Chapter 6 Answer Key

6.1 Section Review

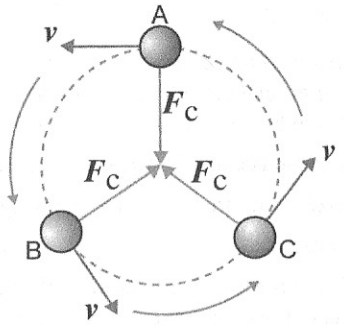
1. Range
2. The magnitude and velocity of one velocity does not affect the magnitude and direction of the other.
3. The horizontal velocity remains constant. The vertical velocity decreases at a rate of 9.8 m/s every second slowing to zero m/s until it reaches its zenith. At its highest point its velocity increases from zero to its initial vertical velocity the instant it strikes the ground.
4. 45 degrees.

6.2 Section Review

1. Answers will vary but might include the following:
   Rotation: spinning wheel on an axle, Earth spinning on its axis daily
   Revolving: ball whirling on a the end of a string, Earth revolving about the sun annually
2. Answers will vary but might include the following: revolutions/second, degrees/second, radians/second
3. They all have the same angular speed but different linear speed; angular speed is independent of their distance from the center of rotation but linear speed is directly proportional to the radius of rotation.

6.3 Section Review

1.



2. Centripetal force is the force directed toward the center of rotation which causes an object to move in a circular path. Centrifugal force is an imaginary force you seem to experience due to the inertia of your mass. Instead of moving in a straight line, you are accelerated toward the center by centripetal force which makes it feel as if you are being pushed away from the center.
3. The force of gravity is proportional to the masses of the objects and inversely proportional to the square of the distance between their centers of mass.
4. The force of gravity between earth and the sun is the force responsible for keeping Earth in orbit around the sun.

6.4 Section Review

1. The center of mass is the point where the object's mass can be considered concentrated, or the intersection of the three axes where the object spins. The center of gravity is the point where the gravitational force acting on the body is concentrated. If gravity is uniform, then they will both be the same. If gravity varies through the object, then they will be different points.

2. To find the center of mass of a symmetric object made of a single material, the center of mass is at the geometric center of the object. For an irregularly shaped object, the object can be suspended from two or more points. The center of mass will be at the intersection of the lines of suspension. The center of mass can also be found by spinning the object and finding the intersection of the three different axes around which the object spins.
3. A pencil is easier to balance on its eraser end than its point end because its center of gravity is lower, which makes it more stable.

Connection Answers

1. Sailboats take a zigzagging course called tacking to sail into the wind.
2. 59 hours, 17 minutes, 56 seconds = 56.44 hours
   1,022 km/56.44 hours = 17.2 kph
3. A marine chart is a type of map projection, with the distortions inherent in all projections. Although the rhumb line looks like a straight line in the projection, it would look more like a spiral or curve if plotted onto the globe. It is not the shortest distance between two locations, unless it's on the Equator or on the same meridian. A great circle route is always the shortest distance between two points on the globe. Use the keyword "loxodrome" in an internet search to research further.

Understanding Vocabulary

1. parabola
2. revolution, rotation
3. satellite
4. centripetal
5. center of gravity

Reviewing Concepts

Section 6.1

1. A displacement vector can be described by (1) a graph, (2) an angle and a magnitude, or (3) an *x*-*y* pair.
2. east = 0°
   north = 90°
   west = 180°
   south = 270°
3. A vector diagram can be used to find an object's displacement graphically. You can draw the components that make up the displacement on graph paper, and the object's displacement will be the resultant vector. This vector can either be measured with a ruler and a protractor to determine its length and angle, or it can be expressed in its *x*-*y* coordinates.
4. speed; direction
5. Answers are:
   a. projectile
   b. projectile
   c. not projectile
6. The horizontal component does not affect the vertical component and vice versa.
7. Since there is no force to cause acceleration, the horizontal velocity is constant. The vertical velocity is not constant; it changes since gravity causes acceleration in the vertical direction.
8. A projectile moves in a curved path because as it travels with constant horizontal velocity, the force of gravity pulls it to the ground.
9. decreases; 9.8 m/s; 2 seconds; 0; 15 m/s; increases; 9.8 m/s; 4 seconds; 15 m/s
10. 45°
11. 70°

Section 6.2

12. Answers are:
    a. revolving
    b. revolving
    c. rotating
13. rotations per second; revolutions per minute
14. 360 degrees in one revolution

15. Answers are:
    a. Their angular speeds are the same.
    b. The ant closer to the edge has a greater linear speed.
16. linear; rotational
17. one circumference

Section 6.3

18. speed up; slow down; change its path from a line to a circle without changing speed.
19. Answers are:
    a. sports car
    b. sports car
    c. sports car
    d. friction between the tire and the road
20. The velocity of an object traveling in a circle is tangent to the circle. The centripetal force at that same point is perpendicular to the velocity, pointing inward to the center of the circle along its radius. Velocity and centripetal force are always perpendicular to each other.
21. Centripetal force is directly proportional to the mass of the object, it is inversely proportional to the radius of the circle it is making, and it is directly proportional to the square of the object's linear speed.
22. a force
23. Centrifugal force is the apparent outward force that seems to pull an object away from the center of the circle it is making. It is not a real force, but an apparent force created by the object's inertia.
24. The force of gravity between the Moon and Earth keeps the Moon in orbit around Earth.
25. Yes there is a force but you don't notice it because the force is so small.
26. Yes, the force that Earth experiences is the same as the force with which Earth attracts you, but Earth's mass is so big that the force doesn't cause it to accelerate (Newton's second law).
27. A satellite is an object that circles around another object with gravity providing the centripetal force.
28. No. Some satellites move in elliptical orbits.

Section 6.4

29. It is at the geometric center of the object; or can be found by spinning the object and finding the intersection of the three different axes around which the object spins.
30. Center of mass of an object is the average position of all the particles that make up an object's mass; center of gravity is the average position of an object's weight. The center of mass of an object and center of gravity of an object are the same if the acceleration due to gravity is the same at every point in an object.
31. Suspend the object from two or more points, trace the line dropping vertically down from each point and find the intersection of the lines; the intersection is the center of gravity
32. An object will topple if its center of mass is not above its area of support; a tall SUV's center of mass is further away from the ground than a car and is more likely to be pushed outside of the area of support during a car accident.
33. As they rock the pole back and forth, they keep the center of gravity of their body and the pole above the wire, which helps them to balance.

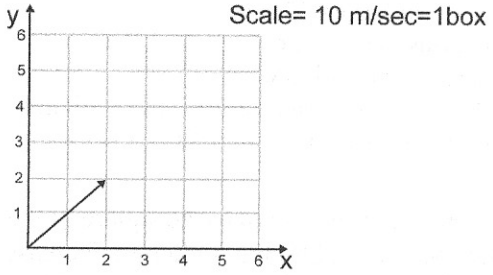
Solving Problems

Section 6.1

1. Answers are:
    a. 4.2 m; 45°
    b. 6.3 m; 18°
    c. 10 km; 37°
    d. 0, 0°

2.

a



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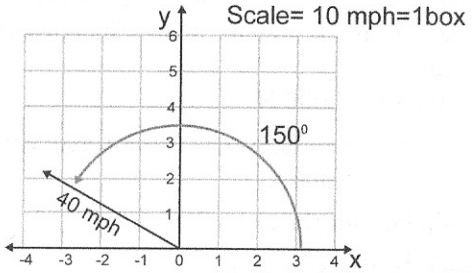

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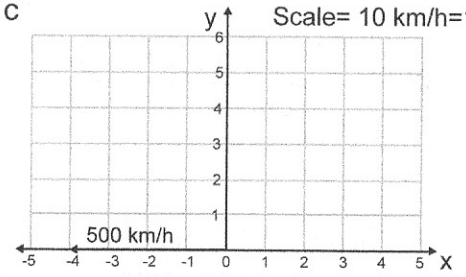
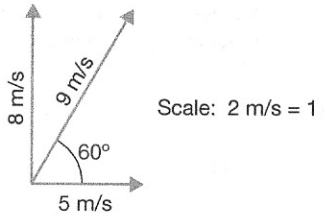


3.

a.



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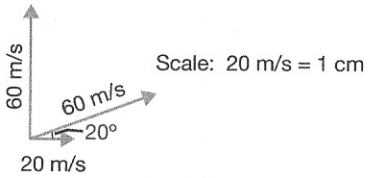


4. Answers are:

a. $d_x = v_x t = (6 \text{ m/s})(2 \text{ s}) = 12 \text{ m}$

b. $d_y = 4.9t^2 = 4.9(2 \text{ s})^2 = 19.6 \text{ m}$

c. horizontal velocity is constant at 6 m/s

d. $v_y = gt = (9.8 \text{ m/s}^2)(2 \text{ s}) = 19.6 \text{ m/s}$

5. Answers are:

a. $v_x = d_x \div t = (30 \text{ m}) \div (3 \text{ s}) = 10 \text{ m/s}$

b. $d_y = 4.9t^2 = 4.9(3 \text{ s})^2 = 44.1 \text{ m}$

c. 10 m/s

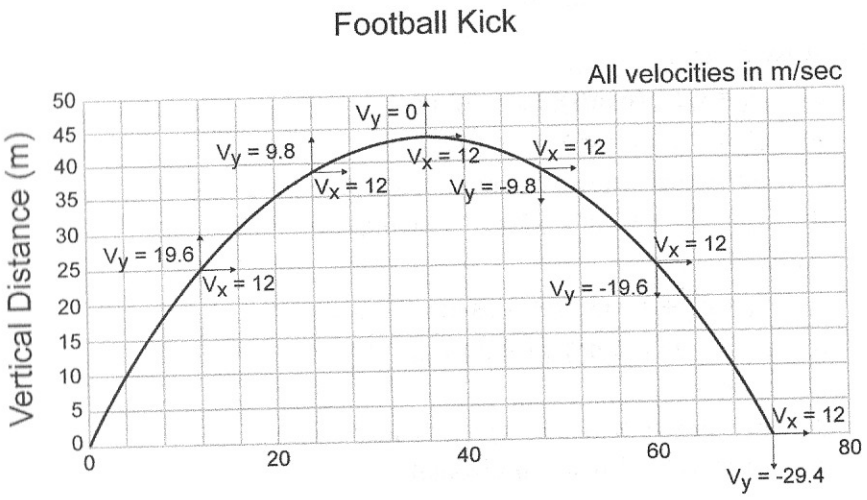
d. $v_y = gt = (9.8 \text{ m/s}^2)(3 \text{ s}) = 29.4 \text{ m/s}$

e. 31 m/s at 71° below horizontal

6.

Time (s)	Horizontal Velocity (m/s)	Vertical Velocity (m/s)	Horizontal Distance (m)	Vertical Distance (m)
0	5	0	0	0
1	5	9.8	5	4.9
2	5	19.6	10	19.6
3	5	29.4	15	44.1
4	5	39.2	20	78.4

7.



Section 6.2

8. 4 rotations per minute
9. Answers are:
   a. 2 rotations per second
   b. 10 rotations × 360 degrees per rotation = 3,600 degrees
   c. 3600 degrees
   d. ÷ 5 seconds = 720 degrees per second
10. Answers are:
    a. $C = 2\pi r = 2\pi(2\text{ m}) = 12.6\text{ m}$
    b. 5 revolutions per minute
    c. 1,800 degrees per minute
    d. $v = C \div t = (12.6\text{ m}) \div (0.2\text{ min/rev}) = 63\text{ m/min}$
    e. 63 m/min ÷ 60 s/min = 1.05 m/s

Section 6.3

11. Centripetal force is proportional to the square of the linear speed: doubling the speed from 20 mph to 40 mph increases the centripetal force by four times (5,000 N)(4 times) = 20,000N
    tripling the speed from 20 mph to 60 mph increases the centripetal force by nine times
    (5,000 N)(9 times) = 45,000 N
12. The truck needs twice as much centripetal force; centripetal force is directly proportional to mass.
13. The force would be four times smaller.
14. The force would be twice as great.
15.

$$F_g = \frac{Gm_1m_2}{r^2} = 6.67\times10^{-11}\frac{(5.97\times10^{24}\text{ kg})(60\text{ kg})}{6.38\times10^{6}\text{ m}}$$

$$F_g = 587\text{N}$$

16.

$$F_g = \frac{Gm_1m_2}{r^2} = 6.67\times10^{-11}\frac{(5.97\times10^{24}\text{ kg})(1.99\times10^{30}\text{ kg})}{1.5\times10^{11}\text{ m}}$$

$$F_g = 3.6\times10^{22}\text{ N}$$

Section 6.4

17. C; B; C
18. Object A will topple because its weight is outside its area of support.

Test Practice

Section 6.1

1. b

$$s = \frac{1}{2}at^2$$

$$t = \sqrt{\frac{2s}{a}} = \sqrt{\frac{2 \times 0.750 \text{ m}}{9.8 \text{ m/s}^2}} = 0.391\text{s}$$

2. c

$$d_x = v_x \times t_x = (4.00 \text{ m/s})(0.391 \text{ s}) = 1.56 \text{ m}$$

3. a

$$v_y = gt = (9.8 \text{ m/s}^2)(0.391 \text{ s}) = 3.8 \text{ m/s}$$

Section 6.2

4. b

$$\omega = \frac{\text{rotations} \times \frac{360°}{\text{rotation}}}{\text{time}} = \frac{2 \text{ rotations} \times \frac{360°}{\text{rotation}}}{3.00 \text{ s}}$$

$$\omega = 240 \, ^\circ\!/_{\text{s}}$$

5. a

$$v = \frac{2\pi r}{t} = \frac{0.400\pi}{2 \text{ revs}/3.00 \text{ s}} = 1.88 \text{ m/s}$$

6. d

$$v = \frac{\pi d}{t} = \frac{0.700\pi}{2.0 \text{ revs}/3.00 \text{ s}} = 3.30 \text{ m/s}$$

Section 6.3

7. d
8. b
9. c
10. d
11. c

Section 6.4

12. b

Applying Your Knowledge

Section 6.1

1. The equation for a parabola shaped like a trajectory is: $y = nx^2 + b$. The equation for a parabola is linear in the horizontal dimension and increases by the square in the vertical dimension. A trajectory is linear with time and increases by the square of the time in the vertical dimension.
2. Since the vertical component of the acceleration of the monkey and the banana are the same (-9.8 m/s^2), they will arrive at the same height after some time, t, which depends upon the horizontal velocity of the "banana gun." The monkey will catch the banana.

Section 6.2

3. The angular speeds of CDs and DVDs are the same, varying between 200 and 500 rpm, depending upon where the laser is "reading" the track. DVDs can hold about 7 times as much information as a CD. Use the key words "CD" and/or "DVD" to start a web search.

Chapter 7 Answer Key

7.1 Section Review

1. Work is the transfer of energy that results from applying a force over a distance.
2. Using $W = mgh$,
   $W_1 = (2\text{ kg})(9.8\text{m/s}^2)(5\text{ m}) = 98\text{ J}$
   $W_2 = (3\text{ kg})(9.8\text{m/s}^2)(4\text{ m}) = 118\text{ J}$
3. No work is done because the force is not applied over a distance.
4. Your power is greater when you run up a flight of stairs because you are doing the same amount of work in a shorter amount of time.

7.2 Section Review

1. A bicycle has wheels and axles, levers (the pedals and kickstand) and gears.
2. $MA = (40\text{ cm})/(2\text{ cm}) = 20$
3. A see-saw is a first-class lever. A baseball bat is a third-class lever. A door on hinges is a second-class lever. Scissors are made up of two first-class levers.
4. 8 times
5. MA = length ÷ height = (15 m) ÷ (3 m) = 5

7.3 Section Review

1. The output work of a simple machine can never be greater than the input work because of friction.
2. A simple machine does work because it exerts forces over a distance. When you design a machine that multiplies force, you must apply the input force over a greater distance.
3. Efficiency is the ratio of a machine's output work to input work. Machines are never 100% efficient because of friction.

Connection Answers

1. The windmill benefitted William's family by providing electricity so that they could have light in the evenings, provided some income through its use as a cell phone charger, and eventually led to William's invitation to speak at the TEDglobal 2007 conference, where he met investors who supported his efforts to build a second windmill for a water pump and enabled William to return to school.
2. Sample answers:
   William had a photo of a windmill but no plans, diagrams, or instructions for how to build one. He overcame this problem by carefully analyzing the photo and figuring out how the windmill worked.
   William did not have most of the supplies needed to build the windmill. He overcame this challenge by using his imagination to figure out ways to used salvaged materials from the junkyard as windmill parts.
   William had to pay a welder to put some of the parts of the windmill together. He did not have spending money for this. William overcame this challenge by loading wood into a truck to earn the money.
3. The windmill uses gears from a bicycle to turn a wheel that spun the generator. The input force is the wind pushing the windmill blades. The output force is the spinning shaft of the generator.

Understanding Vocabulary

1. work-energy theorem
2. power
3. simple machines
4. mechanical advantage
5. efficiency
6. irreversible

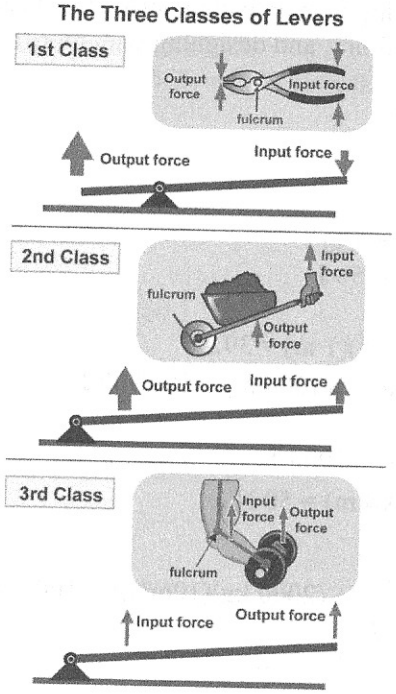
Reviewing Concepts

Section 7.1

1. Because work is a form of energy.
2. Twice as much work.
3. Answers are:
   a. yes
   b. no
   c. yes
   d. no
   e. yes
   f. no
4. In the same direction as the motion of the object.
5. Power is the rate at which work is done.
6. One watt is equal to one joule of work per one second of time.

Section 7.2

7. Answers include: wheel and axle, rope and pulleys, ramp, lever, gears, screw.
8. A wheelbarrow contains the wheel and axle and the lever.
9. Mechanical advantage is defined as the ratio of the output force to the input force. For a mechanical advantage of two, the output force is twice the input force.
10. Simple machines can multiply input forces to get increased output forces but cannot multiply work input to get increased work output. Output work cannot ever exceed input work.
11.



12. 10 N
13. The mechanical advantage of a rope and pulley system is equal to the number of strands directly supporting the load. For a system with four strands, the mechanical advantage is four.
14. A screw is very similar to a ramp that curves.

Section 7.3

15. The output work for a machine cannot be greater than the input work because some of the energy is converted to other forms because of friction.
16. No, because some of the energy is converted to other forms because of friction, the output work is always less than the input work, so efficiency is always less than 100%.

17. A machine's efficiency can be increased by reducing friction. Methods of reducing friction include using ball bearings, oil, slippery substances like teflon®, and designing with more streamlined shapes.

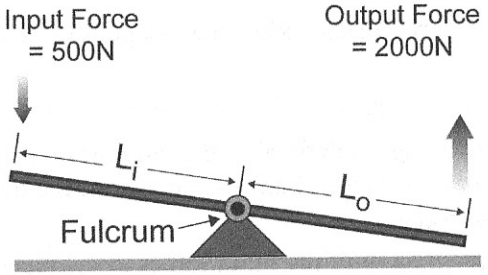
Solving Problems

Section 7.1

1. $W = Fd$
   a. (50 N)(3 m) = 150 J
   b. (25 N)(2 m) = 50 J
   c. 0 J
   d. (4 kg)(9.8 m/s^2)(1 m) = 39.2 J
   e. (60 kg)(9.8 m/s^2)(1000 m) = 588,000 J
2. $W = Fd$
   W = (500 N)(4 m) = 2000 J
3. $F = Wd$ = (200 J)(4 m) = 50 N
4. Answers are:
   a. $KE = \frac{1}{2}\, mv^2 = \frac{1}{2}$ (2000 kg)(10m/s)^2 = 100,000 J
   b. $KE = W = Fd$
      100,000 J = (5,000 N)d
      d = 20 m
5. Answers are:
   a. $W = Fd$
      W = (200 N)(2 m) = 400 J
   b. $P = W \div s$ = (400 J) ÷ (10 s) = 40 W
6. The 200 J machine is more powerful (40 W) than the 500 J machine (25 W).
7. Answers are:
   a. 20 s
   b. 20,000 J
8. Answers are:
   a. $W = Fd$
      W = (500 kg)(9.8 m/s^2)(10 m) = 49,000 J
   b. $P = W \div s$ = (49,000 J) ÷ (8 s) = 6,125 W

Section 7.2

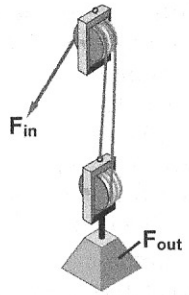
9. M.A. = output force ÷ input force = (15 N) ÷ (5 N) = 3
10. input force = output force ÷ M.A. = (10 N) ÷ 5 = 2 N
11. output force = M.A. × input force = 5(200 N) = 1,000 N
12. Answers are:
    a. M.A. = $L_i \div L_o$
       M.A. = 50 cm ÷ 20 cm = 2.5
    b. output force = M.A. × (input force) = 2.5 × 100 N = 250 N
13. input force = 500 N; output force = 2000 N
    M.A. = $F_o \div F_i$ = 2,000 N ÷ 500 N = 4
    M.A. = $L_i \div L_o$ = 4
    The ratio of input arm to output arm equals 4. Any measurement of input arm that is 4 times the length of the output arm is correct, for example, L_i = 2 m and L_o = 0.5 m.



14. M.A. = $F_o \div F_i$ = 60 N ÷ 20 N = 3
    Three strands of ropes

15. Answers are:

a.



b. M.A. = 2 because it has two strands of rope.
c. M.A. = $F_o \div F_i = 2$
d. F_o. = M.A. $\times F_i = 2 \times 20$ N = 40 N

16. Answers are:

a. $W = Fd = (500 \text{ N})(2 \text{ m}) = 1000$ N
b. work input = work output
length of ramp $\times F_i = W_o$
length of ramp = $W_o \div F_i = (1000 \text{ N}) \div (200 \text{ N}) = 5$ m

17. input work = output work
$d_i \times F_i = d_o \times F_o$
$(1 \text{ m})(50 \text{ N}) = d_o \times (1000 \text{ N})$
$d_o = 0.05$ m

18. input work = output work
$d_i \times F_i = d_o \times F_o$; M.A. = 3
12,000 J = $d_o \times (3000 \text{ N})$
$d_o = 4$ m
$d_i \div d_o = 3$
$d_i = 12$ m

Section 7.3

19. Answers are:

a. E = output work $\div$ input work = 6 J/s $\div$ 60 J/s = 10%
b. The "lost" energy is transformed to heat energy.

20. E = output work $\div$ input work
input work = output work $\div$ E = (300 J) $\div$ 0.5 = 600 J

21. E = output work $\div$ input work
output work = input work $\times$ E = (200 J) $\times$ 0.75 = 150 J

Test Practice

Section 7.1

1. c
2. d
$W = Fd = (50 \text{ N})(2 \text{ m}) = 100$ J
3. a
$W = mgh$
$98 \text{ J} = (10 \text{ kg})(9.8 \text{ m/s}^2)h$
$h = 1$ m
4. a

Section 7.2

5. b
6. c
$MA = L_i/L_o = 6 \text{ m} / 2 \text{ m} = 3$
7. c
8. a
MA = ramp length/ height
$10 = 20 / h$
$h = 2$ m

Section 7.3

9. b
10. d
efficiency = output work / input work
0.80 = (400 J) / (input work)
input work = 500 J

11. b
efficiency = output work / input work
efficiency = (50 kg)(9.8 m/s^2)(10 m) / (7,000 J)
efficiency = 70%

Applying Your Knowledge

Section 7.1

1. Answers will vary depending upon the school building. For example:
   a. Each classroom has 20 fixtures with 3 bulbs per fixture. There are 50 rooms.
   (50 rooms) × (20 fixtures/room) × (3 bulbs/fixture) = 3,000 bulbs
   b. Looking at the fixtures, it is determined that each bulb is 45 W
   c. (3,000 bulbs) × (45 watts) = 135,000 watts
   d. (135,000 watts) × (1 HP/746 watts) = 181 horses

Section 7.2

2. Answers will vary. Examples include:
wedge: knives or razors
1st class lever: can opener
2nd class lever: bottle opener
3rd class lever: clipboard or mouse trap
wheel and axle: door knob
inclined plane: staircase
screw: cork screw or bolt
3. Answers include the following:
wheel and axle: steering wheel, radio control knob, drive shaft, fan pulley
lever: shifting lever, trunk lid, doors, window cranks
screw: screws and bolts holding the vehicle together.
4. A web search using the key words "Egyptian pyramid construction" reveals several sites dedicated to the construction of the pyramids indicating that the inclined plane is the only simple machine that has been conclusively linked to the construction of the pyramids.

Section 7.3

5. Answers are:
   a. No. A perpetual motion machine cannot be built. Energy is dissipated as heat and sound in a Newton's cradle.
   b. No. The first and second law of thermodynamics must be obeyed. Work output cannot ever be more than work input.
   c. Several machines have been invented that purport to break these laws. Examples of two of these machines and an explanation of their operation can be found by doing a web search for "John Gamgee" and "Maxwell's demon."
6. Assuming a 2,000 calorie diet:
(4,184 J/Calorie) × (2,000 Calories/day) = 8.368 × 108 J/day