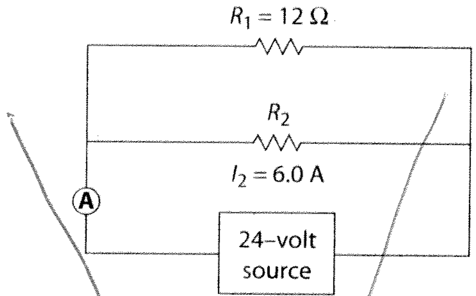
Base your answers to questions 86 through 89 on the circuit diagram below.



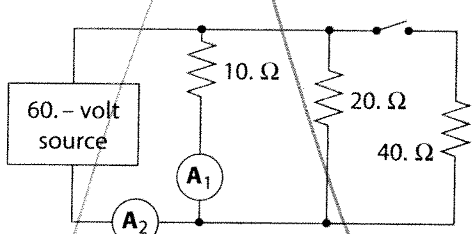
86. The current in ammeter A is (1) 1.0 A (2) 2.0 A (3) 6.0 A (4) 8.0 A

87. How much energy is used by the 12-ohm resistor in 30. minutes? (1) 48 J (2) 3.6×10^3 J (3) 1.1×10^4 J (4) 8.6×10^4 J

88. If resistance R_2 were removed, the potential difference across R_1 would (1) decrease (2) increase (3) remain the same

89. If resistance R_2 were removed, the current in ammeter A would (1) decrease (2) increase (3) remain the same

Base your answers to questions 90 through 94 on the electric circuit below. Note that the switch is in the open position.



90. What is the reading of ammeter A_1? (1) 0.16 A (2) 6.0 A (3) 60. A (4) 600 A

91. What is the reading of ammeter A_2? (1) 9.0 A (2) 2.0 A (3) 12 A (4) 18 A

92. Determine the power developed in the 10.-ohm resistor.

93. Compared to the potential drop across the 10.-ohm resistor, the potential drop across the 20.-ohm resistor is (1) less (2) greater (3) the same

94. Compared to the current through ammeter A_1 when the switch is open, the current passing through ammeter A_1 when the switch is closed is (1) less (2) greater (3) the same

Base your answers to questions 95 through 99 on the following information. An electric heater rated at 4800 watts is operated at 120 volts.

95. Determine the resistance of the heater.

96. Determine the amount of energy used by the heater in 10.0 seconds.

97. If the heater is replaced with one having a greater resistance, the amount of heat energy produced each second will (1) decrease (2) increase (3) remain the same

98. If another heater is connected in parallel with the first one and both operate at 120 volts, the current in the first heater will (1) decrease (2) increase (3) remain the same

99. If the original heater is operated at less than 120 volts, the amount of heat produced will (1) decrease (2) increase (3) remain the same

Magnetism

A **magnet** is a material in which the spinning electrons of its atoms are aligned with one another. This motion of charges relative to each other produces a **magnetic force.** Even if two magnets are at rest relative to each other, they exert magnetic force because the electrons within them are in motion. Many permanent magnets are made of an alloy of aluminum, nickel, and cobalt.

A magnet has two ends called poles, where the magnetic force is strongest. One end is called the north-seeking **magnetic pole** (N-pole), and the other end is the south-seeking magnetic pole (S-pole). No matter how many times a magnet is broken, each piece always has a north pole and a south pole. Like magnetic poles repel each other and unlike poles attract each other. **Magnetism** is the force of attraction or repulsion between magnetic poles. Unmagnetized pieces of iron and steel are readily magnetized by pulling them across a pole of a strong magnet or by having them interact with a direct current.

Earth is like a large magnet with a S-pole near the geographic North Pole (the northern end of its axis of rotation) and an N-pole near the geographic South Pole. The N-pole of a compass, a device having a magnetized needle that can spin freely, is attracted toward Earth's S-pole (geographic North Pole). Earth's magnetic field results from the motion of its molten iron and nickel core.

MAGNETIC FIELDS The region where magnetic force exists around a magnet or any moving charged object is called its **magnetic field.** Just as a gravitational or electric field allows objects to interact without coming into direct contact with each other, a magnetic field allows magnets to interact without touching. A magnetic field exerts a force on any moving charge and can be measured and detected by this effect.

MAGNETIC FLUX LINES Imaginary lines that map out the magnetic field around a magnet are known as **magnetic field lines** or **magnetic flux lines.** Iron filings sprinkled on a card and held above a magnet are often used to map a magnetic field. The filings show the effects of magnetic force in the region surrounding a magnet and produce a pattern similar to the magnetic field lines. Magnetic flux lines always form closed loops and never intersect. Concentrated lines of flux emerge from the N-pole of a magnet, curve around the magnet, and then enter the S-pole of the magnet. The direction of a magnetic field is defined as the direction in which the N-pole of a compass would point in the field. When the field lines are curved, the direction of the field is determined by the direction of the N-pole of a compass placed along the tangent to the field at that point. Figure 4-12 shows the locations of the lines of magnetic flux around some bar magnets and around a horseshoe magnet.

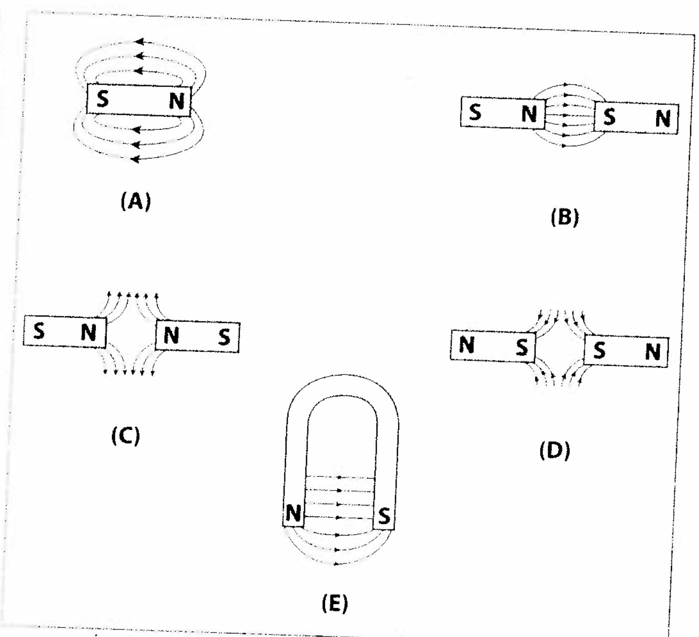


Figure 4-12. Lines of magnetic flux around some bar magnets and a horseshoe magnet

MAGNETIC FIELD STRENGTH The number of magnetic lines of flux per unit area passing through a plane perpendicular to the direction of the lines is called the **magnetic field strength,** B, or flux density. Magnetic field strength is a vector quantity, as are gravitational field strength and electric field strength. The **weber,** Wb, is a derived SI unit for measuring the number of lines of flux. The **tesla,** T, is the derived SI unit of flux density or magnetic field strength. One tesla is equal to one weber per square meter.

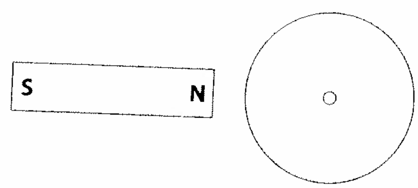
Review Questions

100. A magnetic field is produced by (1) moving electrons (2) moving neutrons (3) stationary protons (4) stationary ions

101. The presence of a uniform magnetic field may be detected by using a (1) stationary charge (2) small mass (3) beam of neutrons (4) magnetic compass

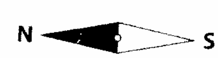
102. Which is the unit of magnetic flux in the SI system? (1) joule (2) weber (3) coulomb (4) ampere

103. The diagram below shows a compass placed near the north pole, N, of a bar magnet.



Which diagram best represents the position of the needle of a compass as it responds to the magnetic field of the bar magnet?

(1)

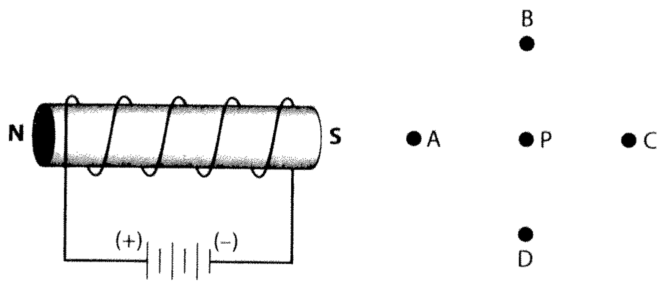


(3)

(2)

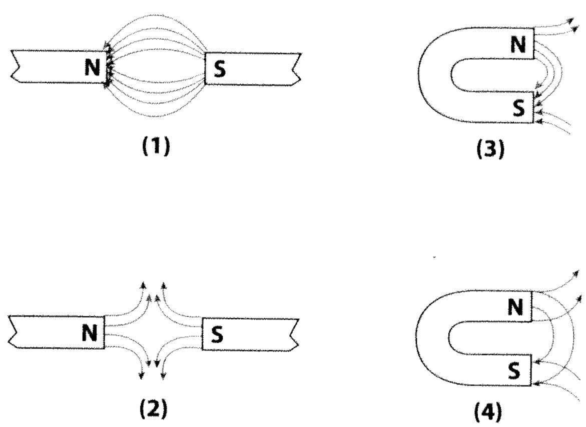
(4)

104. A coil of wire is wrapped around a piece of iron and connected to a battery. Due to the current through the coil, the iron develops a polarity as shown in the diagram below.

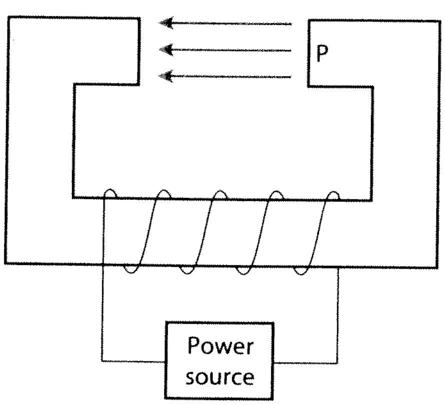


Toward which point would the north pole of a compass placed at point P point?

105. Which diagram correctly shows a magnetic field configuration?

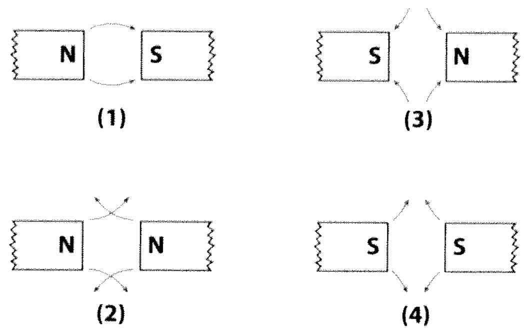


106. The diagram below shows a coil of wire connected to a power supply and wrapped around a U-shaped piece of iron. The arrows indicate the direction of the resulting magnetic field.

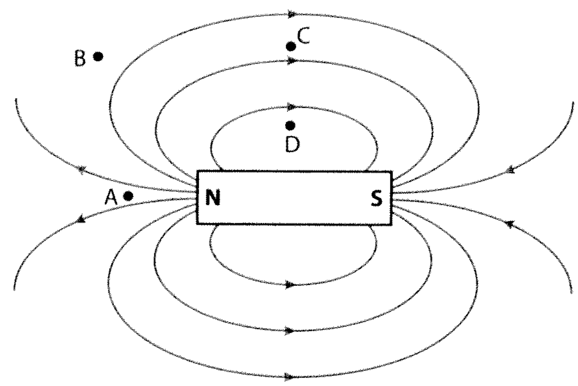


What is the polarity of P? (1) positive (2) negative (3) north (4) south

107. Which diagram best represents the lines of magnetic flux between the ends of two bar magnets?



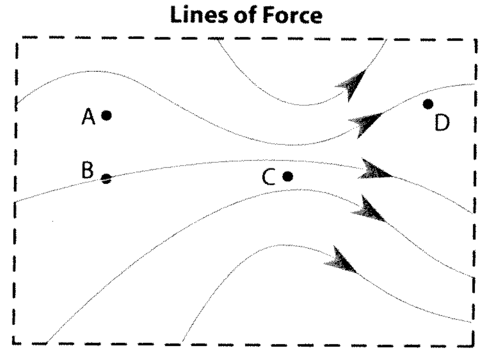
108. The diagram below represents the magnetic lines of force around a bar magnet.



At which point is the magnitude of the magnetic field strength of the bar magnet greatest?

109. The diagram below represents magnetic lines of force within a region of space.

Lines of Force



At which point is the magnetic field strongest?

Electromagnetic Induction

Electromagnetic induction is the process of generating a potential difference in a conductor due to relative motion between the conductor and a magnetic field. If the conductor "cuts" across the magnetic flux lines, a magnetic force acts on the electrons in the conductor, causing them to move from one end toward the other. This results in a difference in the amount of negative charge at each end of the conductor, in other words, a potential difference. The difference in potential created in a conductor due to its relative motion in a magnetic field is called an **induced potential difference.** Figure 4-13 shows a potential difference being induced in a conductor.

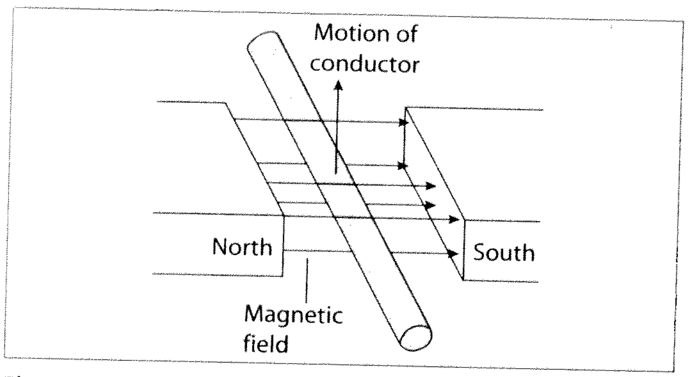


Figure 4-13. Electromagnetic induction: The diagram shows the direction of motion of a straight conductor relative to a magnetic field that produces a maximum induced potential difference in the conductor.

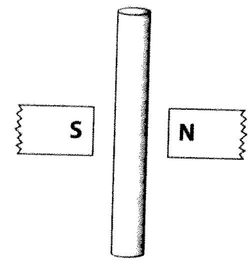
If the conductor is part of a complete circuit, an electric current is induced. If the conductor is moved parallel to the lines of flux (that is, it does not "cut" them) no potential difference is induced and there is no current, even if the conductor is part of a complete circuit.

ELECTROMAGNETIC RADIATION Oscillating or accelerating electric charges produce changing electric and magnetic fields that radiate outward into the surrounding space in the form of waves. Such a combined electric and magnetic wave is called an **electromagnetic wave**. A discussion of electromagnetic waves is included in Topic 5.

Review Questions

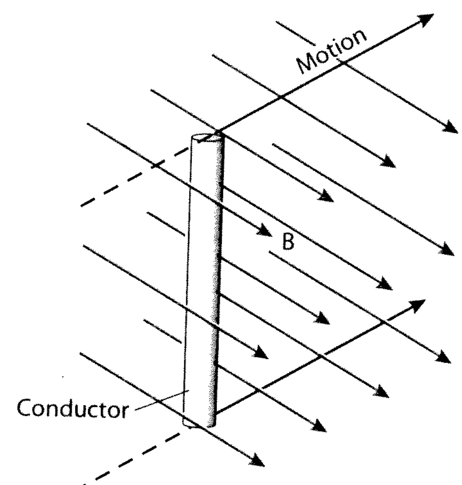
110. For which two angles between the direction of motion of a wire and a magnetic field can a potential difference be induced across the wire? (1) 0° and 45° (2) 0° and 90° (3) 45° and 90° (4) 45° and 180°

111. The diagram below represents a straight conductor between the poles of a permanent magnet.



In which direction should the wire be moved to induce a potential difference? (1) toward N (2) toward S (3) toward the top of the page (4) into the page

112. A conductor is moved perpendicularly through magnetic field B as represented in the diagram below.



What is being induced in the conductor? (1) potential difference (2) resistance (3) power (4) current