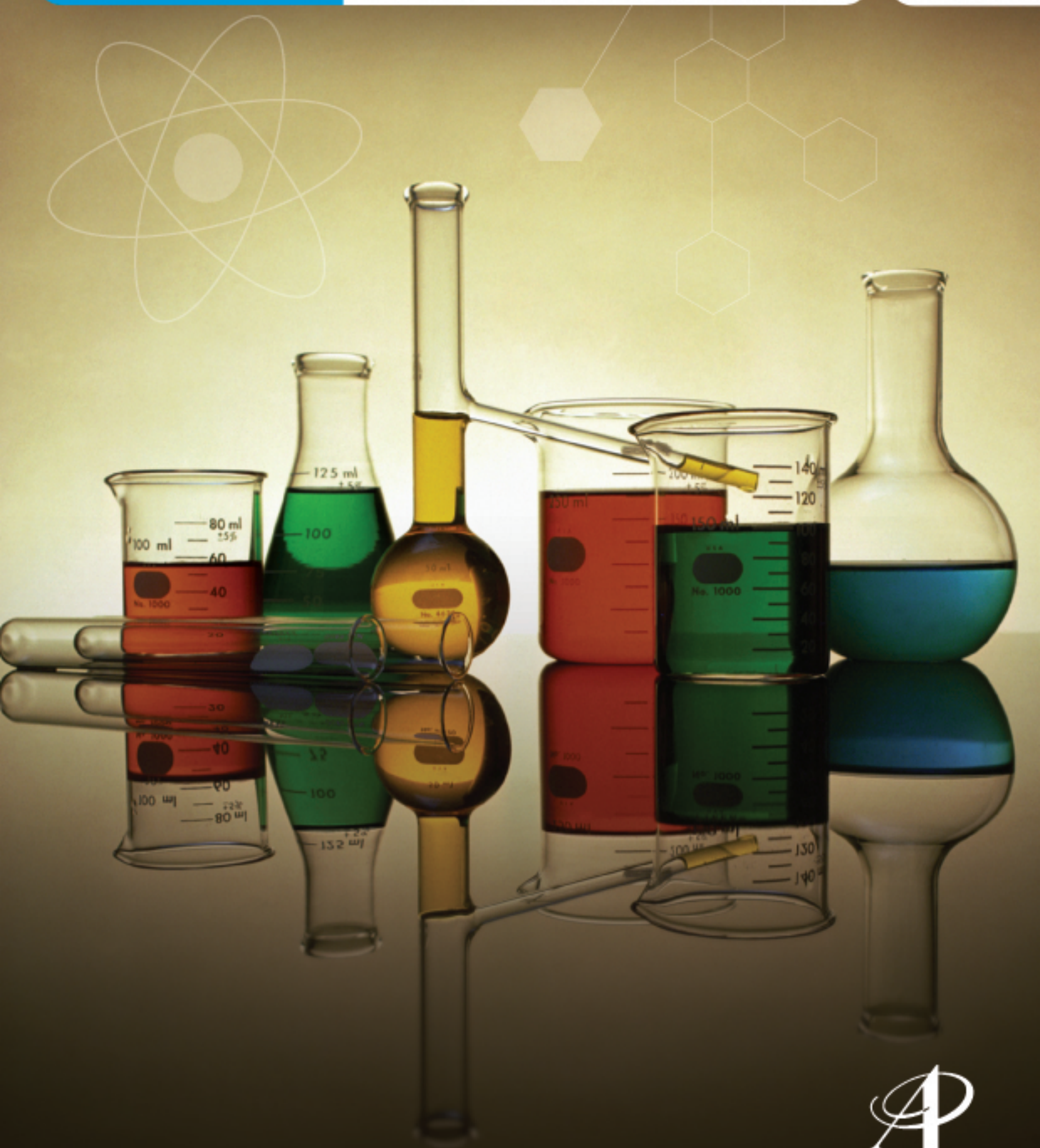
LIFEPAC®

Science



Alpha Omega Publications®

SCIENCE 1208
MAGNETISM

CONTENTS

Author: **James T. Coleman, Ph.D.**
Editor: Alan Christopherson, M.S.
Illustrations: Alpha Omega Graphics

Alpha Omega Publications®
804 N. 2nd Ave. E., Rock Rapids, IA 51246-1759

MAGNETISM

Science LIFEPAC® 1207 dealt with the nature of electric current and was the second unit on *electrophysics*: the relation of the electrical nature of matter to physical systems. Science LIFEPAC 1208 will deal with the force laws for natural and man-made magnets, and with the subject of electromagnetism.

The flow of the electrical charge is a current; when the current flows, a magnetic field is created. You will see that understanding of electromagnetism is being used daily, often without our knowledge. Electromagnetism generates the power that comes to our homes, and electromagnetic transformers send it from the generators over long distances to our homes.

The laws of electromagnetic induction are so regular that an entire power distribution system may be designed for a city, including generators and transformers; and its performance would be predictable before a single wire is connected. Such is the regularity of these electromagnetic laws.

This LIFEPAC will introduce you to the electromagnetic world that the Lord has provided. God has power-generating stations around the earth in the upper regions of the ionosphere, about 100 kilometers above the earth's surface. Above the equator the equatorial electrojet uses the tidal motion of the atmosphere to generate a 100,000 ampere current in that region. This electrojet is part of His invisible creation.

Colossians 1:16 credits God with all Creation, which certainly includes electricity. We cannot see the flow of electrons, but we can the flow's effect, including magnetism and electromagnetism.

OBJECTIVES

Read these objectives. The objectives tell you what you will be able to do when you have successfully completed this LIFEPAC.

When you have finished this LIFEPAC, you should be able to:

1. Sketch various magnetic fields.
2. Write the force law for magnetic pole interactions.
3. Describe forces on charges in magnetic fields.
4. Explain how electric and magnetic field effects interact.
5. Describe the application of electromagnetic induction.
6. Interpret electric and magnetic deflection of electron beams.
7. Explain the operating principles of a cathode ray tube (CRT).

Survey the LIFEPAC. Ask yourself some questions about this study. Write your questions here.

I. FIELDS AND FORCES

Magnetic fields are around us everywhere. The earth's magnetic field is with us wherever we go, as is the gravitational field. We are more aware of the force of gravity, without which we could not walk across the street. The forces due to a magnetic field are more subtle, and we are exposed to these every day. When we walk under electrical power lines, we are exposed to both alternating magnetic fields and the earth's magnetic field. The effects of these fields on the body are not well understood, but their effects on electrical conductors and on currents of electrical charge are well known. This section will introduce the laws for forces between **magnetic poles** (magnets), and the forces on moving electrical charges in magnetic fields.

SECTION OBJECTIVES

Review these objectives. When you have completed this section, you should be able to:

1. Sketch various magnetic fields.
2. Write the force law for magnetic pole interactions.
3. Describe forces on charges in magnetic fields.

VOCABULARY

Study these words to enhance your learning success in this section.

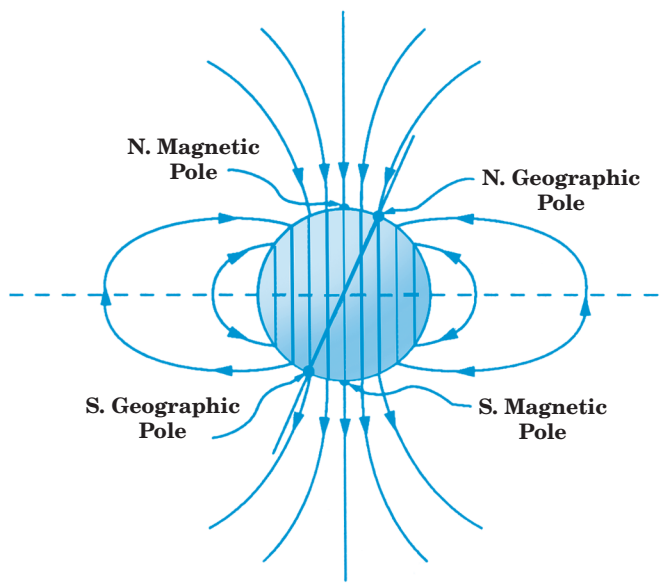
aurora borealis	ionosphere	magnetic pole
electrojet	left hand rule	solenoid
field line	magnetic field	

FIELDS

The region around a **magnetic pole** (magnet) in which a bit of iron experiences a force is called a **magnetic field**. It is the magnet's "sphere of influence." The magnetic field has direction, as defined by the force on a test north pole at any point in the field. The path followed by the test north pole describes a magnetic line of force, or a magnetic **field line**.

Magnetic fields, such as the earth's magnetic field, occur in nature and around such man-made objects as the bar magnet and the **solenoid**.

Natural fields. Magnets have been known to man since the dawn of history. They were probably first regarded with an air of mystery; later they were used as navigational tools. The earth's magnetic field is used as a direction-finding aid. Suspended magnetic needles, acting as compasses, follow the direction of the earth's field lines.



The magnetic field of the earth extends from the center of the earth, up through the oceans, and into

outer space. It influences the outer atmosphere in particular (the **ionosphere**) and has a strong influence on the flow of currents in that region. At great distances from the earth, the earth's magnetic field controls the flow of electrical currents that come from the surface of the sun. The current systems closer to the earth are called **electrojets**. One exists in the region near the North Pole and is called the *auroral electrojet*, which helps to produce the northern lights of high latitudes. Another high current system is near the equator and is called the *equatorial electrojet*. Both current systems are controlled and, to a degree, are generated by the earth's magnetic field.

An estimated 1 million amperes of current flow every night in the auroral electrojet. The Inuit depend upon the northern lights to enable them to see at night.

The northern lights (**aurora borealis**) are a marvelous display of multicolored and beautifully formed sheets of light in the sky. Currents from outer space funnel down the earth's magnetic field lines to form these beautiful displays. Thus the natural magnetic field of the earth has a profound influence on nature and the outer atmosphere. You will study this field and will discover some of its properties and attributes.

Man-made fields. A simple example of a man-made magnetic field is the bar magnet. The magnet has two poles.

The pole that points toward the earth's north pole is termed the *north-seeking pole*, or simply the *north pole*, of the magnet. If the magnet is floated in water on a piece of cork, it will again align itself with the earth's field, with its north pole pointing toward the earth's north pole. The poles behave somewhat like electric charges: Like poles repel and unlike poles attract.

The form of the magnetic field around a bar magnet will be found by experiments you will perform. The direction of the field lines can be traced and will generally be considered to "flow" from the north pole outside the magnet to the south pole. In other words, the presence of a magnetic field is sensed by a test north pole. The similarity to the case of two opposite electric charges ends at this point, because when a bar magnet is cut in half, two new smaller magnets are formed, each complete with a north pole and a south pole. A magnetic field is formed when a current flows in a wire. A compass brought near a current-carrying wire will align itself as shown in Figure 1.

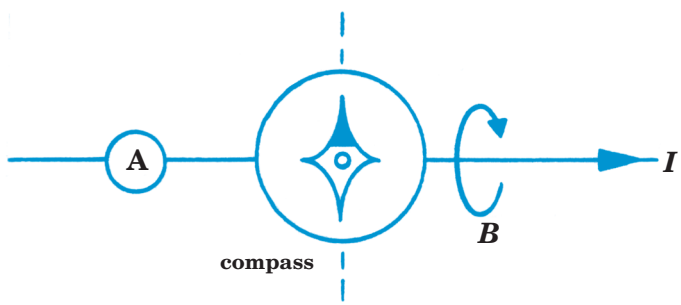
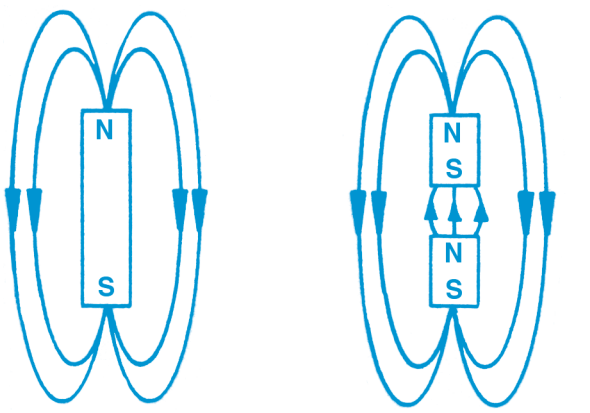


FIGURE 1

The magnetic field B will form as indicated by the compass needle's direction. The needle aligns with the magnetic field.

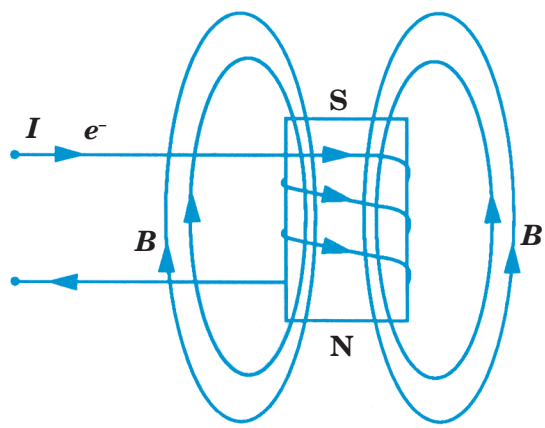
When the wire is wound into a coil, the fields around the wires add to form a *solenoid*. A solenoid is a coil of wire designed to produce a magnetic field by means of a current passed through its windings.

The field around the solenoid will be similar to the one around a bar magnet, with north and south poles as shown. This field is termed an *electromagnet*. Increasing the electric current will produce a stronger magnetic field.



a. Bar Magnet Field **b. Bar Magnet Cut in Half**

BAR MAGNET FIELDS



Choose the correct answer.

1.1 The earth's magnetic field extends _____ .

a. from the earth's surface to the upper atmosphere
b. from the center of the earth to the sun
c. from the earth's core to outer space

1.2 The earth's magnetic field captures the flow of current from _____ .

a. the moon
b. Saturn
c. the sun
d. the center of the earth

1.3 High natural currents flow above the earth's atmosphere in _____ .

a. the aurora
b. upper clouds
c. outer space
d. the asthenosphere

1.4 Two north poles will _____ .

a. attract each other
b. repel each other
c. experience neither attraction nor repulsion
d. cancel each other

1.5 A north compass needle points to the _____ .

a. north magnetic pole
b. south magnetic pole
c. north geographic pole
d. south geographic pole

1.6 The field around a solenoid is _____ .

a. similar to a bar magnet
b. unipolar
c. nonsymmetical

Try this activity to investigate the nature of magnetic fields.

These supplies are needed:

2 bar magnets
3 sheets of stiff cardboard
iron filings

Follow these directions and complete the activities. Place a check in the box after each step is completed.

❑ 1. Place the sheet of stiff cardboard over one of the bar magnets so that the cardboard is level.
❑ 2. Sprinkle the iron filings on the cardboard.
❑ 3. Tap the cardboard to help the filings align with the magnetic field lines.

1.7 Sketch the magnetic field lines or take a Polaroid™ photograph.

1.8 Indicate where the magnetic field lines appear to be concentrated.

❑ 4. Place the north pole of one magnet 1 inch from the south pole of the other magnet.
❑ 5. Place the second cardboard over the two magnets.
❑ 6. Sprinkle iron filings on the cardboard.
❑ 7. Tap the cardboard.

1.9 Sketch the field lines or take a Polaroid™ photograph.

1.10 Indicate where the magnetic field lines appear to be concentrated.