Chapter 37  Electromagnetic Induction

Exercises

37.1 Electromagnetic Induction (pages 741–742)

1. Circle the letter beside the names of the two scientists who, in 1831, independently discovered that electric current can be produced in a wire by simply moving a magnet into or out of a wire coil.
   a. Einstein and Faraday  
   b. Faraday and Henry
   c. Henry and Newton  
   d. Maxwell and Newton

2. Is the following sentence true or false? Voltage is induced whether the magnetic field of a magnet moves past a stationary conductor, or the conductor moves through a stationary magnetic field.  
   **true**  
   Use the figure to answer Questions 3 and 4.

3. When the magnet is pushed into the middle coil, _____ twice _____ as much voltage is induced as in the coil on the left.

4. When the magnet is pushed into the coil on the right, _____ three times _____ as much voltage is induced as in the coil on the left.

5. Describe how the speed at which the person pushes the magnet affects the voltage that is induced in the coils.
   Very slow motion produces hardly any voltage at all. Quick motion induces a greater voltage.

6. Explain why producing voltage by pushing a magnet through a wire loop doesn’t violate the law of conservation of energy.
   Work is done in pushing the magnet into the loop. The induced current in the loop creates a magnetic field that repels the approaching magnet.

7. The phenomenon of inducing voltage by changing the magnetic field around a conductor is  
   **electromagnetic induction**
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37.2 Faraday's Law (page 743)

8. Faraday's law states that the induced voltage in a coil is proportional to the product of what three things?
   a. the number of loops in the coil
   b. the cross-sectional area of each loop
   c. the rate at which the magnetic field changes within those loops

9. The amount of current produced by electromagnetic induction depends not only on the induced voltage but also on what two things?
   a. the resistance of the coil
   b. the resistance of the circuit to which it is connected

10. Is the following sentence true or false? You induce the same voltage when you plunge a magnet in and out of a closed rubber loop as you do when you plunge the magnet in and out of a closed loop of copper.
    
    true

37.3 Generators and Alternating Current (pages 743–745)

11. Describe how each of the following changes as a magnet is plunged into and out of a coil of wire.
   a. Magnetic field strength:
      It increases as the magnet enters the coil and decreases as the magnet leaves the coil.

   b. Voltage:
      It is induced in one direction as the magnet enters the coil and in the other direction as the magnet leaves the coil.

12. What is a generator?
    a machine that produces electric current by rotating a coil within a stationary magnetic field

13. Complete the table to describe the difference in a motor and a generator.

<table>
<thead>
<tr>
<th>Device</th>
<th>Converts</th>
<th>Into</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor</td>
<td>electrical</td>
<td>mechanical</td>
</tr>
<tr>
<td>Generator</td>
<td>mechanical</td>
<td>electrical</td>
</tr>
</tbody>
</table>

14. When the loop of wire of a simple generator is rotated in the magnetic field, there is a change in the number of magnetic lines within the loop.

15. Circle the letter beside the number of times each second that standard alternating current in North America changes its magnitude and direction.
   a. 20
   b. 60
   c. 120
   d. 240

16. Complex generators used in power plants are connected to an assembly of paddle wheels called a(n) turbine.

17. Is the following sentence true or false? Electricity is a source of energy.
    
    false
37.4 Motor and Generator Comparison (page 746)

18. Describe the following effects shown in the figure above.

a. Motor effect:
When the current moves to the right in the wire, the magnet's magnetic field exerts a force on the moving electrons, and the wire is forced upward.

b. Generator effect:
The wire, with no current in it, moves downward through the magnet's magnetic field. The field exerts a force on the electrons along the direction of the wire, creating a current.

19. In both the motor effect and the generator effect, the moving charges experience a force that is \( \text{perpendicular} \) to both their motion and the magnetic field they traverse.

20. Circle the letter beside another name for the generator effect.

a. conservation of charge
b. Coulomb's law
c. conservation of energy
d. law of induction

21. An example of a device functioning as both a motor and a generator is found in hybrid automobile. Explain this effect in each case below.

a. Acting as a motor:
When extra power for accelerating or hill climbing is needed, the device draws current from a battery which acts as a motor to assist the gasoline engine.

b. Acting as a generator:
When braking or rolling downhill causes the wheels to exert a torque on the device, it acts as a generator and recharges the battery.
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37.5 Transformers (pages 747-749)

For questions 22–25, consider two coils of wire that are placed side by side, close but not touching. The primary coil is connected to a battery and the secondary coil is connected to a galvanometer.

22. Another name for the primary coil is the ______ input ______ coil, and another name for the second coil is the ______ output ______ coil.

23. Circle each letter beside something that happens at the moment the switch is closed in the primary circuit.
   a. A current flows in the secondary circuit.
   b. A voltage is applied across the secondary circuit.
   c. A magnetic field exists around the primary coil.
   d. A magnetic field exists around the secondary coil.

24. Circle each letter beside something that continues to happen as long as the switch is closed in the primary circuit.
   a. A current flows in the secondary circuit.
   b. A voltage is applied across the secondary circuit.
   c. A magnetic field exists around the primary coil.
   d. A magnetic field exists around the secondary coil.

25. What effect would an iron core placed inside the primary and secondary coils have on magnetic fields and the galvanometer reading?
   The magnetic fields around both cores would be stronger, and the galvanometer reading would show greater surges of current when the switch is opened or closed.

26. A transformer is a device for increasing or decreasing ______ voltage ______ through ______ electromagnetic induction ______.

27. A transformer works by inducing ______ a changing magnetic field ______ in one coil, which induces ______ an alternating current ______ in a nearby second coil.

28. A step-up transformer has a ______ greater ______ number of turns on the secondary than on the primary.

29. A step-down transformer has a ______ lower ______ number of turns on the secondary than on the primary.

30. Complete the table to describe the relationship between voltage and turns in different transformers.

<table>
<thead>
<tr>
<th>Primary Voltage</th>
<th>Secondary Voltage</th>
<th>Number of Primary Turns</th>
<th>Number of Secondary Turns</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 volts</td>
<td>9 volts</td>
<td>6</td>
<td>18</td>
</tr>
<tr>
<td>6 volts</td>
<td>30 volts</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>9 volts</td>
<td>27 volts</td>
<td>8</td>
<td>24</td>
</tr>
</tbody>
</table>

31. Power in a transformer is the rate at which ______ energy ______ is transferred from one coil to the other in a transformer.

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37.6 Power Transmission (page 750)

32. Almost all electric energy sold today is in the form of alternating current.
33. Power is transmitted great distances at high voltage and low current.
34. Why would transmitting electric energy at low voltages result in large energy losses? Because of heating of the wires.
35. Circle the letter beside a typical voltage at which power is carried from power plants to cities.
   a. 3600 volts
   b. 120,000 volts
   c. 760,000 volts
   d. 2,400,000 volts
36. Circle the letter beside the typical voltage to which a common neighborhood transformer steps down for houses and small businesses.
   a. 20 volts
   b. 60 volts
   c. 120 volts
   d. 240 volts

37.7 Induction of Electric and Magnetic Fields (page 751)

37. According to Faraday's law, an electric field is created in any region in space where a magnetic field is changing with time, and the magnitude of the electric field is proportional to the rate at which the magnetic field is changing.
38. What does an electric charge present where an electric field is created experience? a force.
39. Express the law described by James Clerk Maxwell, which is a companion to Faraday's law.
   A magnetic field is created in any region of space in which an electric field is changing with time.
40. According to Maxwell, the magnitude of a created magnetic field is proportional to the rate at which the electric field changes.
41. What is the direction of the magnetic field that is created by a changing electric field?
   At right angles to the changing electric field.
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37.8 Electromagnetic Waves (pages 753–755)

42. Is the following sentence true or false? It is possible to produce electromagnetic waves by shaking a charged rod back and forth in empty space.   true

43. Circle the letter beside each statement that correctly describes electromagnetic waves.
   a. No medium is required to produce the waves.
   b. The waves move outward in all directions from the vibrating charge that created them.
   c. The electric field is parallel to the magnetic field in the waves.
   d. Both electric and magnetic fields are perpendicular to the direction of motion of the wave.

44. How fast does an electromagnetic wave move?   the speed of light

45. Is the following sentence true or false? The speed of light depends on the frequency, wavelength, and intensity of the radiation.   false

46. Circle the letter beside the name of the scientist who discovered the speed of electromagnetic waves.
   a. Albert Einstein  b. Michael Faraday
   c. James Clerk Maxwell  d. Isaac Newton

47. Describe what would happen to an electromagnetic wave if the following were true.
   a. The wave traveled at less than the speed of light.
      The wave would rapidly die out as the induced waves were weaker and weaker.

   b. The wave traveled at a speed greater than the speed of light.
      The fields would increase to ever greater magnitudes, violating the law of conservation of energy.

48. Describe how a sending antenna is used to produce radio waves.
   A rotating device in the antenna alternately charges the upper and lower parts of the antenna positively and negatively. The charges accelerating up and down the antenna transmit electromagnetic waves.

49. What happens when a radio wave hits a receiving antenna?
   The electric charges inside the antenna vibrate in rhythm with the variations of the field.