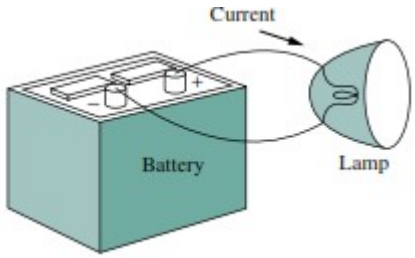
5.3 Relationship of Volts, Current and Resistance

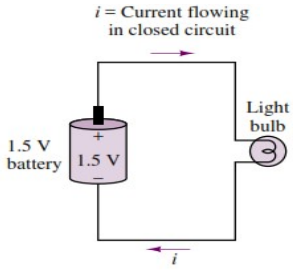
An electric circuit is an interconnection of electrical elements.
A simple electric circuit is shown in the figure below.



It consists of three basic components: a battery, a lamp, and connecting wires. Such a simple circuit can exist by itself; it has several applications, such as a torch light, a search light, and so forth.
The concept of electric charge is the underlying principle for explaining all electrical phenomena. Also, the most basic quantity in an electric circuit is the *electric charge.* We all experience the effect of electric charge when we try to remove our wool sweater and have it stick to our body or walk across a carpet and receive a shock.
Charge is an electrical property of the atomic particles of which matter consists, measured in coulombs (C).
A direct current (dc) is a current that remains constant with time.
Voltage (or potential difference) is the energy required to move a unit charge through an element, measured in volts (V).

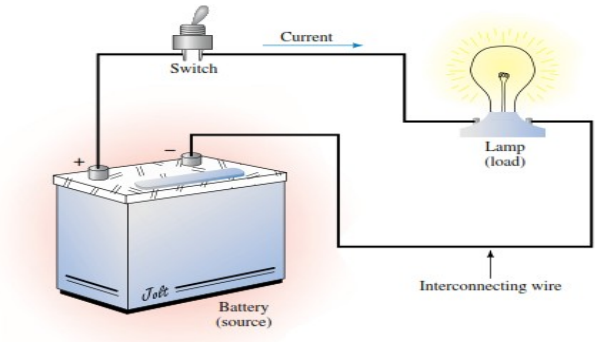
1 volt □□1 joule/coulomb □□1 newton meter/coulomb

Electric current is defined as the time rate of change of charge passing through a predetermined area.
In order for current to flow there must exist a closed circuit.



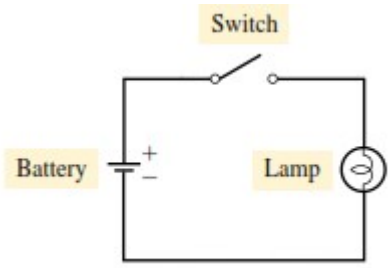
Pictorial Diagrams

Pictorial diagrams are one of the types of diagrams that provide detail.
They help you visualize circuits and their operation by showing components as they actually appear. For example, the circuit shown above consists of a battery, a switch, and an electric lamp, all interconnected by wire. Operation is easy to visualize—when the switch is closed, the battery causes current in the circuit, which lights the lamp. The battery is referred to as the source and the lamp as the load.

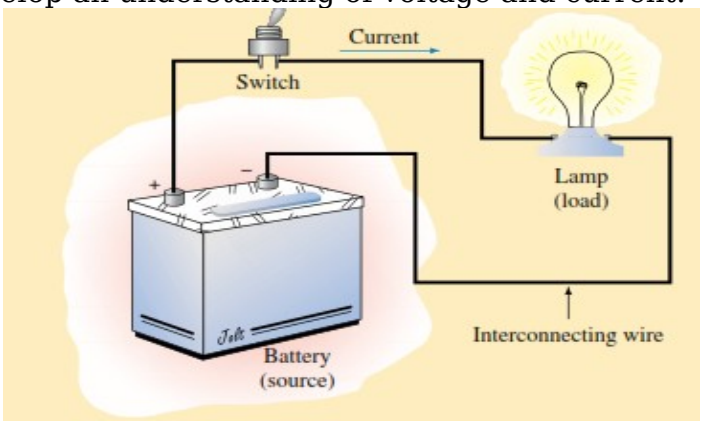


Schematic Diagrams

While pictorial diagrams help you visualize circuits, they are cumbersome to draw. **Schematic diagrams** get around this by using simplified, standard symbols to represent components;



A basic electric circuit consisting of a source of electrical energy, a switch, a load, and interconnecting wire is shown in the figure below. When the switch is closed, current in the circuit causes the light to come on. This circuit is representative of many common circuits found in practice,
including those of flashlights and automobile headlight systems. We will use it to help develop an understanding of voltage and current.



Conductors

Materials through which charges move easily are termed **conductors.** The most familiar examples are metals. Good metal conductors have large numbers of free electrons that are able to move about easily. In particular, silver, copper, gold, and aluminum are excellent conductors. Of these, copper is the most widely used. Not only is it an excellent conductor, it is inexpensive and easily formed into wire, making it suitable for a broad spectrum of applications ranging from common house wiring to sophisticated electronic equipment.

Aluminum, although it is only about 60% as good a conductor as copper, is also used, mainly in applications where light weight is important, such as in overhead power transmission lines. Silver and gold are too expensive for general use. However, gold, because it oxidizes less than other materials,
is used in specialized applications; for example, some critical electrical connectors use it because it makes a more reliable connection than other materials.

Insulators

Materials that do not conduct (e.g., glass, porcelain, plastic, rubber, and so on) are termed **insulators.** The covering on electric lamp cords, for example, is an insulator. It is used to prevent the wires from touching and to protect us from electric shock. Insulators do not conduct because they have full or nearly full valence shells and thus their electrons are tightly bound. However, when high enough voltage is applied, the force is so great that electrons are literally torn from their parent atoms, causing the insulation to break down and conduction to occur. In air, you see this as an arc or flashover. In solids, charred insulation usually results.

Semiconductors

Silicon and germanium (plus a few other materials) have half-filled valence shells and are thus neither good conductors nor good insulators. Known as **semiconductors,** they have unique electrical properties that make them important to the electronics industry. The most important material is silicon. It is used to make transistors, diodes, integrated circuits, and other electronic devices. Semiconductors have made possible personal computers, VCRs, portable CD players, calculators, and a host of other electronic products.

Definition of Voltage: The Volt

In electrical terms, a difference in potential energy is defined as **voltage.** In general, the amount of energy required to separate charges depends on the voltage developed and the amount of charge moved. By definition, *the voltage between two points is one volt if it requires one joule of energy to move one coulomb of charge from one point to the other.*

The battery is the source of electrical energy that moves charges around the circuit. This movement of charges, as we will soon see, is called an electric current. Because one of the battery's terminals is
always positive and the other is always negative, current is always in the same direction. Such a unidirectional current is called **dc** or **direct current,** and the battery is called a **dc source.**

The Ampere

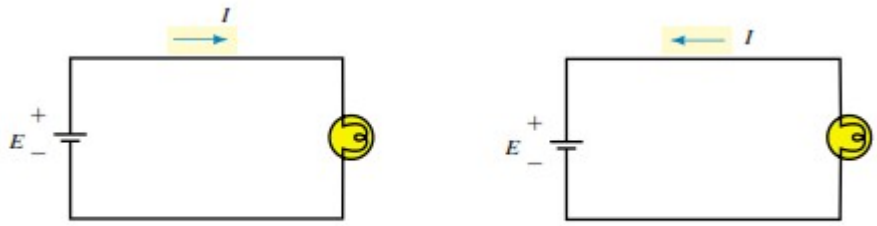
Since charge is measured in coulombs, its rate of flow is coulombs per second. In the SI system, one coulomb per second is defined as one **ampere** (commonly abbreviated A).'''

$$I = \frac{Q}{t}$$

Current Direction

In the early days of electricity, it was believed that current was a movement of positive charge and that these charges moved around the circuit from the positive terminal of the battery to the negative.

Based on this, all the laws, formulas, and symbols of circuit theory were developed. (We now refer to this direction as the **conventional current direction.**)
After the discovery of the atomic nature of matter, it was learned that what actually moves in metallic conductors are electrons and that they move through the circuit. This direction is called the **electron flow direction.**



(a) Conventional current direction (b) Electron flow direction

Batteries
Batteries are the most common dc source. They are made in a variety of shapes, sizes, and ratings, from miniaturized button batteries capable of delivering only a few microamps to large automotive batteries capable of delivering hundreds of amps. All batteries use unlike conductive electrodes immersed in an electrolyte. Chemical interaction between the electrodes and the electrolyte creates the voltage of the battery.
Primary and Secondary Batteries
Batteries eventually become "discharged." Some types of batteries, however, can be "recharged." Such batteries are called **secondary** batteries. Other types, called **primary** batteries, cannot be recharged. A familiar example of a secondary battery is the automobile battery. It can be recharged by passing current through it opposite to its discharge direction. A familiar example of a primary cell is the flashlight battery.
Activity 1
1. How much charge is represented by 4,600 electrons?
2. One sometimes hears statements such as ". . . the voltage through a resistor" or ". . . the current across a resistor." Is this statement correct?
3. Do *not* connect ammeters directly across a voltage source. Why?
4. A certain dry cell is labelled 1.5 v. What does it mean?
5. A battery is marked with 25 Ampere – hour, what does it mean?