Chapter 16 Answer Key

16.1 Section Review

1. A current carrying wire is surrounded by a magnetic field which affects the compass. The compass needle will align itself parallel with magnetic field.
2. A current carrying wire is surrounded by a magnetic field in the shape of concentric circles.
3. By increasing the current flowing through a wire the strength of the magnetic field surrounding the wire will be increased. Wrapping the wire in a several coils will also increase the magnetic field in the center of the coil. The direction of the field can be changed by changing the direction of the current in the wire.
4. Most appliance wires consist of two insulated wires made of many tiny strands of wire woven together. Because the current in each of the two appliance wires flows in opposite directions (due to alternating current) there will be a repulsive force between the two wires. Within each wire, the tiny strands are attracted to one another because the current flows in the same direction in all of the woven strands.

16.2 Section Review

1. Position a magnet such that the pole of the magnet attracts one of the magnets of the rotor and repels another next to it. As the attracted magnet moves toward the pole of the magnet you hold, reverse the polarity of the magnet by flipping it over in your hand. It must be done at the proper time so that the inertia of the rotor and magnet will carry it to a position which will cause the magnet to be repelled as the next magnet is attracted.
2. A commutator reverses the current flowing to the electromagnet which reverses the polarity of the electromagnet.
3. a. A rotor, a rotating part containing magnets b. One of more fixed magnets surrounding the rotor c. A commutator that switches the direction of the current back and forth at the time to cause the rotor to continue to spin.

16.3 Section Review

1. Faraday's law states that the induced voltage is proportional to the rate of change of the magnetic field. If you move a magnet quickly through a coil it induces the most voltage; moving it slowly induces less voltage. If the magnet is stationary in the coil no voltage is induced in the coil.
2. A transformer is used to increase or decrease the voltage of a source.

Connection Answers

1. Answers will vary. Any machine that uses an electric motor could be traced back to Michael Faraday's invention. Faraday was also the first to invent electromagnetic induction, which is the process by which most power plants produce electricity for household use. So any electrical appliance used by students could also be considered to be indebted to the work of Faraday.
2. Materials for either demonstration can be purchased through science supply catalogs or radio/electronics supply stores.

Understanding Vocabulary

1. solenoid
2. rotor; commutator or commutator; rotor
3. generator
4. transformer

Reviewing Concepts

Section 16.1

1. Magnetism is created by moving charges.
2. A magnetic field.
3. Wrapping the right hand around a current carrying wire with the thumb pointing in the direction of the current will cause the fingers to wrap in the direction of the magnetic field that surrounds the wire.
4. The magnetic field becomes stronger as the current increases. Field strength is directly proportional to the current.

5. The direction of the magnetic field will be reversed if the current is reversed.
6. The strength of the field surrounding a wire will decrease as the distance from the wire increases.
7. It is easier and safer to work with a small current.
8. A strong magnetic field can be produced by using a smaller current. For example, a 1-amp current flowing through 50 coils produces the same strength of magnetic field as a single wire carrying 50 amps.
9. The force created is very small; also, the field strength of a magnetic field decreases very rapidly with an increase in distance.

Section 16.2

10. electrical; mechanical
11. So that the polarity of the magnets can be more easily reversed at the proper time in the rotation of the rotor.
12. The commutator reverses the polarity of the electromagnets at the proper time in the sequence of rotation.
13. The current must be continually reversed so the electromagnets will continually change polarity.
14. The main parts of all electric motors are the rotor (with magnets of alternating polarity), field magnets (fixed magnets), and the commutator (for reversing current to the electromagnets).

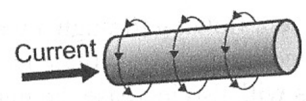
Section 16.3

15. If you move a magnet through a coil of wire it will induce a potential difference in the coil that will cause a current to flow if the coil is part of a circuit.
16. No. A magnet will only induce a voltage in a coil if the magnet is moving relative to the coil.
17. A typical answer might be: The potential difference induced across the ends of a coil is directly related to the speed with which a magnet is passed through a coil. (It is also directly related to the strength of the moving magnet and the number of turns in the coil.)
18. The direction of movement of the magnetic field determines the polarity of the induced voltage. Since the direction of the moving field is continually reversing, the polarity of the induced voltage changes.
19. Generally, it is 120 volts. It may fluctuate a bit, however.
20. The voltage is reduced by using a step-down transformer.
21. power
22. This is a step-up transformer. It increases the voltage.

Solving Problems

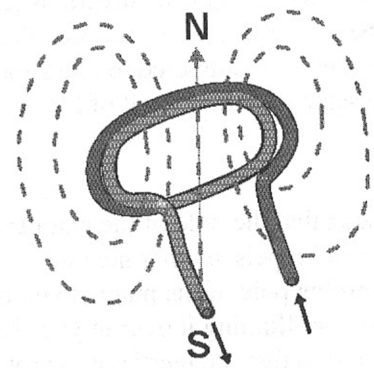
Section 16.1

1.



2. Doubling the current doubles the strength of the magnetic field. Tripling the current triples the strength of the magnetic field. Quadrupling the current quadruples the strength of the magnetic field.

3.



4. Answers are:
   a. Using a stronger magnet causes more current to flow.
   b. Moving the magnet toward the coil faster causes more current to flow.
   c. Reversing the magnet's direction causes the current direction to reverse.
   d. Adding more turns of wire cause more current to flow.
   e. Moving the south pole of the magnet toward the coil will cause the current to flow in the opposite direction. (It will flow from left to right through the bulb.)
   f. If the two bulbs are in series, the current will decrease. If the two bulbs are in parallel, the current will increase.
5. A. Attract
   B. Repel
   C. Repel

Section 16.2

6. The rotor will spin in a counter-clockwise direction.
7. The inertia of the rotor will cause the north end of the permanent magnet to spin slightly past the electromagnet as its polarity changes, and the pole of the electromagnet closest to the rotor acquires a north pole orientation. For this to occur, the current must be flowing from A to B.

Section 16.3

8. Answers are:
   a. $V_1/V_2 = T_1/T_2$
      $V_1/(120\text{ V}) = (1000\text{ V})/(50\text{ V})$
      $V_1 = 2400\text{ V}$
   b. $VV_1/V_2 = T_1/T_2$
      $(120\text{ V})/V_2 = (1000\text{ V})/(50\text{ V})$
      $V_2 = 6\text{ V}$
9. Answers are:
   a. $V_1/V_2 = T_1/T_2$
      $(120\text{ V})/(24\text{ V}) = (500\text{ turns})/T_2$
      $T_2 = 100$ turns
   b. Power Input = Power Output
      $(V_i)(I_i) = (V_o)(I_o)$
      $(120\text{ V})(1\text{ amp}) = (24\text{ V})(I_o)$
      $I_o = 5$ amps

Test Practice

Section 16.1

1. c
2. a
3. a

Section 16.2

4. c
5. c

Section 16.3

6. d
7. a
8. d
9. c

Chapter 17 Answer Key

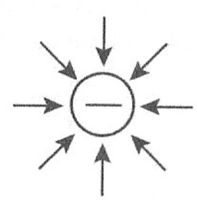
17.1 Section Review

1. Answers may include: sound and light intensity, gravitational, magnetic, and electric fields
2. Intensity decreases by the square of the change; it will decrease by 9 times.
3. Because it takes time for the field to collapse, the effect would not be noticed immediately. Earth would not fly out of orbit immediately.

17.2 Section Review

1. If Earth vanished the gravitational field would not disappear instantly. It takes time for fields to form and to collapse.
2. Gravitational field strength is extremely weak unless associated with large masses such as that of Earth, the moon or the Sun.

17.3 Section Review

1. 

   The field lines indicate the direction a positive test charge would travel if released in the vicinity of the negative charge. Since the negative charge would attract the positive test charge, the arrows point in the direction of the negative charge.
2. 1.0 N
3. Electric fields are created all around us by electric appliances, static electricity, and lightning. Shielding protects appliances, computers, and other sensitive electronics from interference caused by stray electric fields.

Connection Answers

1. The ACE helps scientists predict when magnetic storms are likely to occur. This helps power companies and commercial satellite operators prepare for possible interruptions in service. It also helps NASA plan spacewalks for time periods between magnetic storms to minimize the astronauts' exposure to radiation.
2. Mission planners at NASA are aware of magnetic storm forecasts and plan spacewalks to minimize astronauts' exposure. Astronauts also wear protective gear to help shield them from harmful radiation.
3. Magnetic storms are most likely to occur when there is increased sunspot activity. Sunspot activity peaks ever y 11 years.
4. According to NASA's Marshall Space Flight Center, sunspot activity will peak in 2013. Since the solar cycle is approximately 11 years from peak to peak, sunspot activity is likely to peak again in 2024.

Understanding Vocabulary

1. inverse square law
2. force field
3. shielding
4. source charge
5. electric field

Reviewing Concepts

Section 17.1

1. matter; energy
2. Answers will vary. Examples include: sound intensity field, gravitational field, electric field.
3. energy
4. The strength of the field decreases by the square of the change in distance from the source.
5. watts per unit of area (W/m^2)

6. The force exerted by the field decreases by the inverse of the square of the change in distance from the source.
7. No. Because magnets have two poles that interfere with one another at larger distances, the field of a magnet changes at a greater rate with distance than a field which follows an inverse square law.

Section 17.2

8. mass
9. The gravitational field created by objects is relatively weak. A significantly strong gravitational field is only created by objects with extremely large masses, such as objects the size of Earth or the moon.
10. The strength decreases by the square of the increase in distance from the center of mass of Earth.
11. Earth creates a gravitational field by which we are surrounded. Since a field exerts a force on everything in it, Earth's gravitational field exerts a force on our bodies.
12. newtons/kg (N/kg)
13. Toward the center of mass of Earth.

Section 17.3

14. positive; negative
15. The size of the charge and the distance to the charge.
16. The direction of the field and the relative strength of the field.
17. The closer the field lines are spaced, the greater the relative strength of the field.
18. Newtons per coulomb (N/C) and Volts per meter (V/m).
19. The voltage source creates a field in the conducting wire which applies a force on the electrons. The force accelerates the charged electrons to a speed known as drift velocity. At this speed, collisions between electrons and copper atoms restrict the speed of the electrons to a constant speed in much the same way that friction restricts the speed of an object to a constant speed when constant force is applied.
20. Conductors that are not carrying a current have no net field inside. By covering a wire with a conducting material the wire is shielded to prevent interference.

Solving Problems

Section 17.1

1. Light intensity varies inversely by the square of the distance from the source. By doubling the distance to the source, the intensity is reduced by four times.

$$\text{New Light Intensity} = \frac{2\ \text{W/m}^2}{4} = 0.5\ \text{W/m}^2$$

2. Light intensity varies inversely by the square of the distance from the source. By decreasing the distance to the source by two times, the intensity is increased by four times.

$$\text{New Light Intensity} = 1\ \text{W/m}^2 \times 4 = 4\ \text{W/m}^2$$

Section 17.2

3. Gravitational force varies inversely by the square of the distance from the source. By doubling your distance from the center of the Earth the force exerted on you is reduced by four times.

$$\text{New weight} = \frac{600\ \text{N}}{4} = 150\ \text{N}$$

4.

$$\frac{F}{m} = \text{Field Strength} = \frac{Gm_J}{r_J^2}$$

$$\text{Field Strength} = \frac{\left(6.67\times10^{-11}\ \frac{\text{N-m}^2}{\text{kg}^2}\right)\left(1.9\times10^{27}\ \text{kg}\right)}{\left(7.15\times10^{7}\ \text{m}\right)^2}$$

$$\text{Field Strength} = 2.48\times10^{1}\ \text{N/kg}$$

5.

$$\frac{F}{m} = \text{Field Strength} = \frac{Gm_{io}}{r_{io}^2}$$

$$\text{Field Strength} = \frac{\left(6.67\times10^{-11}\,\frac{\text{N-m}^2}{\text{kg}^2}\right)\left(8.94\times10^{22}\text{ kg}\right)}{\left(1.82\times10^{6}\text{ m}\right)^2}$$

$$\text{Field Strength} = 1.80\text{ N/kg}$$

6.

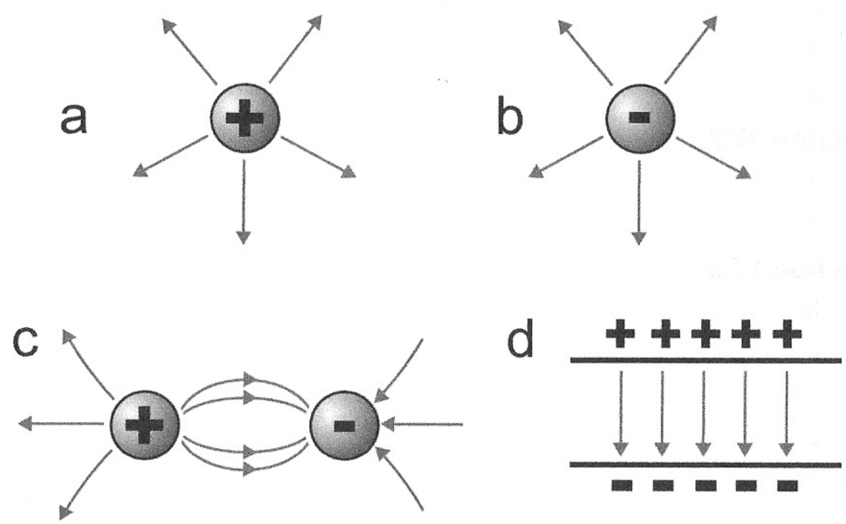
$$\frac{F}{m} = \text{Field Strength} = \frac{Gm_{E}}{r_{E}^2}$$

$$\text{Field Strength} = \frac{\left(6.67\times10^{-11}\,\frac{\text{N-m}^2}{\text{kg}^2}\right)\left(5.98\times10^{24}\text{ kg}\right)}{\left(6.37\times10^{6}\text{ m}\right)^2}$$

$$\text{Field Strength} = 9.8\text{ N/kg}$$

Section 17.3

7. Answers are:



8. In the graphic, the point where the lines are closest together is the point of greatest strength. The point where the lines are farthest apart is the point at which the lines are the weakest. A is the point of greatest strength and D is the point of weakest strength.

9.

$$F = E\times q = (2{,}000\text{ N/C})(0.004\text{ C}) = 8\text{ N}$$

$$F = E\times q = (5\text{ N/C})(2\text{ C}) = 10\text{ N}$$

$$F = E\times q = (5\text{ N/C})(-3\text{ C}) = -15\text{ N}$$

10. The force on the +2 C charge is 10 N down.
The force on the -3 C charge is -15 N up.

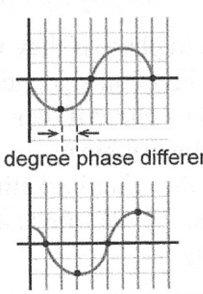
Chapter 18 Answer Key

18.1 Section Review

1. a turn of a bicycle wheel
2. a ferris wheel
3. $T = 1/f$
4. $T = 6$ seconds
   $f = 1/T = 1/6 = 0.17$ hertz

18.2 Section Review

1. Linear motion graphs do not show cycles. Graphs of harmonic motion show repeating cycles.
2. Amplitude = ½ (high point - low point)
   Amplitude = ½(5-(-5)) = 5 cm
3. Amplitude = ½(high point - low point)
   Amplitude = ½(10-(-10)) = 10 degrees
4. Period = total time/ total cycles = 10 s/ 5 cycles = 2 s
   Each cycle has a period of 2 seconds.
5. Period = (ending time - beginning time)
   Period = (6.8 - 4.3) = 2.5 seconds
6.



7. 45/360 = 1/8

18.3 Section Review

1. The restoring force for a pendulum is gravity. The restoring force for a mass on a spring is the push-pull of the spring. The restoring force for a vibrating string is the tension from pulling the rubber band to the side.
2. Changing the amplitude of a pendulum does not change the period. A pendulum has the same period each time you set it in motion unless you change the pendulum itself (such as changing the length of the string).
3. Yes. A trampoline is an oscillator (a system that shows repeating motion) similar to a spring.
4. If you make the length longer, the period gets larger.

Connection Answers

1. Sway is the simple harmonic motion of a building. Wind supplies the periodic force that pushes on the side of the building. The restoring force is provided by the building's mass. Steel columns in the center or hollow rigid tubes at the perimeter of the building may provide restoring force. Other buildings use mechanical means such as a tuned mass damper to provide a restoring force.
2. After the Citicorp center was completed, LeMessurier learned that the building's braces had been bolted rather than welded in a cost-saving measure that compromised the strength of the bracing. An engineering student calculated that if hurricane-force wind hit the building at a certain angle, it could collapse. LeMessurier realized the student was right. He risked his reputation by admitting there was a problem. He personally oversaw the repairs to make the building safe. He is now regarded both as an outstanding engineer and as a model of ethical public service in the business world.
3. The John Hancock Tower's tuned mass damper consists of two 300-ton boxes made of steel and filled with lead, placed on opposite ends of the 58th floor. Each box sits on a lubricated steel plate. The boxes are connected to the building's frame using springs and shock absorbers. When the building sways, the boxes tend to stay still and the floor slides underneath them. When swaying force engages the

springs and shock absorbers, they pull the building back to its equilibrium position.

Understanding Vocabulary

1. cycle
2. period
3. frequency
4. damping
5. phase
6. natural frequency

Reviewing Concepts

Section 18.1

1. Answers are:
   a. linear
   b. harmonic (both if you watch the wave pass a point)
   c. both (the whole car has linear motion, but certain parts, like the wheels, have harmonic motion)
   d. harmonic
2. Small oscillators: (1) oscillating electric and magnetic field vectors of radio, light, and radar electromagnetic waves, (2) electron's orbital motion, (3) molecules in a solid vibrating about their equilibrium position at a given temperature, (4) alternating current circuits voltage, current, and electric charge varying with time.
   Large oscillators: (1) a playground swing, (2) the beating of the wings of a bird or insect, (3) the human heart beating, (4) the speaker of a radio vibrating.
3. Answers are:
   a. one rotation from your starting position to the same position again
   b. one year; one trip around the Sun
   c. one swing from left to right and back to the starting point on the left
4. Answers are:
   a. period: the time to make a complete swing out and back to the starting point.
   b. frequency: the number of swings per second (or per unit of time)
   c. cycle: represented by the motion from the point farthest back in the travel of the swing to the point farthest forward, then back to the point farthest back.
   d. amplitude: one half the distance from the point of greatest backward motion to the point of greatest forward motion.
5. "106.7" means 106.7 megahertz; This represents 106.7 million vibrations per second of the electric wave, or 106.7 million cycles per second.
6. The frequency and period are inversely related. As the frequency increases, the period decreases.
   $T = 1/f$
7. Answers are:
   a. meter, centimeter, degrees
   b. hertz
   c. second, minute, hour
   d. kilogram, gram

Section 18.12

8. The period would be represented by the time difference between a point on the wave representing the oscillation to the same point on the next wave. The amplitude would be represented by 1/2 the distance from the top of a crest to the bottom of a trough.
9. The basketballs would be in phase if they were in identical heights and traveling in the same direction at identical speeds. The basketballs would be 180 degrees out of phase if their motion was separated by a 180 degree difference in the dribble cycle, for example, if one basketball hit the floor as the other basketball hit its maximum height and vice versa. They would be out of phase by some degree if their motion differed in any way.
10. Circular motion involves continuous rotation of an object. One rotation equals one cycle. If you were on a ferris wheel, one cycle would be the time it would take to go one full circle or 360 degrees

On a harmonic motion graph, circular motion and the motion of a pendulum are similar.

Section 18.3

11. Answers are:
    a. The period increases.
    b. The frequency decreases.
12. Gravity
13. Answers are:
    a. When they are lowest to the ground, in the exact center of the swing cycle.
    b. The point at which the bungee cord is its normal length and not stretched or shortened. For a bungee jumper, this would be the place between the highest and lowest points of the jump.
    c. When the string is straight.
14. Resonance occurs when the periodic force of a system matches the natural frequency of the system. At resonance, a large amplitude of vibration occurs with repeated applications of periodic force at the natural frequency of the vibrating body. Examples include: pushing a child at the right time on a playground swing, a vibrating guitar string,

Solving Problems

Section 18.1

1. Period = 1÷ frequency = 1 ÷ (220 Hz) = 0.0045 s
2. Frequency = 1 ÷ period = 1 ÷ (4 s) = 0.25 Hz
3. Period = 24 hours or (24 hr)(60 min/hr)(60 s/min) = 8.64 × 104 s
   Frequency = 1 ÷ period = 1 ÷ (8.64 × 104 s) = 1.16 × 10-5 Hz
4. Answers are:
   a. frequency = 65 beats per minute
      = 65 beats/min ÷ 1 min/60 s = 1.083 beats/s = 1.083 Hz
   b. period = 1 ÷ frequency = 1 ÷ (1.083 Hz) = 0.92 s

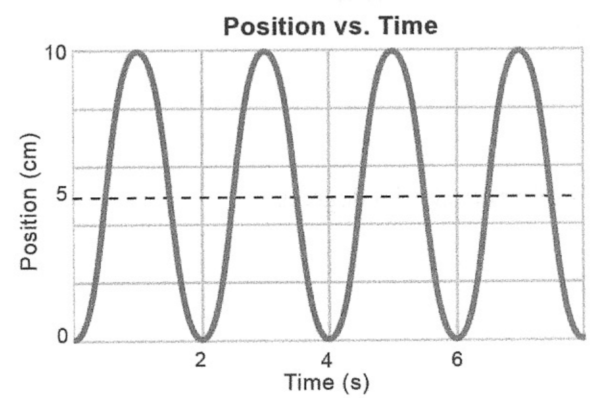
5. Answers are:

	Period (seconds)	Frequency (hertz)
Second hand	60	0.017
Minute hand	3,600	0.000278
Hour hand	86,400	0.0000116

Second hand = 1/60 s = 0.017 Hz
Minute hand = 1/3,600 s = 0.000278 Hz
Hour hand = 1/86,400 s = 0.0000116 Hz

Section 18.2

6. Answers are:
   a. 1 s
   b. frequency = 1/period = 1/1 s = 1 Hz
   c. 1 cm
   d. 5 cycles
7. Answer:



8. B; $^1/_2$ of a 360 degree cycle out of phase.

Section 18.3

9. The period will not be affected by the mass of the bob (as long as the restoring force of this pendulum is due to gravity).

10. Answers are:
    a. tighten or loosen the string by tuning it; touch the string (which effectively shortens it)
    b. shorten or lengthen the ropes; add mass (i.e., a person) to the swing
    c. change mass of ball; length of elastic
    d. adjust the fulcrum of the diving board, or change the length of the diving board.
11. The period of the pendulum decreases as the length of the string decreases.

Test Practice

Section 18.1

1. a
2. d
   $f = 300/5 = 60$ Hz; $T = 1/f = 1/60 = 0.017$ s
3. b
4. b
   $T = 4$ s; $f = 1/T = 1/4 = 0.25$ Hz

Section 18.2

5. c
6. d
7. c
   5/20 = 1/4 of a period = 90 degrees
8. c

Section 18.3

9. a
10. d
11. d
12. a

Applying Your Knowledge

Section 18.1

1. Using an average of 65 beats per minute, there are:
   65 beats/min × 60 min/hr × 24 hr/day = 93,600 beats per day
2. Answers are:
   a. When the Moon is in positions A and C, very high tides (and very low tides) occur. When the Moon is in positions B and D, the tides are not as high or low. However, at all four positions, high and low tides occur on a daily basis.
   b. The Moon revolves around Earth on a monthly basis while Earth spins on its axis on a daily basis. This means that at certain places on Earth there are two strong pulls on the ocean's water each day resulting in two high tides and two low tides (between the high tides).
3. Examples include:

Cycle	Period	Frequency
Earth's Rotation	8.64×10^4 s	1.16×10^{-5} Hz
Earth's revolution around the Sun	3.16×10^7 s	3.16×10^{-8} Hz
Mercury's revolution around the Sun	7.6×10^6 s	1.32×10^{-7} Hz
Mars' revolution around the Sun	6.0×10^7 s	1.67×10^{-8} Hz
Uranus' revolution around the Sun	2.65×10^9 s	3.77×10^{-10} Hz

4. Examples include the up-and-down motion of the needle, the rotation of the spool of thread, the rotation of the bobbin in the bobbin case, and the rotation of the balance wheel on the upper right of the machine.