LIFEPAC® Science

Alpha Omega Publications®

SCIENCE 1206
STATIC ELECTRICITY

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STATIC ELECTRICITY

So far, you have studied topics in physics dealing with kinematics, dynamics, waves, and light. This LIFEPAC® is the first to deal with electrophysics, the relation of the electrical nature of matter to physical systems. Static electricity deals with the physical laws of the interaction of steady electric fields with charges and conductors. These steady fields produce forces on objects and currents in conductors, for example. Our present electronic age is based upon a knowledge of static electricity.

In this LIFEPAC you will study the laws that the Lord has provided in nature that permit such wonders as lightning and the aurora borealis, or northern lights. These electrical phenomena have been provided by the Master Designer. From outer space to the depths of the sea, the laws of electrical charge are at work. These areas also are under the Master Designer's control. Isaiah 30:30 speaks of lightning as "... the lighting down of his arm..."

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. Trace the conceptual development of electric charges.
2. Explain why some materials are good conductors.
3. Solve problems involving Coulomb's law.
4. Tell two ways that charges are transferred.
5. Sketch the configuration of electric fields.
6. Relate electric potential to fields and to energy.
7. Solve problems involving electric field strength.

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

I. ELECTRIC CHARGES

Gravity, magnetism, and electricity are the three forces in the universe that act without need of an intervening medium. Gravity acts across billions of kilometers of high-vacuum space to hold galaxies together. Magnetism is the weakest of the three; nevertheless, it is a significant characteristic of our planet. Electricity, both static and current, plays an integral part in all developed societies.

SECTION OBJECTIVES

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

1. Trace the conceptual development of electric charges.
2. Explain why some materials are good conductors.
3. Solve problems involving Coulomb's law.
4. Tell two ways that charges are transferred.

VOCABULARY

conductor	insulator
Coulomb's law	lightning

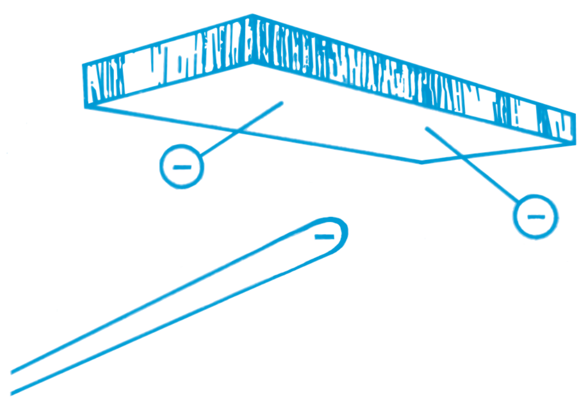
Note: All vocabulary words in this LIFEPAC appear in **boldface** print the first time they are used. If you are unsure of the meaning when you are reading, study the definitions given.

THE NATURE OF CHARGES

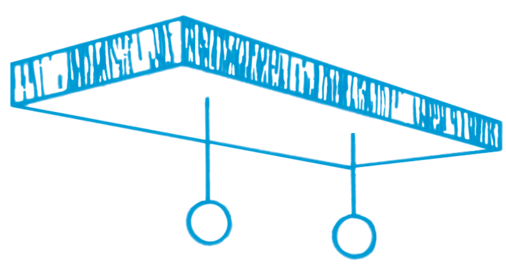
The effect produced by rubbing two nonconducting substances together was known to the Greeks. In more recent times, investigations that would be classified as scientific experiments were performed in England and the United States. A quantitative definition of electrostatic forces has been formulated.

Conceptual development. The early ideas of charge were the result of experiments carried out by William Gilbert (1540-1603), personal physician of England's Queen Elizabeth I. He noted that electric charges were produced by "rubbing a galosh against a fur coat." He also discovered that electric charges could be produced by rubbing a glass wand with a silk handkerchief. William Gilbert made the early discoveries that served as a foundation for our understanding of electrical charges. The ultimate result of these discoveries is our electronic age.

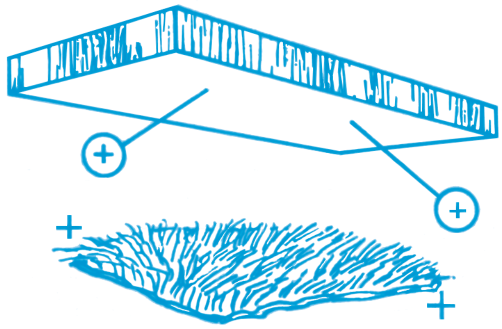
Gilbert did some simple experiments that showed the nature of electrical charges. He suspended two light spheres on threads and brought charged objects near the spheres. He rubbed a rubber wand with a piece of fur and touched the wand to the spheres. He noticed that the spheres repelled each other.



When Gilbert touched (grounded) the spheres with his hand, they returned to their normal positions.



He then rubbed the wand with the fur again, but this time he touched the fur against the spheres. They again became charged and repelled each other.



(charged)

He tried one other experiment, this time touching one sphere with the wand and the other with the fur. The result was that the spheres now attracted each other.

Gilbert concluded that the two charges must be different, and thus that charges occur in two varieties.

Gilbert performed experiments using a glass wand and a silk handkerchief and found that the effects were repeated even though the rubber wand and fur were not used. The properties of electrical charge were thus not limited to the use of the rubber and fur. Gilbert found that a glass wand produced a charge *opposite* to that produced by the rubber wand.

In the late eighteenth century, the American scientist and statesman, Benjamin Franklin, gave names to the electrical charges studied by Gilbert. Franklin called the charge from the fur and the glass rod, *positive*; and the charge on the rubber wand, *negative*. This designation is still in use today. All electrically charged bodies are either negative or positive. The early experiments, however, did not indicate the nature of an electrical charge.

You may have experienced this same process after walking across a rug and getting a shock when you touched the doorknob. The same electrical charge may build up in a clothes dryer. Some fabrics are able to separate the electrical charge into positive and negative portions. The friction of two objects rubbing against each other causes the separation of electricity into the positive and negative parts. Some objects are **insulators** and do not distribute or communicate a charge to any other part of their bodies.

Answer these questions.

1.1 Why do charges build up on clothing in an electric dryer? ______________________________

____

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1.2 Why do some types of fabric build up more charge than others?

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Choose the correct answer.

1.3 Charged spheres repel each other when _____ .

a. they are charged

b. they are charged oppositely

c. they both received the same type of charge

1.4 Charged spheres attract each other when _____ .

a. they are charged by the same object

b. they are touched after grounding

c. the air is dry

d. they are oppositely charged

Complete these sentences.

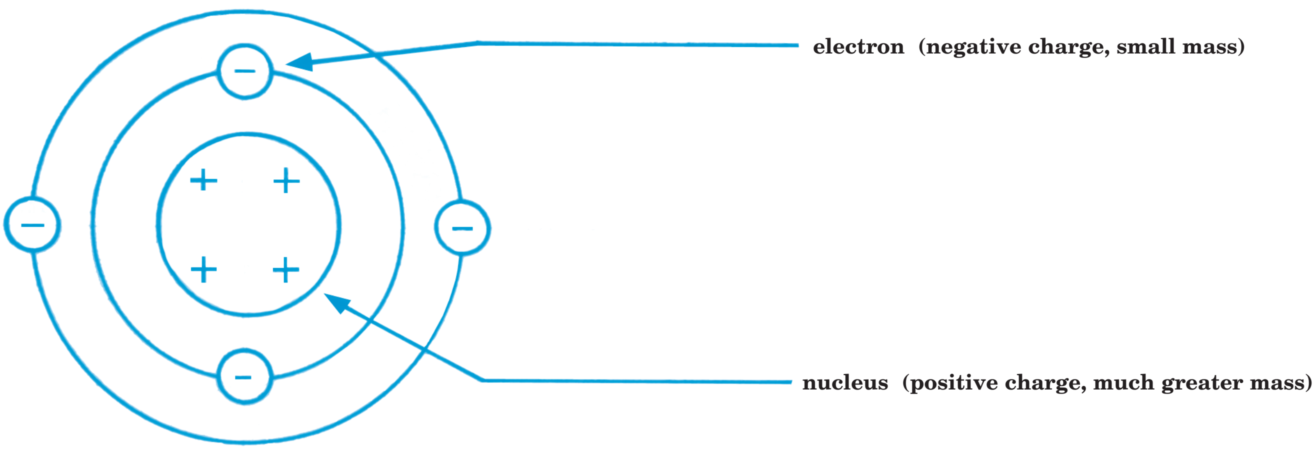
1.5 Electrical charges were named by ______________________ .

1.6 Electrical charges are of ______________________ types.

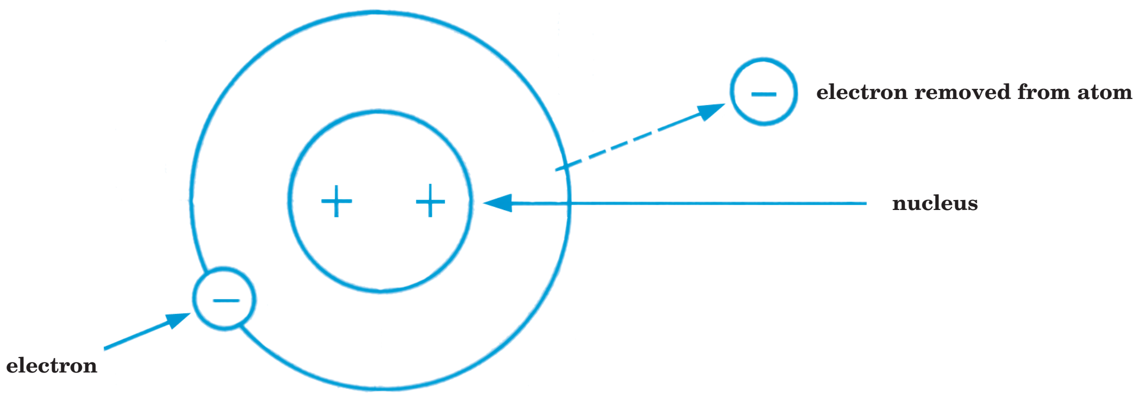
1.7 Gilbert found that a glass wand and rubber wand produce ______________________ charges.

1.8 An object may be charged either a. ______________________ or b. ______________________ .

The electron. What the early experimenters did not realize was that the basic unit of electrical charge is the tiny electron. No one has seen an electron, but we know it has the simplest form of electrical charge. Atoms consist of a positively charged nucleus and negatively charged electrons encircling the nucleus. The charges are in balance. The electrons are found in outer shells surrounding the nucleus.



Conductors have many "free" electrons in their atoms, electrons that can easily be moved away from their normal orbits. If an object has an excess of free electrons, the body is charged negatively. If electrons are removed from the atoms of a conducting material, the balance in each atom is upset. Electrons missing from the outer rings will leave the atom with a net positive charge.



If a conducting material (metal) has electrons drawn from its atoms, the charges on the nucleus of each atom are no longer balanced by the outer-orbit electrons. To make the metal positively charged requires the removal of electrons. The positive charge is thus the result of a lack of electrons in the outer shells of the atoms.

A body becomes negatively charged when electrons are added to the material. These *free electrons* can be transferred by contact. If the outer shells of the atoms all have enough electrons to give a proper balance, additional electrons are considered surplus; the conductor now has a negative charge. The negative charge is the result of a surplus of electrons in the material.