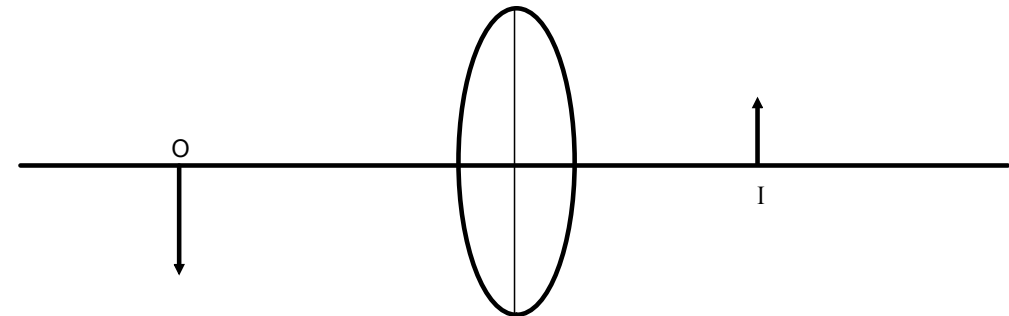
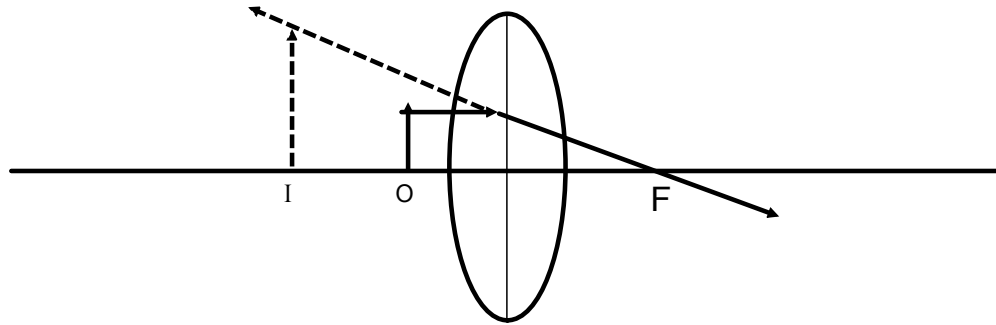
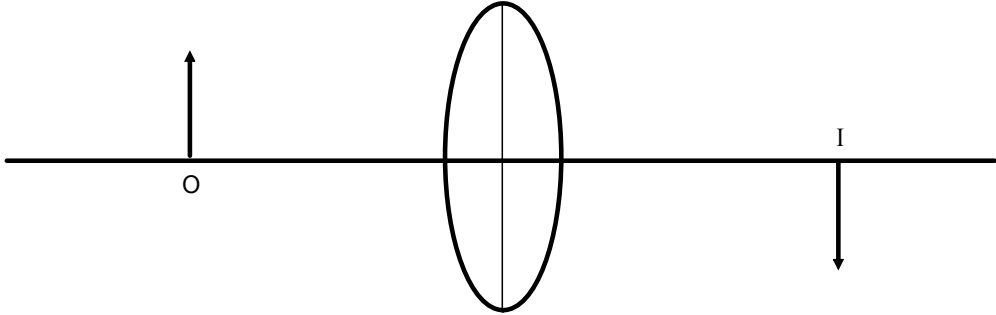
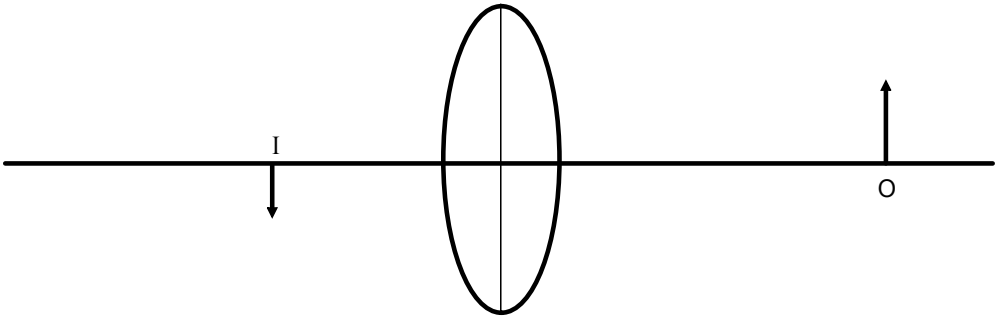
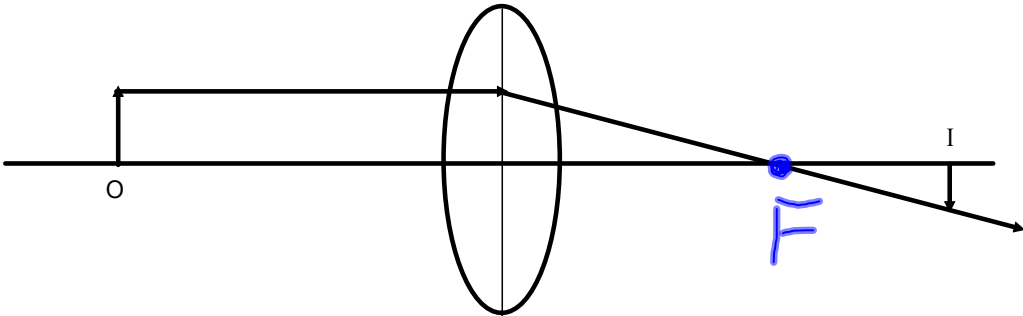




Find the image location and size.



Given the location and size of the object and image, find the principle focus by drawing a light ray from the object that is parallel to the principle axis.

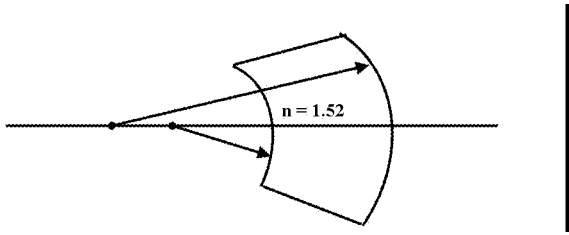


## Part I.

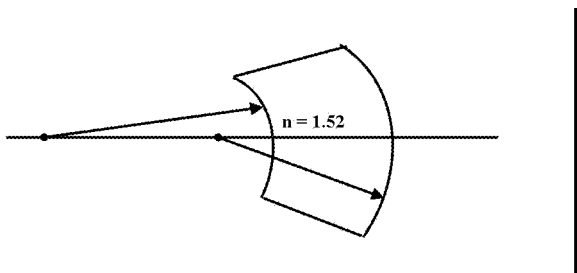
1. A converging lens has a focal length of 20.0 cm. If it is placed 50 cm from an object, at what distance from the lens will the image be?
2. The focal length of a lens in a box camera is 10.0 cm. The fixed distance between the lens and the film is 11.0 cm. If the object is to be clearly focussed on the film, how far must it be from the lens?
3. An object 8.0 cm high is placed 80.0 cm in front of a converging lens of focal length 25 cm. a) Using the lens and magnification equations, determine the image position and its height. b) By means of a scale ray diagram, locate the image and determine its height.
4. A lamp 10.0 cm high is placed 60.0 cm in front of a diverging lens of focal length  $f = 20.0$  cm. a) Using the appropriate equations, calculate the image position and the height of the image. b) By means of a scale ray diagram, locate the image and determine its height.
5. A typical single lens reflex (SLR) camera has a converging lens with a focal length of 50.0 mm. What is the position and size of the image of a 25 cm candle located 1.0 m from the lens?
6. A converging lens with a focal length of 20.0 cm is used to create an image of the Sun on a paper screen. How far from the lens must the paper be placed to produce a clear image?
7. The focal length of a slide projector's converging lens is 10.0 cm.
  - a) If a 35.0 mm slide is positioned 10.2 cm from the lens, how far away must the screen be placed to create a clear image?
  - b) If the height of a dog on the slide film is 12.5 mm, how tall will the dog's image be on the screen?
  - c) If the screen is then removed to a position 15 m from the lens, by how much will the separation between film and lens have to change from part (a)?
8. A candle is placed 36 cm from a screen. Where between the candle and the screen should a converging lens with a focal length of 8.0 cm be placed to produce a sharp image on the screen?
9. An object 5.00 cm height is placed at the 20.0 cm mark on a metre stick. A converging lens with a focal length of 20.0 cm is mounted at the 50.0 cm mark. What are the position and size of the image?
10. A camera lens has a focal length of 6.0 cm and is located 7.0 cm from the film. How far from the lens is the object positioned if a clear image has been produced on the film?
11. A lens with a focal length of 20.0 cm is held 12.0 cm from a grasshopper 7.00 mm high. What is the position and size of the image of the grasshopper?
12. A projector is required to make a real image, 0.5 m tall, of a 5.0 cm object placed on a slide. Within the projector, the object is to be placed 10.0 cm from the lens. What must be the focal length of the lens?
13. A 3.0 cm flower is placed 40.0 cm from a lens with a focal length of 10.0 cm. What is the position, size, and type of image?
14. An object 7.9 cm high is placed at the 35 cm mark on a metre stick. A converging lens with a focal length of  $f = 25$  cm is mounted at the 95 cm mark. a) What is the distance of the image from the optical centre? b) What is the size of the image?
15. A child wants to magnify an ant by a factor of 15.0. The magnifying glass she holds has a focal length of  $f = 75.0$  mm. To get this magnification, how far from the ant should she hold the magnifying glass?

16. A projector, with a focal length of  $f = 14.4\text{mm}$  produces an inverted, enlarged image of a squirrel. If the squirrel is to be enlarged by a factor of 25.0, what must be the separation between the lense and the slide of the squirrel?
17. What is the focal length of lens which has a radius of curvature of 6.00 cm on one side and 12.0 cm on the other side? Both sides are convex and the index of refraction is 1.60.
18. What is the focal length of a plano-convex lens with a radius of curvature of 12.0 cm? The index of refraction of the lens is 1.40.
19. What is the focal length of a plano-concave lens with a radius of curvature of 12.0 cm? The index of refraction of the lens is 1.40.
20. What is the focal length for a lens if both radii are 20.0 cm, the index of refraction is 1.20, and:
  - a) both sides are convex.
  - b) both sides are concave.
  - c) one side is convex and the other is concave.
21. A double convex lens ( $n = 1.50$ ) has radii of curvatures of 18.0 cm.
  - a) What is the focal length in air?
  - b) What is the focal length in water?
22. A converging meniscus flint glass lens has a focal length of 26.5 cm. What is its convex radius if its concave radius measures 8.0 cm?
23. What are the radii of curvature of a double convex Plexiglas lens ( $R_1 = R_2$ ) that has a focal length of 30.0 cm?
24. What is the radius of curvature of a double concave Plexiglas lens ( $R_1 = R_2$ ) that has a focal length of  $-30.0\text{ cm}$ ?
25. Someone has two double convex lenses ( $R_1 = R_2$ ). One is made of crown glass and the other is made of diamond, and each have a focal length of 10.0 cm. What is the radii of curvatures for each lens?
26. What is the index of refraction of a diverging meniscus lens of focal lenth  $-15.5\text{ cm}$ , and has a concave radius of 5.0 cm and a convex radius of 12 cm
27. A person has two identically shaped lenses, one is made of Plexiglas and the other zircon. Which lens has the greater focal length and by what factor?
28. A plano-concave flint glass lens has a focal length of  $-16.0\text{ cm}$  in air. Material of what index of refraction should the lens be placed into to have a focal length of  $+16.0\text{ cm}$ ?
29.
  - a) What is the focal length of a double convex glass lens ( $R_1 = R_2$ ) of radius 20.0 cm for violet light? The index of refraction for violet light is 1.532.
  - b) What is the focal length of the same lens for red light? The index of refraction for red light is 1.513.
30. A converging lens has a focal length of 20.0 cm If it is placed 50 cm from an object, at what distance from the lens will the image be?
31. The focal length of a lens in a box camera is 10.0 cm. The fixed distance between the lens and the film is 11.0 cm. If the object is to be clearly focussed on the film, how far must it be from the lens?
32. An object 2.0 cm high is placed 8.0 cm from the focal point of a double convex lens made of quartz. The lens has a radii of curvature of 20.0 cm and 5.0 cm. Calculate the position and size of the image.

33. What is the focal length of the following lens? Is it converging or diverging?



34. What is the focal length of the following lens? Is it converging or diverging?



**Answer List**

- |   |   |
|---|---|
| <p>1. <math>d_i = 33.3 \text{ cm}</math></p> <p>3. a) <math>d_i = 36 \text{ cm}; h_i = -3.6 \text{ cm}</math></p> <p>5. <math>d_i = 5.3 \text{ cm}; h_i = -1.3 \text{ cm}</math></p> <p>7. a) <math>d_i = 5.10 \text{ m}</math></p> <p style="padding-left: 20px;">b) <math>h_i = -62.5 \text{ cm}</math></p> <p style="padding-left: 20px;">c) <math>0.13 \text{ cm}</math></p> <p>9. <math>d_i = 60.0 \text{ cm}; h_i = -10.0 \text{ cm}</math></p> <p>11. <math>d_i = -30.0 \text{ cm}; h_i = 1.75 \text{ cm}</math></p> <p>13. <math>d_i = 13.3 \text{ cm}; h_i = -1.00 \text{ cm};</math> real image</p><br><p>15. <math>d_o = 70.0 \text{ mm}</math></p> <p>17. <math>f = 6.7 \text{ cm}</math></p> <p>19. <math>f = -30 \text{ cm}</math></p><br><p>21. a) <math>f_{air} = 18 \text{ cm}</math></p> <p style="padding-left: 20px;">b) <math>f_{water} = 70 \text{ cm}</math></p> <p>23. <math>R = 30.6 \text{ cm}</math></p> <p>25. <math>R_{crown} = 10.4 \text{ cm}, R_{diamond} = 28.4 \text{ cm}</math></p> <p>27. Plexiglas has the greater focal length by a factor of <math>f_{plex} = 1.80f_{zircon}</math></p> <p>29. a) <math>f_{violet} = 18.8 \text{ cm}</math></p> <p style="padding-left: 20px;">b) <math>f_{red} = 19.5</math></p> <p>31. <math>d_o = 110 \text{ cm}</math></p> <p>33. <math>f = -4.13 \text{ cm}.</math> It is a diverging lens.</p> | <p>2. <math>d_o = 110 \text{ cm}</math></p> <p>4. a) <math>d_i = -15 \text{ cm}; h_i = 2.5 \text{ cm}</math></p> <p>6. <math>d_i = 20.0 \text{ cm}</math></p> <p>8. <math>d_i = 12 \text{ cm}</math> and <math>d_o = 24 \text{ cm};</math> or <math>d_i = 24 \text{ cm}</math> and <math>d_o = 12 \text{ cm}</math></p><br><p>10. <math>d_o = 42 \text{ cm}</math></p> <p>12. <math>f = 9.1 \text{ cm}</math></p> <p>14. a) <math>d_i = 43 \text{ cm}</math></p> <p style="padding-left: 20px;">b) <math>h_i = -5.6 \text{ cm}</math></p> <p>16. <math>d_o = 15.0 \text{ mm}</math></p> <p>18. <math>f = 30.0 \text{ cm}</math></p> <p>20. a) <math>50 \text{ cm}</math></p> <p style="padding-left: 20px;">b) <math>-50 \text{ cm}</math></p> <p style="padding-left: 20px;">c) <math>f = \infty</math></p> <p>22. <math>R_{convex} = 5.5 \text{ cm}</math></p><br><p>24. <math>R = -30.6 \text{ cm}</math></p> <p>26. <math>n = 1.55</math></p> <p>28. <math>n_{material} = 4.71</math></p><br><p>30. <math>d_i = 33.3 \text{ cm}</math></p><br><p>32. <math>d_i = 18.1 \text{ cm}</math></p> <p>34. <math>f = 19.7 \text{ cm}.</math> It is a converging lens.</p> |
|---|---|

## Diffraction Problems

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1. In Young's double slit experiment, a monochromatic (only one wavelength) source of wavelength 550 nm illuminates slits that are  $4.0 \times 10^{-6}$  m apart. What angle does the first order maximum occur? Second order? Third order? Is there a mathematical pattern?
2. Given that the second-order maximum occurs at  $22^\circ$  and the light of wavelength 600 nm is used, what is the double slit separation? [3.2  $\mu$ m]
3. Two slits are 0.015 mm apart and the second-order maximum is 7.8 mm away from the centre line. If that maximum is 1.1 m from the slits, what is the wavelength of light used? [ $5.3 \times 10^{-6}$  m]
4. In an interference experiment, yellow light of wavelength 580 nm illuminates a double slit. If the screen is 1.3 m away and the distance between the centre line and the 9<sup>th</sup> maximum is 38.5 cm, find the slit separation. [1.83 mm]
5. A diffraction grating with 2000 slits per centimeter is used with red light of wavelength 650 nm. Find the order number of the maximum occurring at  $15.1^\circ$ . [n=2]
6. What is the distance to the n=2 maximum for a diffraction grating with 20000 slits per meter if the screen is 0.90 m away and orange light with wavelength 600 nm is used? (assume  $\theta \leq 15^\circ$ ) [0.022 m]
7. The distance between the central line and the 5<sup>th</sup> maximum is 65 cm when the grating is 92 cm from the screen. What is the wavelength of the light if the diffraction grating has 250 lines per millimeter? [447 nm]
8. Two identical diffraction gratings are set up the same distance from a screen. A red laser of wavelength 675 nm is aimed at one grating and a green laser of wavelength 515 nm at the other. The distance to the first maximum for the red laser is 3.7 cm, what is the distance for the first maximum for the green laser? (assume  $\theta \leq 15^\circ$  for both gratings) [2.8 cm]
9. What is the value of  $\theta$  for the n = 2 maximum if an orange laser beam of wavelength 615 nm is fired through a diffraction grating with  $2 \times 10^4$  lines per millimeter?

## Practice Problems and Chapter and Unit Review Problems

### Chapter 1 Review

#### Problems for Understanding

15. 2.6%  
 16. (a) 0.03%  
 17. (a) 11.5 Hz  
 (b) 11 Hz  
 (c) 11 Hz

### Chapter 2

#### Practice Problems

1.  $-1.0$  m/s  
 2.  $1.2$  m/s[N57°W]  
 3. (a)  $0.29$  m/s (b)  $75$  m or  $175$  m  
 (c)  $75$  m (d)  $0.87$  m/s  
 4. for linear segments:  $2.5$  m/s,  
 $-7.5$  m/s,  $0.0$  m/s,  $3.8$  m/s

### Chapter 2 Review

#### Problems for Understanding

15. (a) with respect to the ground  
 (b) with respect to the truck  
 17. (a)  $17$  km (b)  $7.0$  km[S]  
 (c)  $7.0$  km[N]  
 18.  $26$  km[W]  
 19. (a)  $0.40$  km [downstream]  
 (b)  $0.53$  km/h [downstream]  
 20.  $4.35$  years  
 21. (a)  $11.4$  km from Vectorville  
 (b)  $0.571$  h or  $34.2$  min  
 22. (a) uniform (b) non-uniform  
 (c) non-uniform (d) non-uniform  
 (e) uniform  
 24.  $-2.8$  m/s<sup>2</sup>  
 25.  $2.7$  m/s,  $0.45$  m/s<sup>2</sup>  
 26.  $2.0 \times 10^1$  m[E] from the foul line  
 28. (1)  $0$  to  $3.0$  s, (2)  $3.0$  to  $8.0$  s, (3)  $8.0$   
 to  $12$  s, (4)  $12$  to  $18$  s  
 30. (a)  $41$  km  
 (b)  $28$  km[W28°N]  
 (c)  $46$  km/h  
 (d)  $31$  km/h[W28°N]

### Chapter 3

#### Practice Problems

1.  $8.0$  m/s<sup>2</sup>  
 2.  $2.5$  m/s<sup>2</sup>[up]  
 3.  $24$  m/s  
 4. (a)  $5.0$  m (b)  $1.6$  m/s<sup>2</sup>  
 5.  $34$  s  
 6.  $6 \times 10^2$  m

7.  $10$  m/s  
 8. (a)  $4.0 \times 10^2$  km[E28°N]  
 (b) W28°S  
 9. (a)  $5.0$  km (b) E37°S  
 10.  $5.8$  km[18° away from the horizontal  
 from the lookout]  
 11. (a)  $62.6$  km [W11.3°N]  
 (b) E11.0°S  
 12. (a) (i)  $27$  km[N] (ii)  $24$  km[N12°E]  
 (iii)  $24$  km[S12°W]  
 (b) (i)  $27$  km[N] (ii)  $24$  km[N12°E]  
 (iii)  $6.0$  km[W34°N]  
 13.  $67$  km/h [W48°N]  
 14.  $346$  km/h[E30.0°N]  
 15.  $10$  m/s in direction  $7^\circ$  away from  
 the normal to the boards, towards  
 the puck's initial direction  
 16. (a)  $8.4$  m/s[N7.1°W]  
 (b)  $5.5$  m/s[N40°E]  
 (c)  $3.6$  m/s[E57°N]  
 17.  $5.7$  km/h[S42°W]  
 18. (a)  $48$  km/h[W29°N]  
 (b)  $1.2 \times 10^2$  km/h [E29°S]  
 19.  $5.8 \times 10^3$  m[N23°W]  
 20. (a)  $9.2$  km[N24°W]  
 (b)  $3.1$  km/h[N24°W]  
 21.  $1.8$  m/s[downstream]  
 22.  $12$  m/s[S24°W]  
 23. (a) N20.5°E  
 (b)  $227$  km/h[N30.0°E]  
 (c)  $1.10$  h  
 24. (a)  $1.6 \times 10^2$  km[W18°N]  
 (b)  $3.0 \times 10^2$  km/h[N],  
 $2.2 \times 10^2$  km/h[W],  
 $2.5 \times 10^2$  km/h[S]  
 (c)  $1.3 \times 10^2$  km/h[W18°N]  
 25. (a) N25°E (b)  $69$  s  
 26. (a)  $2.1$  km[W54°N]  
 (b) S54°E  
 (c)  $2.4$  h  
 27. (a)  $1.6$  m/s[E18°S]  
 (b)  $3.9$  m/s<sup>2</sup>[SW] or  
 $5.1 \times 10^4$  km/h<sup>2</sup>[SW]  
 19. (b)  $3.6$  km[S34°W]  
 20. (a)  $6.6$  km[N31°W]  
 (b)  $4.4$  km/h[N31°W]  
 21. (b)  $7.9$  m/s[NW]  
 22. (a)  $18$  km[W24°S]  
 (b)  $14$  km/h[W24°S]  
 23. (a)  $1.3$  m/s[N] (b)  $3.7$  m/s[S]  
 24. (a) [E26°N] (b)  $1.7$  m/s[E]  
 (c)  $47$  min  
 25.  $4.4$  m/s[N5.4°E]  
 26.  $12$  km[W24°N]  
 27. (a)  $2.0 \times 10^1$  km[N16°E]  
 (b)  $9.9$  km/h[N16°E]  
 28.  $0.217$  m/s<sup>2</sup>[S19.7°W]  
 29. (a) He should aim upstream at an  
 angle  $41^\circ$  with respect to the  
 river bank.  
 (b)  $2.3$  min

### Unit 1 Review

34.  $13$  km[E13°S]  
 35.  $64$  km/h[E51°S]  
 36. (a)  $0.50$  h (b)  $55$  km[S]  
 (c)  $110$  km/h[S]  
 37. (i) B (ii) C (iii) A (iv) D  
 38. (a)  $3.7 \times 10^2$  km (b)  $79$  km/h  
 39.  $7.2$  s  
 41. (a)  $0.4$  km (b)  $6$  min  
 (c)  $1$  km  
 42.  $2.5$  m/s<sup>2</sup>[N]  
 43.  $5.0 \times 10^1$  m  
 44.  $9.0$  s  
 45.  $20$  s  
 46. (i) A (ii) C (iii) E  
 47. (a)  $5.1$  km[S28°E]  
 (b)  $1.7$  m/s[S28°E]  
 48.  $1.8$  m/s[N19°E];  $8.8 \times 10^2$  s;  
 $5.3 \times 10^2$  m downstream  
 49. (a)  $7.4$  m/s[N] (b)  $9.5$  m/s[N]  
 (c)  $5.3$  m/s[N]  
 50. (a) Deke (b)  $6.2$  min  
 51.  $4.9 \times 10^2$  m  
 53.  $59$  km/h[E17°S]  
 54.  $45$  km/h[E45°S]  
 55. Heading[N23.5°W];  
 $201$  m/s[N30.0°W]  
 56.  $1.9 \times 10^4$  m/s<sup>2</sup>[N]  
 57.  $6.8$  m/s<sup>2</sup>[NW]  
 58.  $3.9$  m/s[NE]

### Chapter 3 Review

#### Problems for Understanding

11.  $3$  m/s  
 12.  $-1.9$  m/s  
 13. (a)  $17$  m/s (b)  $2.8$  m/s<sup>2</sup>  
 14. (a)  $27$  m (b)  $8.0$  m/s  
 15. (a)  $-1.2$  m/s<sup>2</sup> (b)  $6.9$  s  
 16.  $1.2 \times 10^2$  m[down]  
 17. (a)  $23$  s (b)  $550$  m  
 18. (a)  $71$  km/h[SW]



## Chapter 4

### Practice Problems

- 23 N
- (a) 66.722 kg (b) 656.03 N  
(c) 605.81 N
- $W_{\text{Earth}} = 2.05 \times 10^3 \text{ N}$ ,  
 $W_{\text{Moon}} = 3.43 \times 10^2 \text{ N}$
- $3.25 \times 10^{-2} \text{ m/s}^2$
- (a) 5.89 N (b) 3.50 N; 0.595  
(c)  $\mu_k$
- (a)  $1.23 \times 10^3 \text{ N}$  (b) 527 N  
(c) 264 N
- $1.95 \times 10^2 \text{ N}$
- 0.34

## Chapter 4 Review

### Problems for Understanding

- 11 kg
- 90.4 N, 205 N
- $1.2 \times 10^2 \text{ N}$
- 62%
- 0.87
- $2.0 \times 10^2 \text{ kg}$
- 49 N
- 37.5% or a 171 N reduction
- (a)  $4.4 \times 10^3 \text{ N}$  (b)  $1.5 \times 10^3 \text{ N}$   
(c) 0.25

## Chapter 5

### Practice Problems

- $0.55 \text{ m/s}^2[\text{E}]$
- $0.53 \text{ m/s}^2[\text{E}]$
- 1.7 kg
- 1.6 m[N]
- (a)  $5.6 \text{ m/s}^2[\text{E}]$  (b)  $2.0 \times 10^2 \text{ m}[\text{E}]$
- 0.23
- $9.6 \times 10^{-13} \text{ N}$
- $9.3 \text{ m/s}$
- $-7.7 \text{ m/s}^2$
- (a) 0.249 N (b) 0.00127
- 78 N
- (a) 58 N (b)  $16 \text{ m/s}^2$
- 6.7 m
- $40 \text{ N}[\text{N}30^\circ\text{E}]$
- (a) 43 N[E] (b) 7.4 N[N]  
(c) 15 N[E] (d)  $15 \text{ N}[\text{W}28^\circ\text{S}]$
- (a)  $1.4 \times 10^3 \text{ N}$  (b)  $3.9 \times 10^2 \text{ N}$
- (a)  $F_x = 120 \text{ N}$ ,  $F_y = -86 \text{ N}$   
(b)  $3.3 \times 10^2 \text{ N}$   
(c) 38 N  
(d)  $1.5 \text{ m/s}^2$
- $1.6 \times 10^3 \text{ N}$ ,  $9.1 \times 10^2 \text{ N}$

- (a) 21 N (b) 15 N
- (a) 74 N (b) 34 N
- negative;  $5.9 \times 10^2 \text{ N}$
- down (negative);  $6.9 \times 10^2 \text{ N}$
- up (positive);  $5.9 \times 10^2 \text{ N}$
- 15 m/s
- (a)  $1.2 \text{ m/s}^2$  (b)  $0.16 \text{ m/s}^2$   
(c) 12 s
- 0.061
- 0.34 m
- 0.37
- (a)  $11.5 \text{ kg m/s}[\text{E}]$   
(b)  $2.6 \times 10^8 \text{ kg m/s}[\text{W}]$   
(c)  $8.39 \times 10^7 \text{ kg m/s}[\text{S}]$   
(d)  $5.88 \times 10^{-24} \text{ kg m/s}[\text{N}]$
- 43.6 N·s[down]
- $2.58 \times 10^5 \text{ N} \cdot \text{s}[\text{S}]$
- $4.52 \times 10^6 \text{ N}[\text{S}]$
- $2.6 \text{ kg m/s}[\text{forward}]$
- $-38 \text{ kg m/s}$
- $8.8 \text{ kg m/s}[\text{up}]$

## Chapter 5 Review

### Problems for Understanding

- $0.4 \text{ m/s}^2$
- (a)  $3.8 \times 10^2 \text{ N}$  (b)  $0.18 \text{ m/s}^2$
- $50 \text{ N}[\text{E}70^\circ\text{N}]$
- (a)  $0.80 \text{ m/s}^2$  (b) 16 N
- (a)  $v = 0$ ;  $a = -9.8 \text{ m/s}^2$   
(b)  $3.5 \text{ m/s}$ ;  $-9.8 \text{ m/s}^2$
- (a)  $1.34 \text{ m/s}^2$  (b) 334 N
- 1.2 N
- (a)  $0.062 \text{ m/s}^2$  (b)  $0.40 \text{ m/s}^2$   
(c) A friction force of magnitude 3.4 N operates to reduce the ideal acceleration ( $a = F/m$ )
- 11 m
- (a)  $5.4 \text{ m/s}[\text{down}]$   
(b)  $3.7 \times 10^4 \text{ N}[\text{up}]$
- $1.3 \text{ m/s}^2$
- (a)  $a_2 = 2.5a_1$  (b)  $d_2 = 2.5d_1$
- (a) 9.00 N (b)  $-132 \text{ N}$   
(c) 141 N (d) 0.451
- $18 \text{ kg m/s}[\text{N}]$
- $1.5 \times 10^3 \text{ kg}$
- $1.20 \text{ m/s}[\text{S}]$
- $6.0 \times 10^3 \text{ m/s}[\text{forward}]$
- (a)  $0.023 \text{ N} \cdot \text{s}[\text{E}]$  (b)  $0.036 \text{ N} \cdot \text{s}[\text{S}]$
- $3.8 \times 10^3 \text{ N}$
- $3.6 \times 10^{-2} \text{ s}$
- (a)  $16 \text{ kg m/s}[\text{S}]$  (b)  $6.4 \times 10^{-3} \text{ s}$
- $2.5 \times 10^4 \text{ N}[\text{E}]$
- $2.9 \times 10^4 \text{ N}[\text{backward}]$

## Unit 2 Review

- (a)  $4.70 \times 10^2 \text{ N}$  (b) 178 N  
(c)  $1.24 \times 10^3 \text{ N}$
- (a)  $3.7 \times 10^2 \text{ N}$  (b)  $1.9 \times 10^2 \text{ N}$
- (a) 62 N (b) 31 N
- $4.60 \times 10^3[\text{E}]$
- 89.7 kg
- $0.441 \text{ m/s}[\text{E}0.0121^\circ\text{N}]$
- (b) It would accelerate in the horizontal direction.  
(c) It would have constant velocity.  
(d) It would slow down and stop.
- $1.2 \times 10^2 \text{ N}[\text{up}]$
- (a) 2.00 (b) 2.00
- (a)  $1.5 \times 10^4 \text{ N}$  (b)  $3.8 \times 10^3 \text{ N}$   
(c)  $2.5 \text{ m/s}^2$   
(d)  $22 \text{ m/s} = 81 \text{ km/h}$   
(e) 9.0 s
- $2.0 \times 10^2 \text{ N}$
- $6.9 \times 10^3 \text{ N}$
- (a) 612 N (b) 437 N  
(c) 786 N (d) 612 N
- (a)  $1.7 \times 10^2 \text{ N}$  (b) 29 m/s
- (a)  $2.74 \times 10^3 \text{ N}[\text{W}]$   
(b)  $1.05 \times 10^3 \text{ N}[\text{W}]$
- $3.5 \times 10^4 \text{ kg m/s}[\text{N}]$
- (a)  $6.6 \text{ kg m/s}$   
(b)  $4.0 \times 10^1 \text{ kg m/s}$   
(c)  $3.0 \times 10^3 \text{ kg m/s}$
- (a)  $9.6 \text{ kg m/s}[\text{N}]$   
(b)  $-17 \text{ kg m/s}[\text{N}]$   
(c)  $17 \text{ kg m/s}[\text{S}]$   
(d)  $2.6 \times 10^2 \text{ N}[\text{N}]$   
(e)  $2.6 \times 10^2 \text{ N}[\text{S}]$
- (a) 45 N (b) 42 m/s

## Chapter 6

### Practice Problems

- $5.7 \times 10^3 \text{ J}$ ; 42 m
- 82 m
- $2.30 \text{ m/s}^2$
- 6.33 m
- 225 N
- 10.9 m
- (a) 0 J  
(b) force is perpendicular to direction of motion
- $3.00 \times 10^2 \text{ J}$
- (a) 0 J  
(b) no forces are acting so no work is done (velocity is constant)
- (a) 0 J  
(b) the tree did not move, so  $\Delta d$  is zero

11. A. 180 J      B. 65 J  
     C. 0 J      D. ~230 J
14. (a)  $4.1 \times 10^3$  J    (b)  $-4.1 \times 10^3$  J  
     (c) gravity and applied force
15. raising: +126 J; lowering: -126 J
16.  $1.9 \times 10^3$  J
17.  $1.4 \times 10^2$  N
18.  $40.0^\circ$
19. 81.1 J
20.  $1.0 \times 10^1$  kg
21. 1810 J
22. 11.5 m/s
23.  $4.1 \times 10^6$  m/s
24. 0.36 J; 3.6 N 6.35 kg
25. 6.35 kg
26. 3000 N; 40 M; 160 m;  $d \propto v^2$
27. 87 J
28.  $2.4 \times 10^6$  J
29. 4.08 m
30. 1.16 m
31. (a) 2370 J      (b) 2370 J
32. 16.0 J
33.  $1.51 \times 10^6$  J
34. (a)  $1.59 \times 10^5$  J    (b)  $2.38 \times 10^5$  J  
     (c)  $3.97 \times 10^5$  J
35.  $5 \times 10^2$  N/m
36. (a) 0.414 m      (b) -455 N
37. 0.0153 kg
38. 1.0 J
39. 0.30 m
40. 1.4 J
41.  $1.5 \times 10^2$  W
42. 15.4 kW; 20.7 hp
43. No, the student will be 1.15 s late
44. (a) 75%  
     (b) into friction of moving parts
45. 25.5%
46. 19.0%
47. (a)  $\text{Eff}_{\text{incand}} = 4\%$ ,  $\text{Eff}_{\text{fl}} = 8\%$   
     (b) the florescent bulb heats up less than the incandescent bulb
48. 87.2%
49. (a) 66.3 J    (b) 6.01 J    (c) 90.9%
50. 34%

## Chapter 6 Review

### Problems for Understanding

15. (a) Ground pushes up, gravity pulls down, engine propels car forward, ground resists backward.  
     (b) The forward force (from the car's engine) does work.
16. 44 N

17.  $3.50 \times 10^2$  J
18.  $1.44 \times 10^4$  J
19.  $6.2 \times 10^2$  J
20. 4.38 J
21. 5.0 m:  $1.0 \times 10^2$  J, 13 m/s;  
     15.0 m:  $5.8 \times 10^2$  J, 31 m/s;  
     25.0 m:  $8.1 \times 10^2$  J, 36 m/s
22.  $73^\circ$
23. the 55 kg athlete
24. (a) 3.2 m/s;  $3.4 \times 10^2$  J
25.  $5.0 \times 10^1$  kg
26. (a) 0.035 N      (b) -0.025 J  
     (c) 0.025 J
27. (a) 16 J      (b) 16 J
28. (a)  $7.7 \times 10^3$  J    (b)  $6.7 \times 10^3$  J  
     (c) 9.4 m/s; 8.7 m/s  
     (d) infinity (no friction);  
          $1.3 \times 10^2$  m
29.  $2.6 \times 10^3$  J
30.  $4.5 \times 10^2$  N/m
31. (a) 0.38 J      (b) 9.6 N
32. 3.6 m/s
33. 2.3 m/s
34. 0.45 m
35. 0.096 m
36.  $3.5 \times 10^2$  W
37. (a)  $2.7 \times 10^5$  J    (b)  $2 \times 10^6$  J  
     (c)  $4 \times 10^6$  J    (d)  $4.5 \times 10^9$  J
38. (b) 1.0 m/s<sup>2</sup>    (c) 4.6 m  
     (d) 56 J      (e) 18 W
39. 5 kW

## Chapter 7

### Practice Problems

1. 13 m/s
2. 7.7 m
3. 4.8 m
4. 5.1 m
5.  $E_g = 4140$  J;  $E_k = 4140$  J;  
      $v = 5.12$  m/s
6. ball: 610 J, 22 m/s; shot: 13 J, 22 m/s
7.  $1.0 \times 10^1$  m
8. 15 floors; 49.3 m/s 152 J
9. (a) 0.28 m      (b) 1.3 m/s  
     (c) 17 m/s<sup>2</sup>
10.  $1.4 \times 10^3$  N/m
11. 57 m/s
12. (a) 80.4 m/s    (b) 5.98 m/s
13. (a) 39.6 cm    (b) 16.9 J
14. (a) 469 g      (b) 65.2 cm  
     (c) 61.3 cm
15.  $6.59 \times 10^3$  N/m

16. 0.42 m
17. (a) 405 N/m      (b)  $44.1$  m/s<sup>2</sup>
18. 11 m/s
19. 14.3 m/s
20.  $7.40 \times 10^2$  J
21. (a) 11 J      (b) 6.7 m/s  
     (c) 4.2 m/s
22. -7.4 J; -180 N
23. 43.1 m/s; 8.9%
24. 75 N
25. 2.7 m/s
26. 0.11 m/s[in the direction that car A was travelling]
27. 2.10 m/s[S]
28. 0.11 m/s[E]
29.  $-2.43 \times 10^2$  m/s
30.  $v_2 = 6.32$  m/s[41.5° counterclockwise from the original direction of the first ball]; the collision is not elastic:  $E_k = 12.1$  J;  $E'_k = 10.2$  J
31.  $1.24 \times 10^5$  kg km/h =  
      $3.44 \times 10^4$  kg m/s[N39.5°W];  
     the collision was not elastic:  
      $E_k = 3.60 \times 10^6$  kg m<sup>2</sup>/h<sup>2</sup>;  
      $E'_k = 1.80 \times 10^6$  kg m<sup>2</sup>/h<sup>2</sup>

## Chapter 7 Review

### Problems for Understanding

20. 0.36 m
21. 17 J; 4.2 m/s
22. 30 m/s
23. 1.3 m/s
24. 0.77 m/s; 0.031 m
25. 5.0 m/s
26. (a)  $-8.7 \times 10^2$  J    (b) -1.8 m
27. 3.1 m/s[E]
28. -2.3 m/s
29. 1.3 m/s[forward]
30. 0.17 m/s[forward]
31. (a) 0.21 m/s      (b) 13 kg·m/s  
     (c) 95%

## Unit 3 Review

38. 16.8 m/s
39. 31 m/s, 22 m/s, 18 m/s
40. (a)  $-5.8 \times 10^3$  J    (b) 3.6  
     (c) yes,  $\mu > 1$
41. (a)  $6.1 \times 10^3$  N    (b)  $1.8 \times 10^7$  J
42. (a)  $1.3 \times 10^4$  kg m/s  
     (b)  $-1.3 \times 10^4$  kg m/s  
     (c)  $-1.3 \times 10^4$  kg m/s  
     (d) 19 m/s
43. 260 m/s
44. (a) 780 J      (b) It loses 780 J

45.  $-7.9 \times 10^3$  N  
 46. (a) 0.24 J (b) 48 J  
 47. (a) 0.32 m (b) 12 J  
 48. 15 kg  
 49. 60.0 m  
 50. (a)  $1.46 \times 10^4$  J  
 (b)  $1.46 \times 10^4$  J; 12.5 m/s  
 51. 3.1 m/s  
 52. (a) 0.47 m  
 53. (a) 6.0 N (b) 0.15 J (c) 0.023 J  
 54.  $1.16 \times 10^3$  J. No, work is done by friction forces.  
 55. (a) 4.4 m/s (b) 3.5 m/s

## Chapter 8

### Practice Problems

1. 0.98 Hz; 1.0 s  
 2. 7.5 to 11 Hz  
 3. 29.7 s  
 4. 0.04 Hz; 2.5 s  
 5. 7.5 m/s; 0.80 s  
 6.  $1.4 \times 10^9$  Hz  
 7.  $3.1 \times 10^{-4}$  Hz  
 8. (a) 8.80 Hz (b) 853 m  
 (c) constant frequency  
 9. (a) 1.34 m (b) 0.670 m

## Chapter 8 Review

### Problems for Understanding

21. 0.25 Hz  
 22. the wavelength doubles  
 23. 0.4 m  
 24.  $1.67 \times 10^{-2}$  Hz; 5.72 m  
 25. (a) 1.4 Hz (b) 3.7 cm/s  
 26. 1.6 Hz  
 27. 680 km  
 28. (a) 1.2 Hz (b) 0.84 s  
 29. (a) 1.02 s (b) 2.56%  
 (c) 225 h or 9.38 days  
 (d) shorten the pendulum

## Chapter 9

### Practice Problems

1. (a)  $3.5 \times 10^2$  m/s (b)  $3.4 \times 10^2$  m/s  
 (c)  $3.5 \times 10^2$  m/s (d)  $3.2 \times 10^2$  m/s  
 2. (a) 35.6 °C (b) 11.9 °C  
 (c) 5.1 °C (d) -20.3 °C  
 3. (a)  $6.2 \times 10^2$  m  
 4. 0.005 s  
 5.  $2.0 \times 10^2$  m  
 6. (a) 5.8 s (b)  $6.7 \times 10^{-6}$  m  
 (c) 2.8 km  
 7. 1.31, ice

8. 29.7°  
 9. 51°  
 10. 39.5°  
 11. 31.0°  
 12. 47.2°  
 13. 58.9°  
 14. 78.5°  
 15. 2.6 m  
 16. (a) 68 cm (b) 85 cm  
 17. (a) 96 cm, 160 cm  
 (b) 64 cm, 96 cm  
 18. 19 cm, 57 cm  
 19. 32 cm, 96 cm  
 20. (a) 1.34 m (b) 64 Hz  
 21. 512 Hz, 768 Hz  
 22. (a) 64.9 Hz (b) 130 Hz, 195 Hz  
 23. (a) 175 Hz (b) 1.97 m  
 24. (b) 6.00 Hz  
 25. 9.0 beats  
 26. 251 Hz or 261 Hz  
 27. (a) 443 Hz

## Chapter 9 Review

### Problems for Understanding

40. (a) 307 m/s (b)  $3.3 \times 10^2$  m/s  
 (c) 343 m/s (d) 352 m/s  
 41. (a) 40.7 °C (b) 22.0 °C  
 (c) 3.39 °C (d) -22.0 °C  
 42. 4.0 °C  
 43.  $7.0 \times 10^2$  m  
 44. (a) 436.5 Hz or 443.5 Hz  
 (b) If, as the string is tightened, the beat frequency increases, then the guitar was at 443.5 Hz, while if the beat frequency decreases, then the guitar was at 436.6 Hz.  
 45. (a) The human brain responds to harmonics, i.e. simple fraction ratios of pitch.  
 46. (a) Increases in pitch at specific, well-defined tube lengths.  
 (b)  $L_1 = 0.098$  m,  $L_2 = 0.29$  m,  $L_3 = 0.49$  m,  $L_4 = 0.68$  m  
 47. (a) 0.38 m (b)  $9.0 \times 10^2$  Hz  
 48. The well is less than 176 m deep.  
 49. 0.062 m  
 50.  $2.8 \times 10^3$  km/h  
 51.  $1.3 \times 10^2$  m  
 52. Yes, with 0.03 s to spare.  
 53. (a) 55° (b) 110°  
 54. 56°  
 55. 38°  
 56. 1.95  
 57. 22.8°

58. The ray exits at 30°, 5.7 cm from the bottom corner (assuming it entered 3.5 cm from the same corner).  
 59.  $2.4 \times 10^{-9}$  s  
 60. (a) 1.2 (b) 11° (c) 39°  
 61. 22°  
 62. 68°  
 63. 4 cm  
 64.  $4.8 \times 10^2$  nm  
 65. 589 nm

## Unit 4 Review

### Problems for Understanding

39. 3.0 m/s  
 40. 0.167 Hz  
 41. 0.8 m  
 42.  $7.14 \times 10^9$  Hz  
 43. 0.73 m  
 44. 312 Hz  
 45. 0.259 m  
 46. 382.8 Hz or 385.2 Hz  
 47. 2.4 s  
 48. 2.00 m  
 49. -8 °C  
 50.  $1.60 \times 10^8$  m/s  
 51.  $1.0 \times 10^{-9}$  s  
 52. 1.4  
 53. 25°  
 54. 15°  
 55. 1.39  
 56. 60°  
 57. 38.6°  
 58. 0.12 m;  $2.5 \times 10^9$  Hz;  $4.0 \times 10^{-10}$  s  
 59.  $2.1 \times 10^5$  Hz;  $1.4 \times 10^3$  m  
 60.  $5.5 \times 10^{16}$  cycles  
 61.  $1.5 \times 10^2$  m  
 62.  $9.4607 \times 10^{15}$  m  
 63.  $8 \times 10^{-7}$  m

## Chapter 10

### Practice Problems

1. (a) 4.1 m, 15 m  
 (b)  $-6.6$  m/s<sup>2</sup>, 4.6 m/s<sup>2</sup>  
 (c) -11.3 m/s, -11.3 m/s  
 2. (a) 6.84 km, 18.8 km  
 (b) 2.6 m/s, -1.5 m/s  
 (c) -2.3 m/s, 6.4 m/s  
 3.  $3.0 \times 10^1$  km[E],  $5.2 \times 10^1$  km[N]  
 4. (a) 5.9 km[E34°?]  
 (b) [W56°N]  
 5. (a) W17°S  
 (b) 8.7 min

6. 15 m/s in a direction  $4.9^\circ$  to the shuttle
7. (a)  $1.6 \times 10^2$  N[W $58^\circ$ S]  
(b)  $2.1 \times 10^2$  N[W $16^\circ$ N]  
(c)  $1.3 \times 10^2$  N[S $50^\circ$ W]
8. (a)  $1.6 \times 10^2$  N[W $58^\circ$ S]  
(b)  $2.1 \times 10^2$  N[W $16^\circ$ N]  
(c)  $1.3 \times 10^2$  N[S $50^\circ$ W]
9.  $1.5 \times 10^3$  N by each cable
10. (a) No (b)  $> 1.7 \times 10^2$  N
11. (a)  $20^\circ$  (b)  $0.028$  m/s<sup>2</sup>
12.  $4.0 \times 10^2$  N
13. (a)  $> 8.3 \times 10^2$  N (b)  $> 7.3 \times 10^2$  N
14.  $-1.9$  m/s<sup>2</sup>
15. No, the climber must limit his descent to  $a = -2.5$  m/s<sup>2</sup>
16. (a) downward (b)  $-1.1$  m/s<sup>2</sup>  
(c) 87 N
17.  $1.7 \times 10^2$  N
18.  $1.8$  m/s<sup>2</sup>
19.  $0.49$  m/s<sup>2</sup>; 39 N
20. 14 kg; 75 N
21. 62 kg;  $1.6$  m/s<sup>2</sup>
22. 17 N
23. Both of them will rise, with  $a = +1.0$  m/s<sup>2</sup>
24. (a) 3.88 N (b) 2.04 m/s<sup>2</sup>
25. 0.67 s
26. 2.77 s
27. (a) 0.69 m/s (b) 0.81 N
28. (a) 0.91 N (b) 0.87 m/s<sup>2</sup>  
(c) 5.3 N
29. 65 N·m
30.  $5.1 \times 10^2$  N·m
31.  $1.1 \times 10^3$  N
32.  $9.6 \times 10^2$  N
33. (a)  $4.3 \times 10^2$  N (b)  $6.7 \times 10^2$  N
34.  $4.4 \times 10^2$  N
35.  $6.4$  m/s[ $40.0^\circ$  counterclockwise]
36.  $1.16$  m/s[ $6.1^\circ$  clockwise from original direction]
37.  $V_A = 34.3$  km/h[S];  
 $V_B = 67$  km/h[E]
38. 1.4 Kg, 2.6 m/s [83° counterclockwise from the x-axis]
39.  $V_2 = 6.32$  m/s[ $41.5^\circ$  counterclockwise from the original direction of the first ball]; the collision is not elastic:  $E_k = 12.1$  J;  $E'_k = 10.2$  J
40.  $1.24 \times 10^3$  kg km/h =  
 $3.44 \times 10^4$  kg m/s[N $39.5^\circ$ W];  
the collision was not elastic;  
 $E_k = 3.60 \times 10^6$  kg km<sup>2</sup>/h<sup>2</sup>;  
 $E'_k = 1.80 \times 10^6$  kg km<sup>2</sup>/h<sup>2</sup>
41. 261 m/s

42. The cart will stop at 0.018 m; therefore, it will not reach the end of the track.

43. 55.5 km/h = 15.4 m/s

44. 18.2 m/s

45. 3.62 m/s; 1.71 m

## Chapter 10 Review

### Problems for Understanding

23. (a) N $36^\circ$ E (b) 1.5 m/s[E]  
(c) 29s
24. (a)  $1.0 \times 10^2$  N[E $27^\circ$ N]  
(b) 34 N[S $0.61^\circ$ E]  
(c)  $1.5 \times 10^2$  N[ $67^\circ$  counterclockwise from the x-axis]
25.  $2.3 \times 10^2$  N [ $1.4^\circ$  to the right of backward]
26. (a) No (c) 2.8 kg (d) 5.7 m/s<sup>2</sup>
27.  $3.9 \times 10^2$  N[up],  $5.0 \times 10^2$  N[up]
28. (a)  $8.58 \times 10^3$  N  
(b)  $1.00 \times 10^4$  N[ $43.3^\circ$  cw from arm]
29. 4.4 m/s[ $35.2^\circ$  clockwise]
30. (a) 0.29 m/s[W $21^\circ$ N]  
(b) 70%

## Chapter 11

### Practice Problems

1. 677 m [before drop point]
2. 4.67 m/s
3. 89.6 m, 45.2 m/s [60.3° below the horizontal]
4. 0.156 m
5. 3.05 m/s
6. 0.55 m
7. 74 m
8. (a) 153 m  
(b) 5.00 m/s [down]
9. 85 m
10.  $4.0 \times 10^1$  m
11. 18 m/s [52° below the horizontal]
12. 2.8 m/s
13. (a) 58.9 m (b) 21.0 m (c) 4.14 s
14.  $33.2^\circ$ ; 2.39 m; 1.40 s
15. 47.0 m/s
16.  $2.7 \times 10^2$  m
17. (a) 48.6 N (b) 54.2 N (c) 9.62 m/s
18.  $5.9 \times 10^3$  N
19. 84 m
20. 103 m
21. 13 m/s (47 km/h)
22. 19.1 m/s (68.8 km/h)
23.  $20.1^\circ$

## Chapter 11 Review

### Problems for Understanding

15. (a)  $3.0 \times 10^1$  m (b) 3.7 s
16.  $2.7 \times 10^2$  m
17. (a) 2.1 s (b) 34 m  
(c) 8.5 m [above the ground]  
(d)  $v_x = 16$  m/s;  $v_y = +3.8$  m/s  
or  $-3.8$  m/s  
(e)  $38.2^\circ$
18. 52 m/s
19. Yes. It travels 330 m.
20. (a) 7.4 s (b) 67 m  
(c)  $1.2 \times 10^2$  m (d) x: 34 m, y: 53 m  
(e)  $v_x = 17$  m/s;  $v_y = -23$  m/s
21. (a) 2.1 m/s (b) 1.2 m/s<sup>2</sup>
22. (a)  $1.33 \times 10^{14}$  m/s<sup>2</sup>  
(b)  $1.21 \times 10^{-16}$  N
23. 0.33
24. 8.9 m/s
25.  $33^\circ$
26. 9.90 m/s
27. 0.62
28. (a)  $4.64 \times 10^2$  m/s  
(b) 2.0 N (for  $m = 60.0$  kg)  
(c) Toward the centre of Earth; gravity  
(d)  $mg = 589$  N (for  $m = 60.0$  kg)  
(e)  $N = mg - mv^2/r = 587$  N  
(f)  $mg - N = ma_c$ ; because  $mg > N$ , there is a net acceleration toward the centre of Earth.

## Chapter 12

### Practice Problems

1.  $3.58 \times 10^{22}$  N
2.  $1.99 \times 10^{20}$  N
3.  $5.1 \times 10^{-3}$  m. This is much smaller than the radii of the bowling balls.
4.  $3.61 \times 10^{-47}$  N
5.  $5.0 \times 10^{24}$  kg
6. 0.25 m
7.  $F_{\text{Uranus}} = 0.80 \times F_{\text{Earth}}$
8.  $0.9 \times$  Earth – Moon distance
9.  $1.899 \times 10^{27}$  kg
10.  $1.472 \times 10^{22}$  kg
11.  $2.74 \times 10^5$  m
12.  $1.02 \times 10^3$  m/s
13. (a)  $6.18 \times 10^4$  s (17.2 h)  
(b)  $7.93 \times 10^2$  m/s
14.  $4 \times 10^{41}$  kg =  $2 \times 10^{11} \times M_{\text{Sun}}$
15.  $7.42 \times 10^3$  m/s;  $8.59 \times 10^5$  m
16.  $7.77 \times 10^3$  m/s;  $5.34 \times 10^3$  s (89.0 min)

17. (a)  $5.21 \times 10^9$  s (165 years);  
 $5.43 \times 10^3$  m/s  
 (b) It will complete one orbit, after its discovery, in the year 2011.

## Chapter 12 Review

### Problems for Understanding

22.  $1/8$   
 23. (c) F  
 24. (b)  $a/3$   
 25. (a)  $3.0 \times 10^4$  m/s  
 (b)  $6.0 \times 10^{-3}$  m/s<sup>2</sup>  
 26.  $1.8 \times 10^{-8}$  m/s<sup>2</sup>  
 27.  $9.03 \text{ m/s}^2 = 92\%$  of acceleration due to gravity at Earth's surface  
 28.  $4.1 \times 10^{36}$  kg =  $2.0 \times 10^6 \times m_{\text{Sun}}$   
 29.  $2.7 \times 10^{-10}$  N  
 30. (a)  $5.3 \times 10^5$  m  
 (b)  $5.7 \times 10^3$  s = 95 min  
 31.  $1.02 \times 10^3$  m/s;  
 $2.37 \times 10^6$  s = 27.4 days  
 32. (a) Yes. (b)  $5.69 \times 10^{26}$  kg  
 33. (a)  $4 \times 10^{15}$  kg (b)  $4 \times 10^{27}$  kg  
 (c)  $m_{\text{Oort}} = 700m_{\text{Earth}} = 2m_{\text{Jupiter}}$

## Chapter 13

### Practice Problems

1. 0.494 s  
 2. 17 N/m  
 3. (a) 0.253 s (b) 8.4 m/s  
 (c) 7.4 m/s  
 4.  $8.2 \times 10^4$  N/m  
 5. (a) 71 N/m  
 (b) 0.897 s using  $k = 71.05$  n/m  
 6. (a)  $k = 2.2 \times 10^3$  N/m  
 (b) 0.98 s  
 7. 1.3 s  
 8. 4.0 m  
 9. 0.25 m  
 10. 0.88 s

## Chapter 13 Review

### Problems for Understanding

22. 0.245 s, 0.297 s, 0.42 s, 0.149 s,  
 0.181 s, 0.26 s  
 23. 0.48 s  
 24. (a) 0.82 J (b) 1.37 m/s  
 25. (a) 81 J (b)  $8.0 \times 10^2$  N/m  
 (c) 0.13 s  
 26. 44 N/m  
 27. 0.21 s  
 28. 0.016 m  
 29. 0.097 m  
 30. 1.5 m/s

## Unit 5 Review

33. 15 N[E19°S]  
 34.  $1.4 \text{ m/s}^2$   
 35. (a)  $7 \times 10^3$  N  
 (b)  $9.15 \times$  true weight  
 36.  $17^\circ$   
 37. (a)  $9.8 \times 10^2$  N (b) 13 km  
 38. (a)  $33 \text{ m/s}^2$  (b) 23 N  
 39. (a) 21.3 m/s (b) 1.53 m  
 (c) down  
 40. (a)  $4.4 \times 10^2$  N;  $1 \times$  weight  
 (b)  $2.0 \times 10^2$  N;  $0.45 \times$  weight  
 (c)  $4.4 \times 10^2$  N;  $1 \times$  weight  
 (d)  $6.8 \times 10^2$  N;  $1.5 \times$  weight  
 41. 29 m/s  
 42.  $4.2 \times 10^3$  m/s  
 43. (a)  $4.6 \times 10^2$  m/s  
 (b)  $7.9 \times 10^2$  m/s  
 44. 59.7 m  
 45.  $44^\circ$   
 46. (a) 0.342 J (b) 1.45 m/s

## Chapter 14

### Practice Problems

1. 0.34 N  
 2. 0.80 m  
 3.  $5.1 \times 10^{-7}$  C  
 4. 0.50 N (attractive)  
 5. 0.17 N (repulsive)  
 6. 0.12 m (directly above the first proton)  
 7.  $F_A = 1.2 \times 10^{-2}$  N[W73°S];  
 $F_B = 1.6 \times 10^{-2}$  N[E63°N];  
 $F_C = 4.6 \times 10^{-3}$  N[W36°S]  
 8. 8.7 N[E18°N]  
 9.  $2.0 \times 10^{-8}$  C  
 10.  $7.9 \times 10^{-8}$  C  
 11.  $1.5 \times 10^5$  N/C (to the right)  
 12. 0.019 N[W]  
 13.  $2.5 \times 10^4$  N/C (to the left)  
 14.  $-4.0 \times 10^{-4}$  C  
 15. 3.8 N/kg[down]  
 16. 52 N[down]  
 17. 3.46 kg  
 18. 2.60 N/kg[down]  
 19.  $2.60 \text{ m/s}^2$ [toward centre]  
 20.  $-7.8 \times 10^5$  N/C (toward the sphere)  
 21.  $-1.2 \times 10^{-5}$  C  
 22. 0.32 m  
 23.  $5.80 \times 10^9$  electrons  
 24.  $-1.5 \times 10^6$  N/C (toward the sphere)  
 25. 0.080 m  
 26.  $5.3 \times 10^8$  N/C[81.4° above the +x-axis]

27.  $1.9 \times 10^4$  N/C[86.7° above the +x-axis]  
 28.  $3.4 \times 10^6$  N/C[23.7° above the -x-axis]  
 29.  $2.25 \times 10^{14}$  N/C (toward the negative charge)  
 30.  $2.9 \times 10^7$  N/C[73.6° above the +x-axis]  
 31.  $5.7 \times 10^{-2}$  N/kg  
 32.  $3.81 \times 10^7$  m  
 33. 8.09 N/kg[toward centre]  
 34.  $5.82 \times 10^{23}$  kg  
 35.  $5.0 \times 10^{-11}$  N/kg[toward centre]  
 36. 8.09 N/kg[toward centre]  
 37.  $1.03 \times 10^{26}$  kg  
 38.  $-4.7 \times 10^{-2}$  J  
 39. 0.18 J  
 40.  $5.1 \times 10^2$  m  
 41.  $1.55 \times 10^{-4}$  C. The signs of the two charges must be the same, either both positive or both negative.  
 42.  $4.8 \times 10^6$  N/C  
 43.  $1.5 \times 10^{10}$  m  
 44.  $2.9 \times 10^{-5}$  J  
 45.  $-4.7 \times 10^{-12}$  C  
 46. If the positive charge is placed at 0.0 cm and the negative charge is placed at 10.0 cm, there are two locations where the electric potential will be zero: 6.2 cm and 27 cm.  
 47.  $1.1 \times 10^6$  V  
 48. 8.0 V  
 49.  $-2.1 \times 10^6$  V  
 50.  $1.6 \times 10^6$  V  
 51.  $1.4 \times 10^{-6}$  C  
 52. 2.0 V  
 53. 12 J  
 54.  $-2.4 \times 10^4$  V  
 55. (a)  $1.9 \times 10^5$  V  
 (b)  $1.2 \times 10^{-3}$  J  
 (c) A. It takes positive work to move a positive test charge to a higher potential. Since in this case, you invest positive work to move your positive test charge from B to A, A must be at a higher potential.  
 56. 5.3 cm and 16 cm to the right of the positive charge.  
 57. any point lying on a line midway between the two charges and perpendicular to the line that connects them  
 58. The potential is zero 3.4 cm above the origin and 24 cm below the origin.

59. If the distances of the first and second charges,  $q_1$  and  $q_2$ , from the point of zero potential are  $d_1$  and  $d_2$ , then  $d_2$  must satisfy  $d_2 = (-q_2/q_1)d_1$ , with  $q_2 > 0$ . For example, if  $q_2 = -8.0\mu\text{C}$ , then  $d_2 = 16$  cm and the charge would be located either 24 cm to the right of  $q_1$  or 8.0 cm to the left of  $q_1$ . Other solutions can be similarly determined.
60. 4.0 cm to the right of the  $-4.0\mu\text{C}$  charge.

## Chapter 14 Review

### Problems for Understanding

18.  $9 \times 10^3$  N  
 19.  $2.3 \times 10^{-8}$  N  
 20. 5.6 cm  
 21.  $F_A = 4.5 \times 10^{-2}$  N to the left;  
 $F_B = 0.29$  N to the right;  
 $F_C = 0.24$  N to the left  
 22.  $F_A = 3.8$  N[N3.0°E];  
 $F_B = 4.4$  N[E23°S];  
 $F_C = 4.7$  N[W26°S]  
 23.  $F_Q = 8.2 \times 10^{-8}$  N;  
 $F_g = 3.6 \times 10^{-47}$  N  
 24. The charges on Earth ( $q_E$ ) and the Moon ( $q_M$ ) must satisfy  $|q_E| \times |q_M| = 3.3 \times 10^{27}$  C<sup>2</sup>, and they must have opposite signs.  
 25.  $4.2 \times 10^{42}$   
 26.  $-57$  C  
 27.  $5.2 \times 10^{-3}$  N  
 28. (a)  $8.65 \times 10^{25}$  kg  
 (b) 8.81 N/kg  
 (c) 881 N  
 29.  $2/9$   $g_{\text{Earth}} = 2.18$  N/kg  
 30. (a)  $8.24 \times 10^{-8}$  N  
 (b)  $2.19 \times 10^6$  m/s  
 (c)  $5.14 \times 10^{11}$  N/C  
 (d) 27.2 V  
 31.  $1.86 \times 10^{-9}$  kg =  $2.04 \times 10^{21} \times m_{\text{actual}}$   
 32.  $9 \times 10^{-5}$  N[W]  
 33. 0.51 m  
 34.  $6.0 \times 10^4$  N/C[E37°N]  
 35. (a)  $-8 \times 10^{-8}$  J  
 (b) It loses energy.  
 36.  $-3 \times 10^{-6}$  J  
 37.  $2.8 \times 10^2$  C  
 38. (a)  $4.5 \times 10^3$  V  
 (b) Yes; the spheres have to be at equal potential, because the same point cannot have two different potentials.  
 (c) big sphere: 52 nC;  
 small sphere: 23 nC
39. (a)  $E = 0$ ;  $V = 2.2 \times 10^5$  V  
 (b)  $E = 4.3 \times 10^5$  N/C;  $V = 0$   
 40. (a) 2.3 J (b)  $1.2 \times 10^6$  V  
 (c) X  
 41. (a)  $4.0 \times 10^5$  V (b) R

## Chapter 15

### Practice Problems

1. 20.0 V  
 2. 0.378 J  
 3.  $6.5 \times 10^{-2}$  C  
 4. 40.0 V  
 5. 8.0 s  
 6.  $4.23 \times 10^3$  J  
 7. 50 A  
 8. 57 s  
 9.  $7 \times 10^4$  C  
 10. 2.8 A  
 11.  $4.6 \times 10^7$  J  
 12. 0.133 A  
 13. (a) 9.38 A  
 (b)  $2.11 \times 10^{22}$  elementary charges  
 14.  $5.25 \times 10^{20}$  elementary charges  
 15. (a) 3.3 A (b) 1.7 V  
 16. 2.2  $\Omega$   
 17. 4.08 m  
 18.  $1.6 \times 10^{-6}$  m  
 19. 0.45  $\Omega$   
 20. 2.4 mm  
 21. 16  $\Omega$   
 22. 12.5 A  
 23. 5.0 V  
 24. (a)  $9.9 \times 10^2$  C (b) 2.1 A  
 25. 11.6  $\Omega$   
 26. 7.50 min  
 27. (a) 33 V, 53 V and 79 V respectively  
 (b) 75  $\Omega$  (c)  $1.6 \times 10^2$  V  
 28. (a) 91.0 V (b) 156 V  
 29. 42.0  $\Omega$   
 30. (a) 8.00  $\Omega$  (b) 224 V (c) 32.0  $\Omega$   
 31. 44.0  $\Omega$   
 32. 0.667 A, 1.00 A and 1.33 A respectively; 3.00  $\Omega$   
 33.  $R_{\text{coil}} = 6.00$   $\Omega$ ,  $R_{\text{bulb}} = 20.0$   $\Omega$ ,  
 $R_S = 4.62$   $\Omega$   
 34.  $R_{\text{unknown}} = 8.00$   $\Omega$ ,  $R_S = 4.80$   $\Omega$   
 35. (a) 11.2  $\Omega$  (b) 21.6  $\Omega$ , 30.0  $\Omega$   
 36. (a) 38.4  $\Omega$  (b) 2.25 A (c) 91.5 V  
 37. (a) 15.4  $\Omega$  (b) 9.76 V (c) 1.02 A  
 38. (a) 14.8 V (b) 14.6 V  
 39. (a) 11.4 V (b) 11.2 V  
 40. (a) 7.3 A (b) 16  $\Omega$

41. (a)  $6.0 \times 10^1$  W (b) 27 W  
 (c)  $1.1 \times 10^2$   $\Omega$   
 42. (a) 840 W  
 (b) The power output drops to 1/4 its original value, or 210 W  
 43. (a)  $P_a = 720$  W,  $P_b = 1.6 \times 10^3$  W  
 (b)  $P_a/P_b = 4/9$ ;  $V_a/V_b = 2/3$ ;  
 $P_a/P_b = (V_a/V_b)^2$   
 44.  $1.0 \times 10^3$  W  
 45. (a) 400 W  
 (b) 200 W. Increasing the resistance decreased the current for the given potential difference.  
 46. 48.0 V  
 47. 15  $\Omega$   
 48. 294 W  
 49.  $2.00 \times 10^3$  C  
 50. (a) 550 W (b)  $5.0 \times 10^6$  J  
 51. 3.75 cents  
 52. 1.08 cents  
 53. (a)  $1.4 \times 10^2$  W (b) 0.50 cents

## Chapter 15 Review

### Problems for Understanding

24.  $3 \times 10^3$   $\Omega$   
 25. (a) 12 A (b)  $2.5 \times 10^3$  C  
 (c)  $3.0 \times 10^5$  J  
 26.  $5.0 \times 10^5$  J  
 27. 1.77 cents  
 28. 37.5  $\Omega$   
 29.  $I_1 = 6.0$  A,  $V_1 = 150$  V,  
 $I_2 = 1.0$  A,  $V_2 = 3.0 \times 10^1$  V,  
 $I_3 = 5.0$  A,  $V_3 = 3.0 \times 10^1$  V  
 30. 9.93 s  
 31. (a) 1.9  $\Omega$  (b)  $1.4 \times 10^2$   $\Omega$   
 (c) 0.82 A (d) 98 W  
 32. 24.3 V, 0.517  $\Omega$

## Chapter 16

### Practice Problems

1. 0.72 N[left]  
 2. 7.7 N[down]  
 3. 6.38 A[down]  
 4. 0.204 T[out of page]

## Chapter 16 Review

### Problems for Understanding

27. (a) 2 times increase  
 (b) 9 times increase  
 (c) 2 times increase

## Unit 6 Review

38.  $8.23 \times 10^{-8}$  N

39.  $\pm 14 \mu\text{C}$   
 40.  $1.5 \times 10^4$  electrons  
 41.  $1.8 \times 10^{13} \text{ C}$   
 42.  $-1.0 \times 10^4 \text{ C}$   
 43. 0.12 m  
 44.  $9.2 \times 10^{-26} \text{ N}$   
 45.  $1.1 \times 10^{-5} \text{ C}$   
 46.  $6.2 \times 10^{12}$  electrons  
 47. (a) 0 J (b)  $-8.6 \times 10^{-7} \text{ J}$   
 (c) equipotential surfaces  
 48. 0.10 T  
 49. 1.2 A (into page)  
 50. (a) 14 N[up] (b) 0  
 51. 4.00  $\Omega$ ; 1.2 A, 5.0 V  
 52. Series 5.00  $\Omega$ ; 1.2 A, 6.2 V  
 Parallel 5.00  $\Omega$ , 3.8 V; 7.5  $\Omega$ ;  
 5 A, 3.8 V  
 53. (a) 17 V (b) 6.5  $\Omega$  (c) 14 V

## Chapter 17

### Practice Problems

1. (a)  $4.8 \times 10^{-13} \text{ s}$  (b)  $1.5 \times 10^{-13} \text{ s}$   
 2. 257 s  
 3.  $0.94c = 2.8 \times 10^8 \text{ m/s}$   
 4. 702 km  
 5. 0.31 m  
 6. (a)  $1.74 \times 10^8 \text{ m/s}$   
 (b) The sphere's diameter appears contracted only in the direction parallel to the spacecraft's motion. Therefore, the sphere appears to be distorted.  
 7. 465  $\mu\text{g}$   
 8.  $1.68 \times 10^{-27} \text{ kg}$   
 9.  $0.9987c = 2.994 \times 10^8 \text{ m/s}$   
 10.  $4.68 \times 10^{-11} \text{ J}$   
 11.  $1.01 \times 10^{-10} \text{ J}$   
 12.  $2.6 \times 10^8 \text{ m/s}$   
 13.  $7.91 \times 10^{-11} \text{ J}$   
 14.  $1.64 \times 10^{-13} \text{ J}$   
 15.  $1.3 \times 10^9 \text{ J}$   
 16.  $4.3 \times 10^9 \text{ kg/s}$

## Chapter 17 Review

### Problems for Understanding

18. 0.87c  
 19. (a) 3.2 m (b) 1.9 m  
 (c)  $6.8 \times 10^{-8} \text{ s}$   
 20. (a)  $2.5 \times 10^{-27} \text{ kg}$  (b)  $1.7 \times 10^{-27} \text{ kg}$

21. plot  
 22.  $3.0 \times 10^2 \text{ m/s}$   
 23. (a) c (b) c (c) c  
 24. (a) 3.2 (b)  $5.8 \times 10^{-8} \text{ s}$   
 (c) 16 m  
 25.  $1.2 \times 10^{-30} \text{ kg}$ , which is 1.3 times its rest mass  
 26. (a)  $4.1 \times 10^{-20} \text{ J}$  (b)  $4.1 \times 10^{-16} \text{ J}$   
 (c)  $1.3 \times 10^{-14} \text{ J}$  (d)  $5.0 \times 10^{-13} \text{ J}$   
 (e) (a) and (b)  
 27.  $0.14c = 4.2 \times 10^7 \text{ m/s}$   
 28.  $3 \times 10^4$  light bulbs  
 29.  $4.8 \times 10^{-30} \text{ kg}$ ;  $m/m_0 = 5.3$ ;  
 $0.98c = 2.9 \times 10^8 \text{ m/s}$   
 30. (a) 1.4 g (b) 29% or 0.40 g

## Chapter 18

### Practice Problems

1. (a) 2.40 J  
 (b)  $1.25 \times 10^{15} \text{ Hz}$   
 (c) UV  
 2.  $1.26 \times 10^{15} \text{ Hz}$   
 3. calcium  
 4.  $275 \text{ nm} \leq \lambda \leq 427 \text{ nm}$   
 5.  $4.28 \times 10^{-34} \text{ kg}\cdot\text{m/s}$   
 6.  $9.44 \times 10^{-22} \text{ kg}\cdot\text{m/s}$   
 7.  $4.59 \times 10^{-15} \text{ m}$   
 8.  $3.66 \times 10^{25}$  photons  
 9.  $1.11 \times 10^{10} \text{ Hz}$ ; radio  
 10.  $1.05 \times 10^{-13} \text{ m}$   
 11.  $7.80 \times 10^{-15} \text{ m}$   
 12.  $1.04 \times 10^{-32} \text{ m}$   
 13.  $2.39 \times 10^{-41} \text{ m}$   
 14.  $5.77 \times 10^{-12} \text{ m}$   
 15.  $2.19 \times 10^6 \text{ m/s}$

## Chapter 18 Review

### Problems for Understanding

16. (a)  $1.24 \times 10^{15} \text{ Hz}$   
 17. (a) 2.900 eV  
 (b) lithium  
 18.  $1.5 \times 10^{15} \text{ Hz}$   
 19. 2.2 eV  
 20.  $5.8 \times 10^{18}$  photons/s  
 21. (a)  $1.2 \times 10^{-27} \text{ kg m/s}$   
 (b)  $1.3 \times 10^{-27} \text{ kg m/s}$   
 (c)  $9.92 \times 10^{-26} \text{ kg m/s}$   
 22.  $1.7 \times 10^{17} \text{ Hz}$   
 23.  $5.5 \times 10^{-33} \text{ kg m/s}$

24. (a)  $3.1 \times 10^{-7} \text{ m}$   
 (b)  $6.14 \times 10^{-10} \text{ m}$   
 (c)  $4.7 \times 10^{-24} \text{ kg m/s}$

## Chapter 19 Review

### Problems for Understanding

16. (a)  $4.8 \times 10^{-10} \text{ m}$   
 (b) -1.5 eV, This is the  $n = 3$  energy level.  
 17. 486 nm  
 18. (a)  $6.9 \times 10^{14} \text{ Hz}$  (b)  $4.4 \times 10^{-7} \text{ m}$   
 (c) -0.54 (d)  $1.3 \times 10^{-9} \text{ m}$   
 (e)  $9.5 \times 10^{-8} \text{ m}$

## Unit 7 Review

### Problems for Understanding

26. (a) 0.14c (b) 0.045c  
 27. (a)  $9 \times 10^{16} \text{ J}$  (b)  $3 \times 10^7 \text{ a}$   
 28. (a) 3.1 light-year (b) 4.7 a  
 (c) 6.3 a  
 29. (a)  $1.1 \times 10^{-13} \text{ J}$   
 (b)  $1.3 \times$  rest mass energy  
 (c)  $2.1 \times 10^{-30} \text{ kg}$  or  $2.3 \times$  rest mass  
 30. (a)  $3 \times 10^9 \text{ J}$  (b)  $4 \times 10^{-8} \text{ kg}$   
 31. 1.12 eV =  $1.80 \times 10^{-19} \text{ J}$   
 32. 4.7 eV =  $7.5 \times 10^{-19} \text{ J}$   
 33. (a)  $1.05 \times 10^{15} \text{ Hz}$   
 (b) 287 nm  
 34. (a) 1.25 nm (b) 0.153 nm  
 35. (a)  $2.47 \times 10^{15} \text{ Hz}$   
 (b)  $1.22 \times 10^{-7} \text{ m}$   
 (c) Lyman  
 36. 486 nm  
 37. (a)  $3.0 \times 10^{-19} \text{ J}$   
 (b)  $8.1 \times 10^{17}$  photons  
 38. (a)  $6.91 \times 10^{14} \text{ Hz}$   
 (b)  $4.34 \times 10^{-7} \text{ m}$   
 (c)  $-0.544 \text{ eV} = -8.70 \times 10^{-20} \text{ J}$   
 (d) 1.32 nm  
 (e)  $9.49 \times 10^{-8} \text{ m}$   
 (f) UV

## Chapter 20

### Practice Problems

1. 0.06066 u =  $1.0073 \times 10^{-28} \text{ kg}$   
 2.  $1.237 \times 10^{-11} \text{ J}$   
 3.  $2.858 \times 10^{-10} \text{ J}$   
 4.  $2.6 \times 10^9 \text{ a}$   
 5.  $3.5 \times 10^3 \text{ a}$   
 6.  $8.49 \times 10^{-8} \text{ mg}$

## Chapter 20 Review

### Problems for Understanding

12. (a) 20 p, 20 n, 18 e  
(b) 26 p, 30 n, 26 e  
(c) 17 p, 18 n, 18 e
13. (a)  $1.4765 \times 10^{-11}$  J  
(b)  $1.7927 \times 10^{-10}$  J
14.  ${}_{90}^{230}\text{Th} \rightarrow {}_2^4\text{He} + {}_{88}^{226}\text{Ra}$
15. (a) 1/4 (b) 1/16  
(c) 1/4096
16. (a) 4.876 MeV  
(b)  $v_{\text{He}} = 1.520 \times 10^7$  m/s;  
 $v_{\text{Rn}} = 2.740 \times 10^5$  m/s  
(c) 98.1%
17.  $1.19 \times 10^{-7}$  g
18. 43 min
19.  $1.2 \times 10^4$  a
20. (a) 200 (b) 600  
(c) 25 (d) 775
- (e)  ${}^{\text{D}}N = {}^{\text{P}}N_0 \left( 1 - \left( \frac{1}{2} \right)^{\frac{\Delta t}{T_{1/2}}} \right)$ , where

${}^{\text{D}}N$  is the number of daughter nuclei at any time  $t$ ,  ${}^{\text{P}}N_0$  is the number of parent nuclei at time  $t = 0$ , and  $T_{1/2}$  is the half-life of the parent nucleus.

21. (a)  $\frac{N_{\text{U}}}{N_{\text{Pb}}} = \frac{\left(\frac{1}{2}\right)^{\frac{\Delta t}{T_{1/2}}}}{1 - \left(\frac{1}{2}\right)^{\frac{\Delta t}{T_{1/2}}}}$
- (b)  $4.26 \times 10^9$  a;  $3.89 \times 10^9$  a;  
 $2.93 \times 10^9$  a
- (c) Since the ratios and therefore the ages differ, the rocks must not have solidified at the same time.
- (d) More than one half-life has elapsed.

## Chapter 21

### Practice Problems

1.  $0.14168$  u =  $2.3527 \times 10^{-28}$  kg;  
 $2.114 \times 10^{-11}$  J
2.  $2.818 \times 10^{-12}$  J
3. (a)  $0.0265$  u =  $4.40 \times 10^{-29}$  kg;  
 $3.96 \times 10^{-12}$  J  
(b)  $5.96 \times 10^{11}$  J

## Chapter 21 Review

### Problems for Understanding

20.  $8.194 \times 10^{-14}$  J
21.  ${}_0^1\text{n} + {}_{92}^{235}\text{U} \rightarrow {}_{37}^{90}\text{Rb} + {}_{55}^{144}\text{Cs} + 2{}_0^1\text{n}$

## Unit 8 Review

26. (a)  $3.96 \times 10^{-12}$  J/reaction  
(b)  $9.68 \times 10^{37}$  reactions/s  
(c)  $6.64 \times 10^{-27}$  kg/reaction  
(d)  $6.43 \times 10^{11}$  kg/s  
(e)  $9.82 \times 10^9$  a
27. (a)  $4.40 \times 10^{-29}$  kg  
(b) 0.6580%  
(c)  $1.18 \times 10^{45}$  J  
(d)  $9.59 \times 10^9$  a
28. 88.2 N
29. 5.9 days
30.  $9.580 \times 10^{-13}$  J