UNIT

1

ATOMIC STRUCTURE

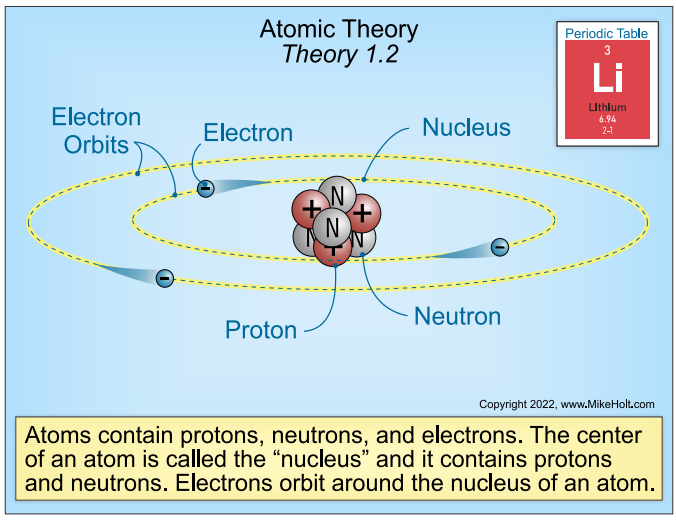
1.1 Introduction

To understand electricity, you must first understand the physics that apply to electricity. The foundation of electricity begins with the structure of an atom which includes protons, neutrons, and electrons and how they interact with each other. In this unit you will learn:

- the atomic structure of an atom
- the law of electrical charges
- about static charge and static electricity
- what lightning is and how lightning protection works

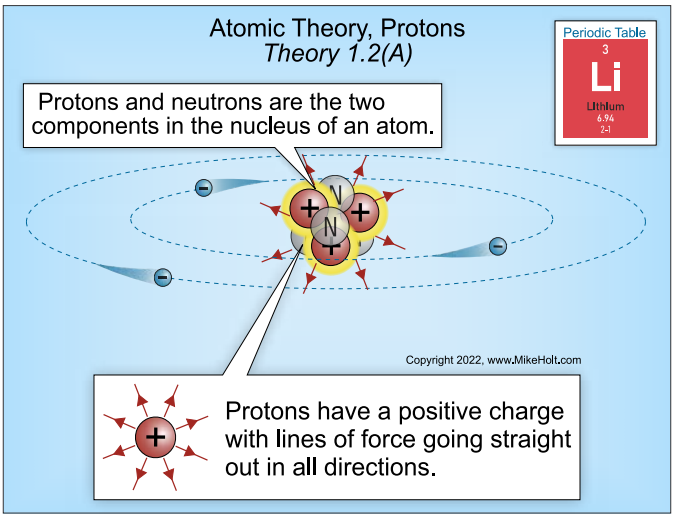
1.2 Atomic Theory

An atom contains three types of subatomic particles: protons, neutrons, and electrons. The center of an atom is called the "nucleus" and it contains protons and neutrons. Electrons orbit around the nucleus of an atom. ▸Figure 1–1



▸Figure 1–1

(A) Protons. Protons have a positive charge with lines of force going straight out in all directions. ▸Figure 1–2



▸Figure 1–2

(B) Neutrons. Neutrons have no charge and therefore no lines of force. ▸Figure 1–3

(C) Electrons. Electrons have a negative charge with lines of force going inward in all directions. Electrons are smaller than protons or neutrons and are about 1,800 times lighter. Electrons actively participate in the transfer of energy. ▸Figure 1–4

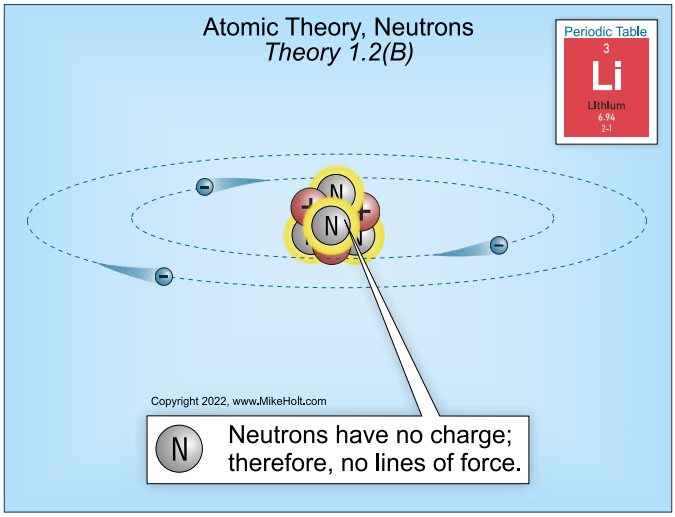


Figure 1–3

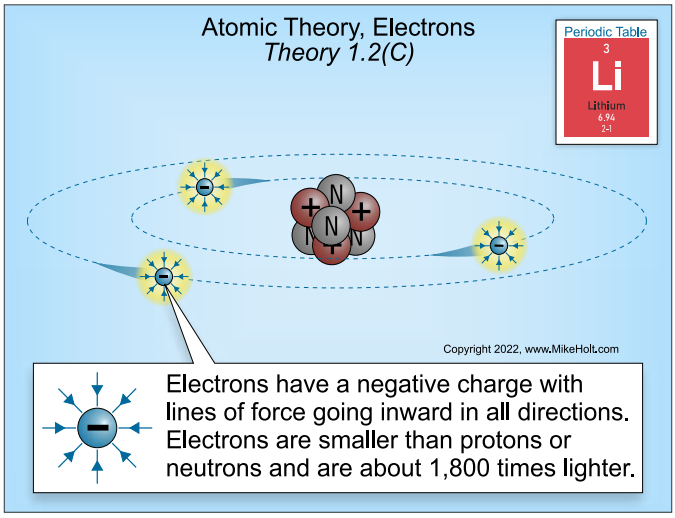


Figure 1–4

(D) Nucleus. The nucleus of an atom only contains protons and neutrons. They are about the same size, have nearly the same mass, and remain in the center of an atom. Figure 1–5

1.3 Electrostatic Field

Subatomic particles that attract or repel other subatomic particles follow Coulomb's Law which states that, "Particles with like electrostatic charges repel each other and particles with unlike electrostatic charges attract each other."

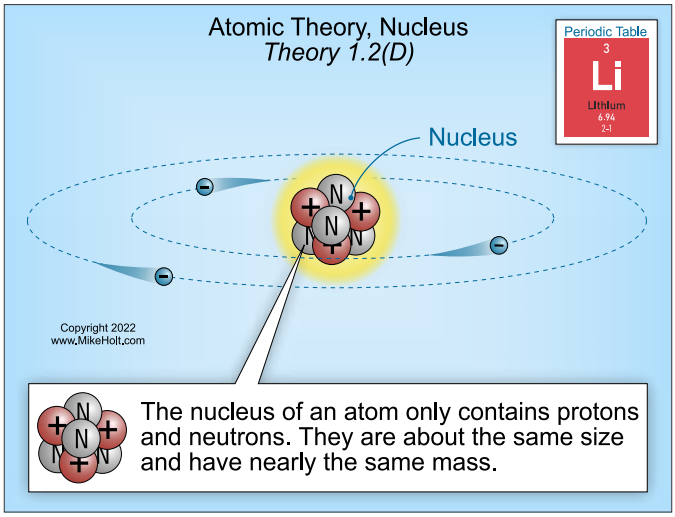


Figure 1–5

The negative charges of electrons repel the negative charges of electrons; the positive charges of protons repel the positive charges of protons; while the negative charges of electrons and the positive charges of protons attract each other. Figure 1–6, Figure 1–7, and Figure 1–8

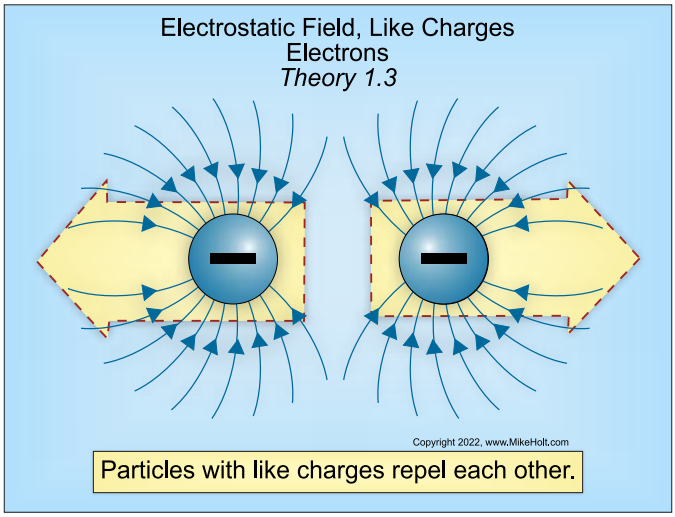


Figure 1–6

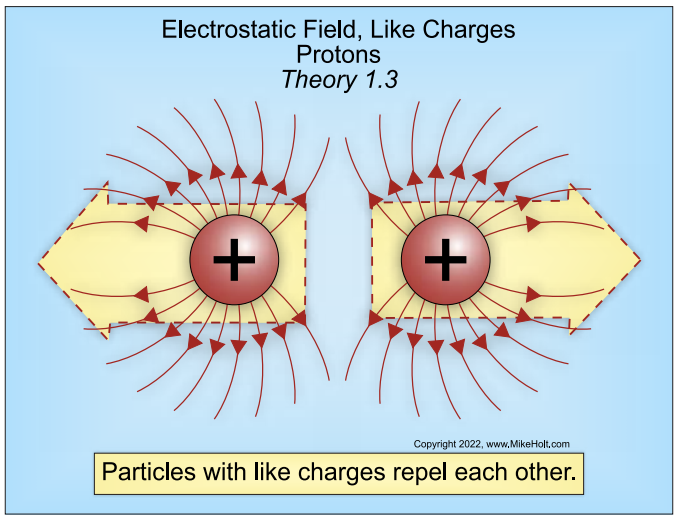


Figure 1–7

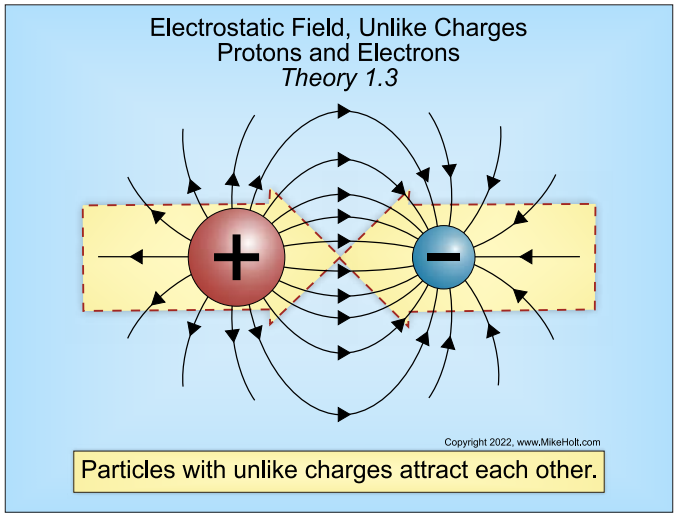


Figure 1–8

1.4 Atomic Charge of an Atom

The atomic electrostatic charge of an atom is either balanced, negative, or positive depending on the number of electrons compared to the number of protons.

(A) Balanced Atomic Charge. When an atom's charge is balanced, it means there are an equal number of positive and negative charges within the atom. Under this balanced atomic charge condition, the number of electrons is equal to the number of protons. Figure 1–9

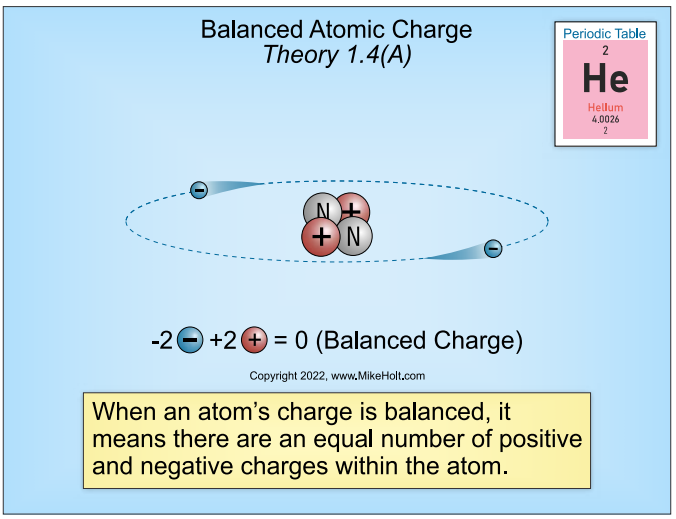


Figure 1–9

(B) Negative Atomic Charge. An atom that contains more electrons than protons has a negative charge. This happens when an atom gains an extra electron(s) in its electron cloud. Figure 1–10

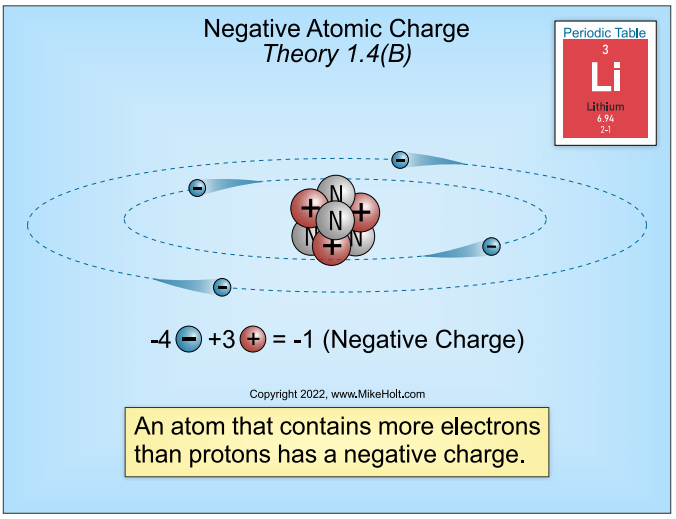


Figure 1–10

(C) Positive Atomic Charge. An atom that contains more protons than electrons has a positive charge. This happens when an atom loses an electron(s) from its electron cloud. Figure 1–11

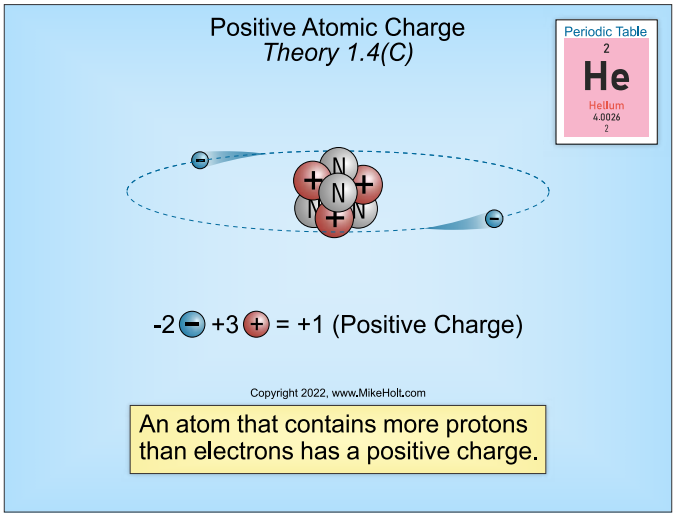


Figure 1–11

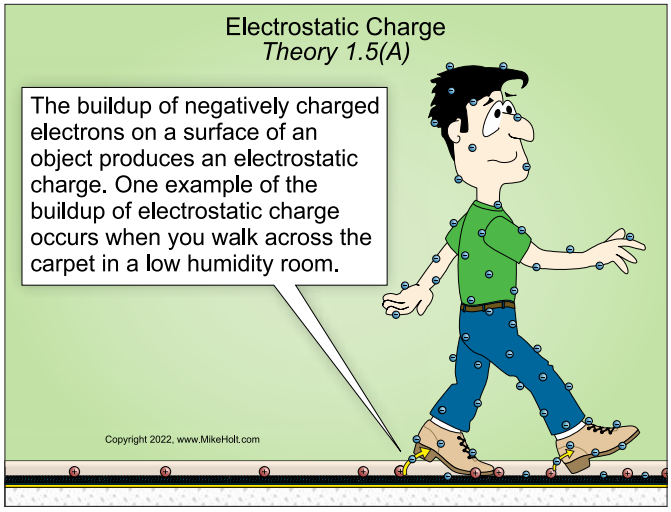


Figure 1–12

Author's Comment:

- There are a few "atomic models" that represent atomic structures; for simplicity, this material uses Bohr's model showing the electrons, protons, and neutrons.

1.5 Electrostatic Charge and Discharge

(A) Electrostatic Charge. Electrostatic charge is a condition that exists when there is an excess of, or a deficiency of, electrons between objects that have been separated. When unlike materials are in contact with each other, electrons from one material move to the surface of the other, but the protons remain on the original surface. When the objects are quickly separated, both materials display a charge because one material has an excess of electrons (negative charge), while the other has fewer electrons (positive charge).

The buildup of negatively charged electrons on a surface of an object produces an electrostatic charge. One example of this is the electrostatic charge that builds up when you walk across the carpet in a room with low humidity. Figure 1–12

(B) Electrostatic Discharge. The buildup of an electrostatic charge can be so large that it can discharge to a nearby positively charged object. The human body in a low humidity area may experience a dangerous static discharge of thousands of volts. Figure 1–13

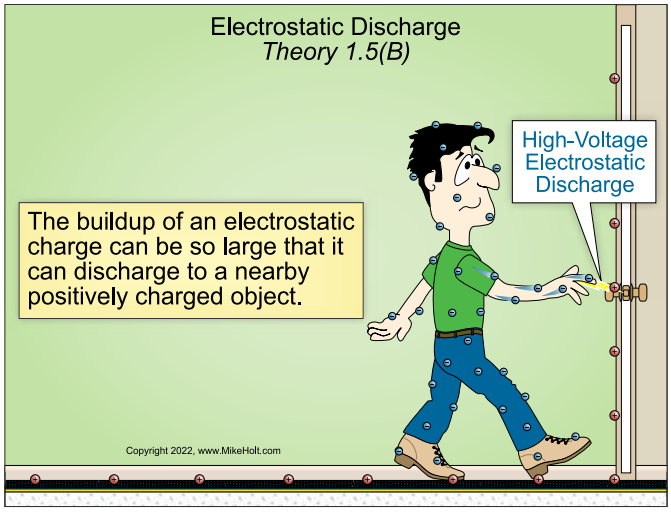


Figure 1–13

Danger

An electrostatic discharge can result in:

- ignition of flammable or explosive liquids, gases, dusts, or fibers Figure 1–14
- damage to sensitive electronic equipment
- loss of electronically stored data

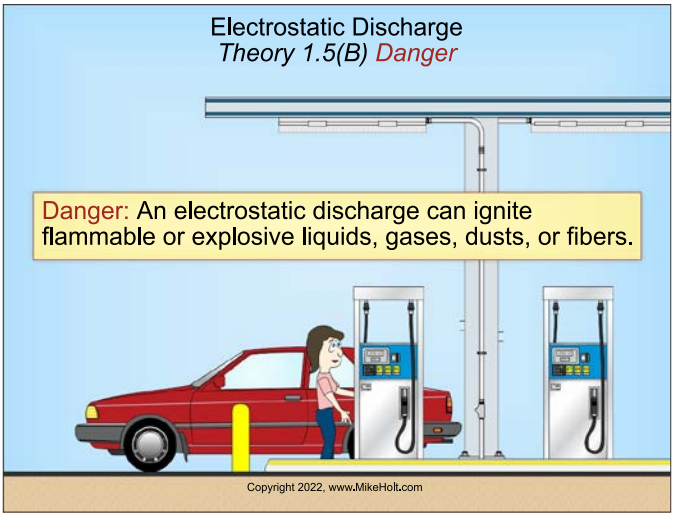


Figure 1–14

1.6 Lightning

(A) Electrostatic Charge. Lightning is the discharging of high-voltage cells of electrostatic charge within clouds to, and from, the Earth and sometimes to space. The electrostatic charge in a cloud is the result of friction caused by air movement within the cloud. Figure 1–15

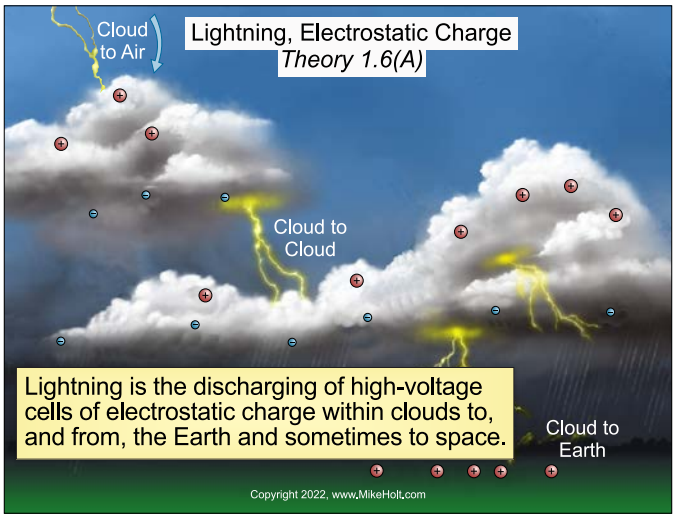


Figure 1–15

(B) Discharge. Negative electrostatic charges in clouds are attracted to positive electrostatic charges in other clouds, the Earth, or space.

(1) Step-Down Leader. As a cloud's electrostatic charge builds up, it creates an ionized path from the cloud toward the Earth; this ionized path is called a "stepped-down leader." Figure 1–16

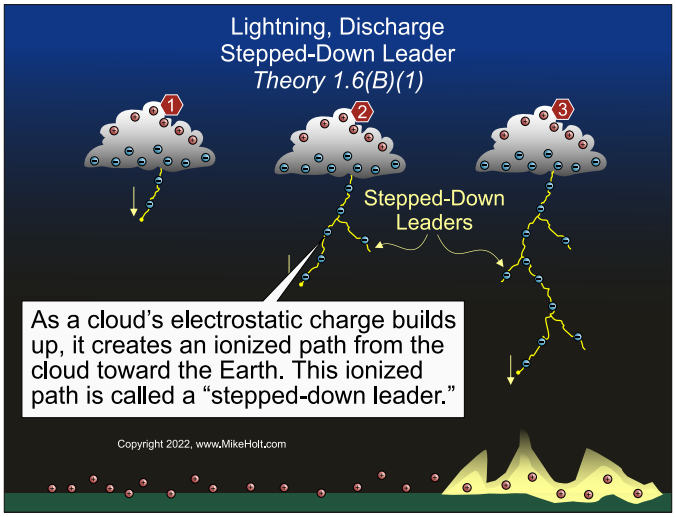


Figure 1–16

(2) Step-Up Streamer. At the same time the stepped-down leader originates, a similar ionized path called a "stepped-up streamer" rises from the Earth or other positively charged object. When the ionized path of the stepped leader and streamer connect, an electrostatic discharge or lightning strike occurs. Figure 1–17

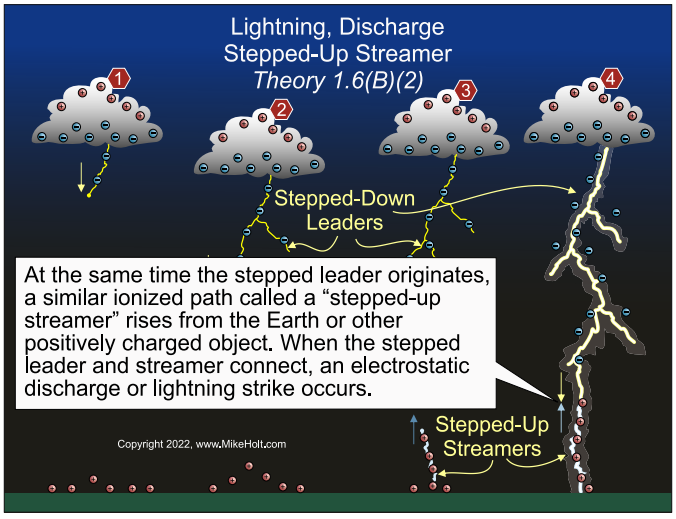


Figure 1–17

(3) Electrostatic Discharge. An electrostatic discharge (lightning strike) neutralizes the positive and negative electrostatic charges between the stepped-down leader and stepped-up streamer. Figure 1–18

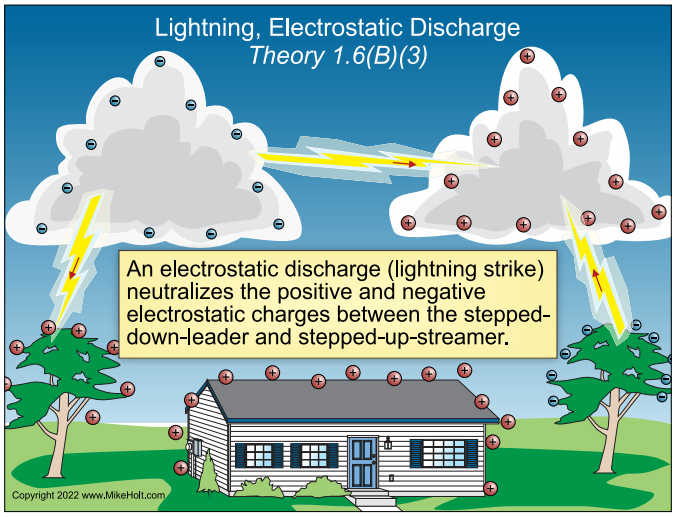


Figure 1–18

Caution

CAUTION: Lightning generally strikes a point of higher elevation such as trees, buildings, or transmission lines; however, lightning can strike an object at a lower elevation like a person in an open field.

(C) Death, Injuries, and Property Damage. Each year lightning causes deaths, injuries, and billions of dollars in property damage. When lightning strikes a nonconductive object, it will produce a high temperature at the strike point resulting in cracked concrete or the ignition of combustible materials. Figure 1–19

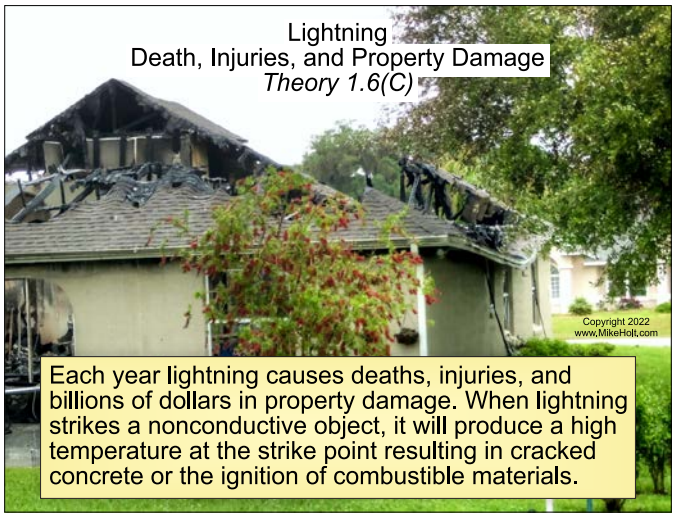


Figure 1–19

1.7 Lightning Protection System

A lightning protection system is designed to protect property and persons against a direct lightning strike. The lightning protection system intercepts a lightning strike and provides a safe path for it to discharge to the Earth.

Lightning protection systems consist of a strike termination device, called an "air terminal" or "lightning rod," placed on top of the structure to be protected. These strike termination devices are connected by large wires, and the wires are then connected to the Earth. Figure 1–20

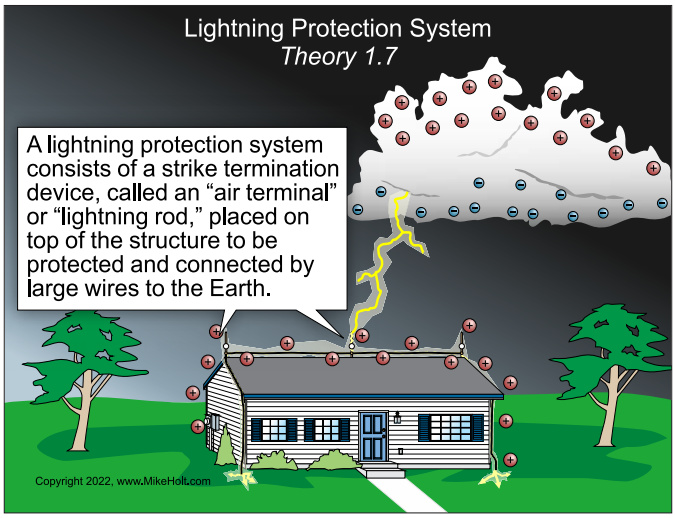


Figure 1–20

Author's Comment:

- To adequately protect property from lighting, lightning protection systems should be installed in accordance with the requirements contained in NFPA 780, *Installation of Lightning Protection Systems.*