Lecture 1

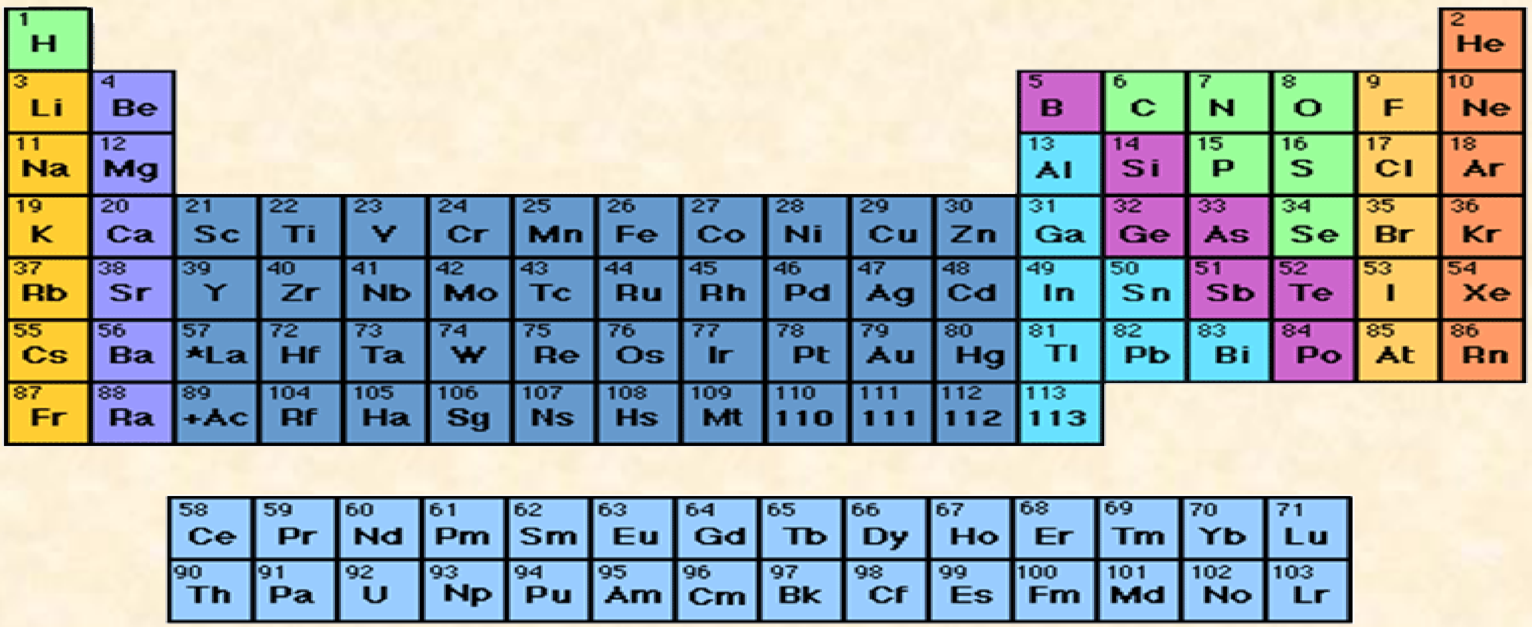
Electrical Basics

Introduction to Electricity

Electricity at the Atomic Level

Elements

The simplest form of matter



Atoms

Smallest piece of an element containing all of the properties of that element

Electricity at the Atomic Level

Components of an Atom

Nucleus

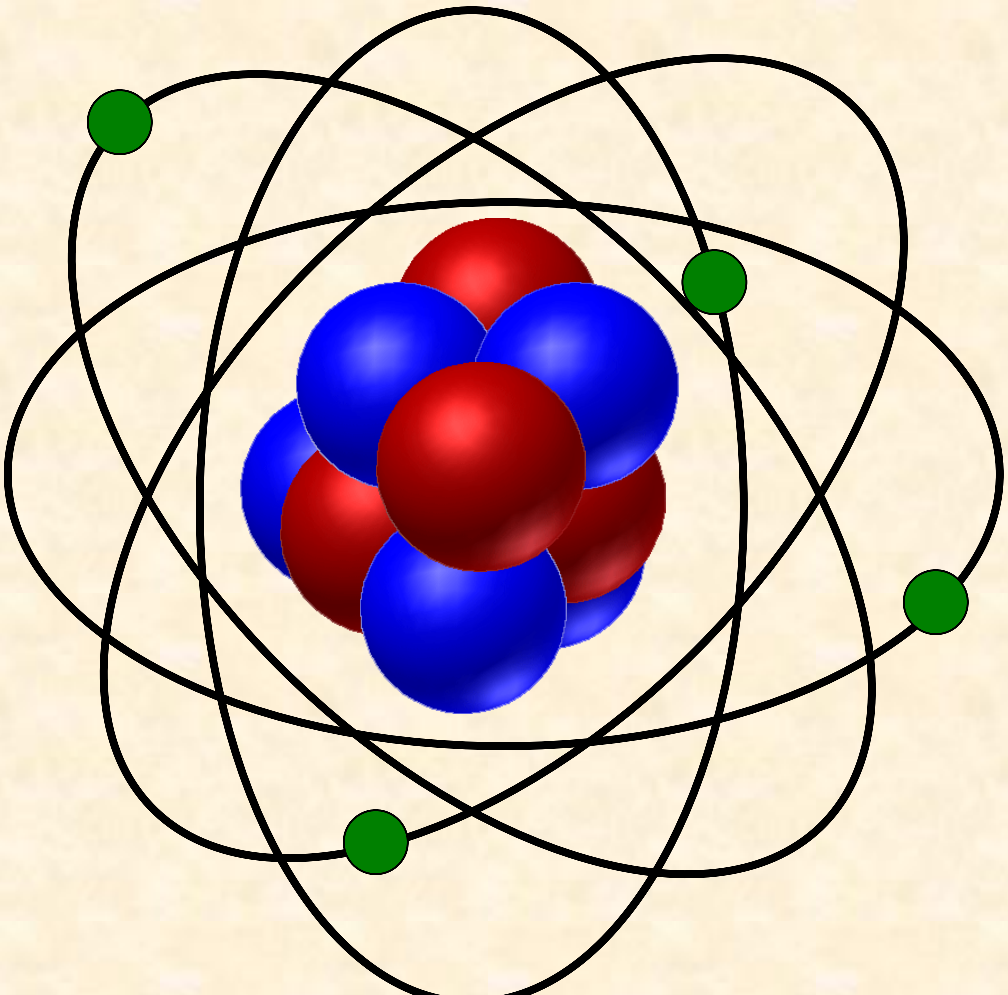
The center portion of an atom containing the protons and neutrons

Protons

Positively charged atomic particles

Neutrons

Uncharged atomic particles



Electricity at the Atomic Level

Everything is made of atoms which contain **POSITIVE** particles called **PROTONS** and **NEGATIVE** particles called **ELECTRONS**.

Electrons

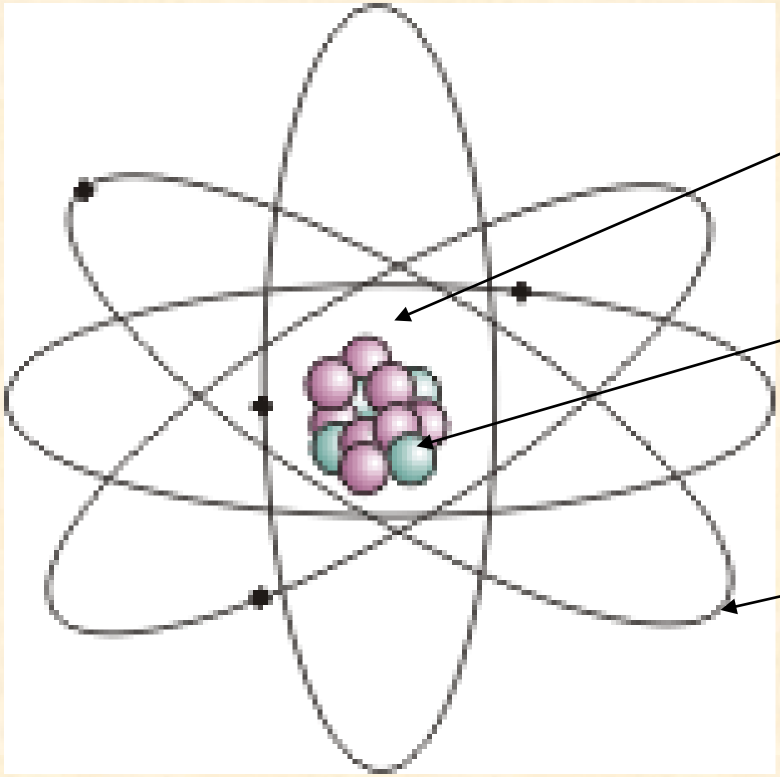
Negatively charged particles

Electron Orbitals

Orbits in which electrons move around the nucleus of an atom

Valence Electrons

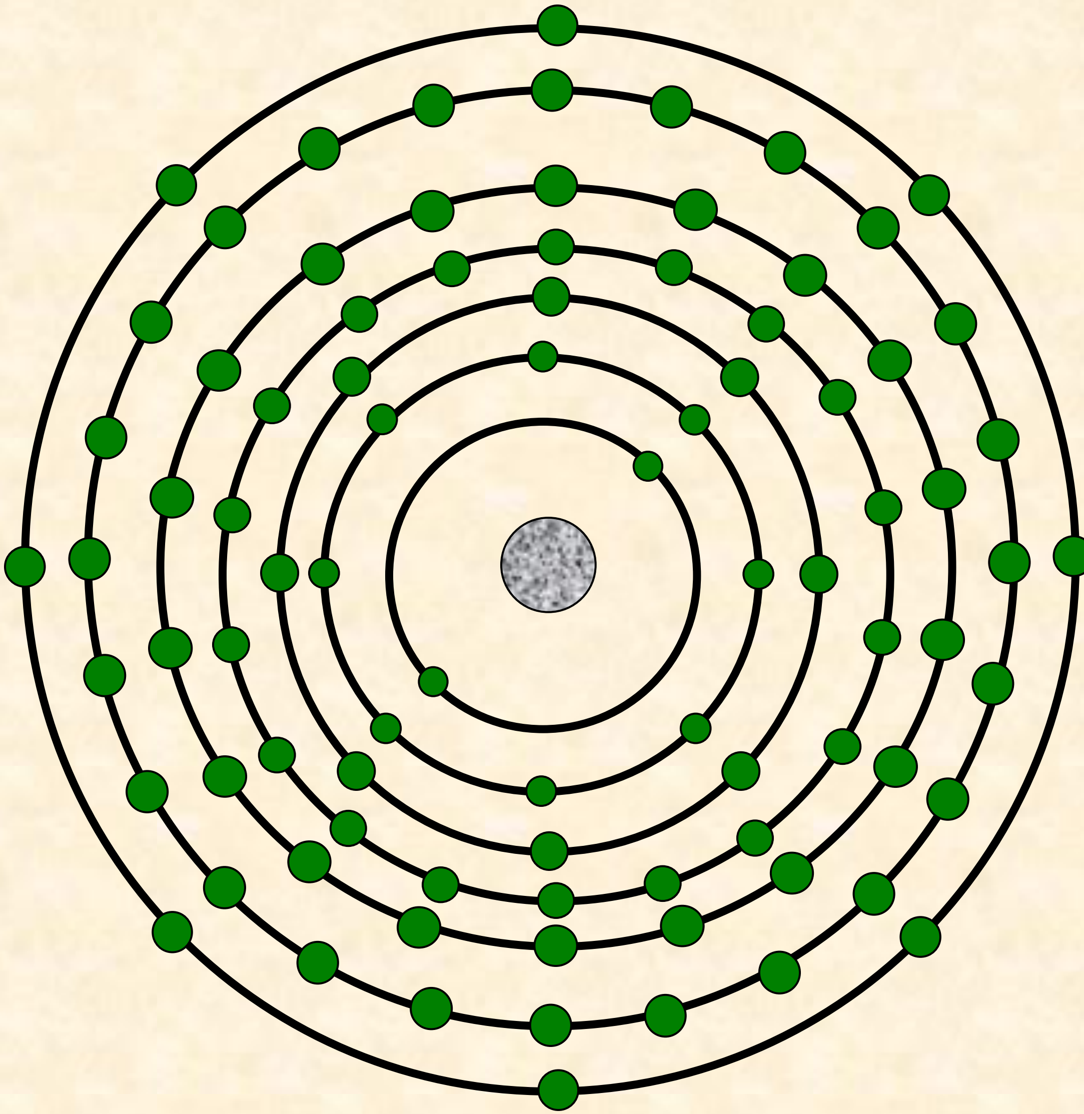
The outermost ring of electrons in an atom



Electricity at the Atomic Level

Electron Orbits

Orbit Number	Maximum Electrons
1	2
2	8
3	18
4	32
5	50
6	72
Valence Orbit	8



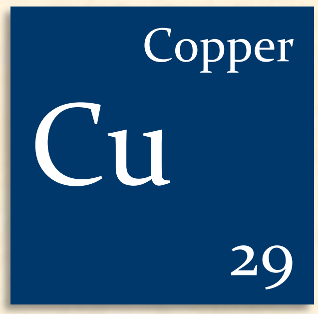
Orbits closest to the nucleus fill first

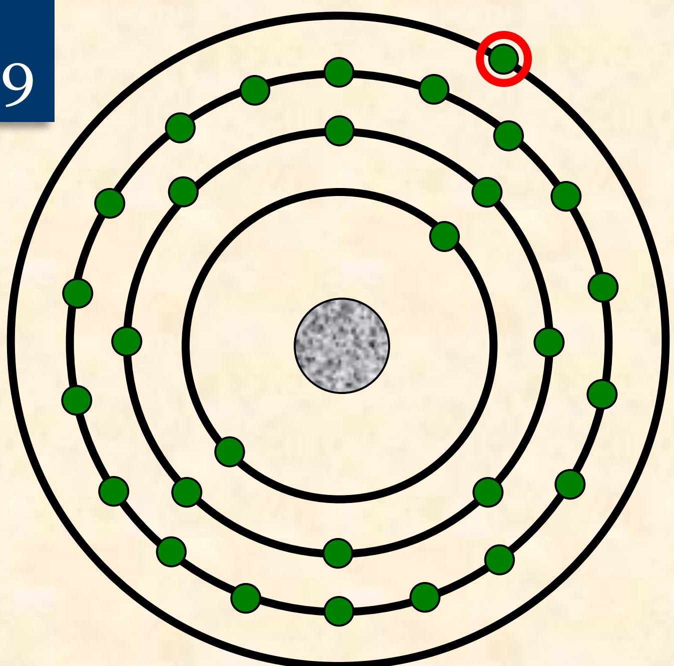
Electricity at the Atomic Level

Electron Orbits

Atoms like to have their valence ring either filled (8) or empty(0) of electrons.

How many electrons are in the valence orbit? 1

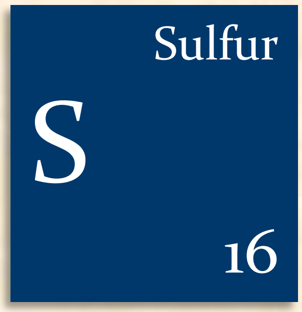


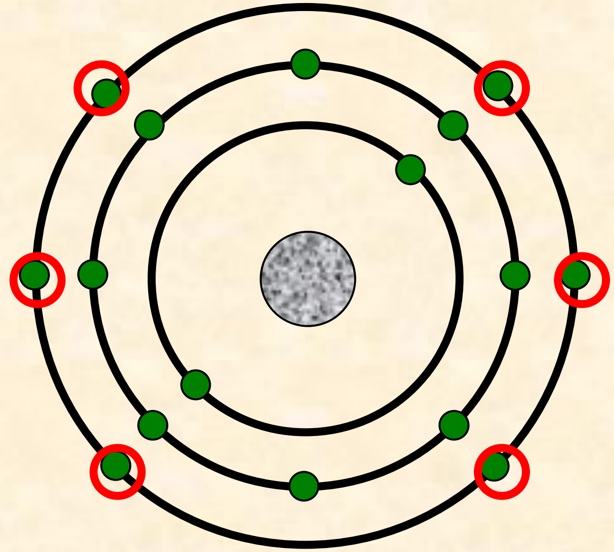


copper is a conductor

Electricity at the Atomic Level

Electron Orbits





How many electrons are in the valence orbit?

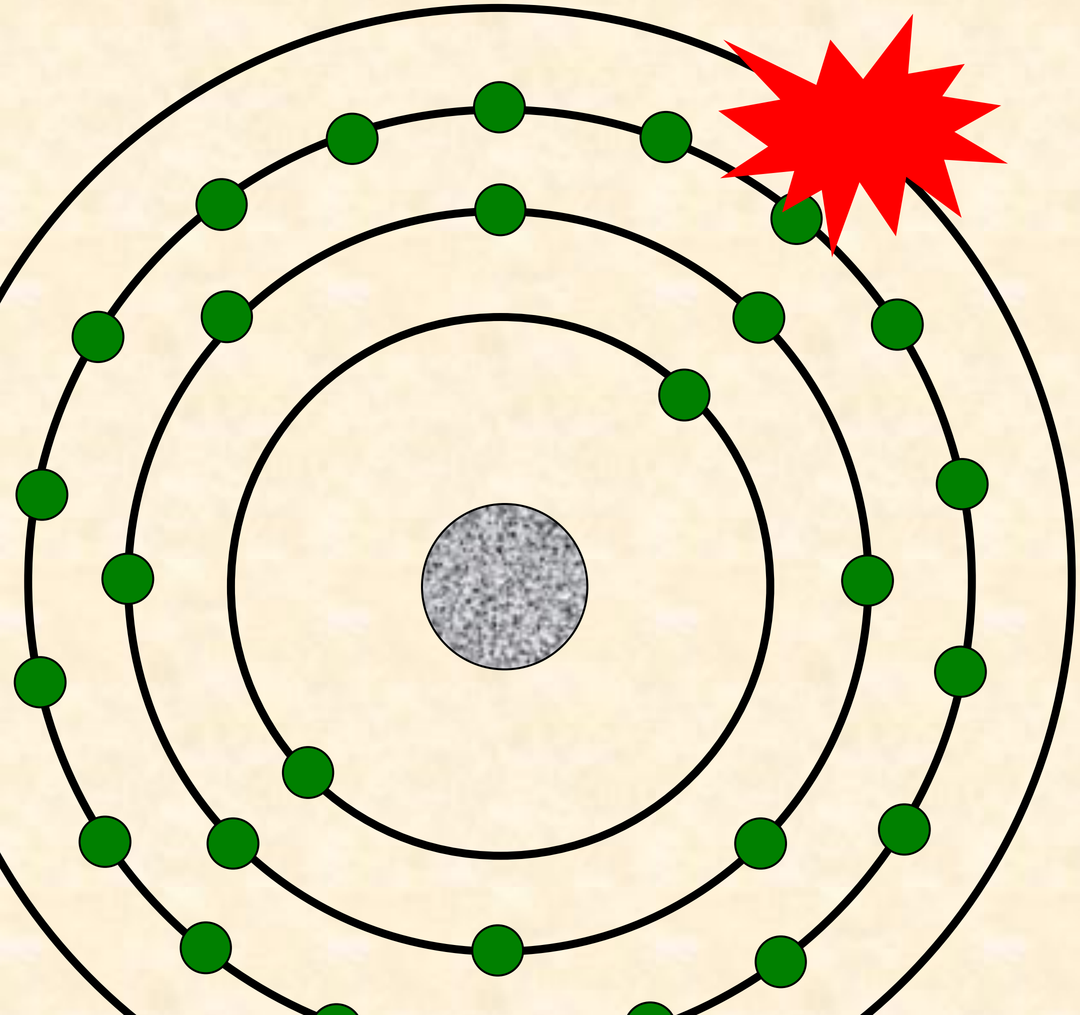
6

Sulfur is a insulator

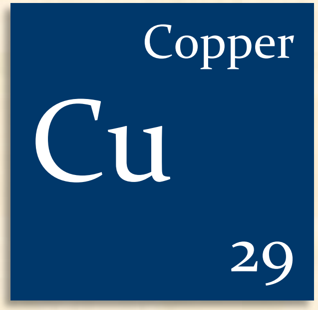
Electricity at the Atomic Level

Electron Flow

An electron from one orbit can knock out an electron from another orbit.



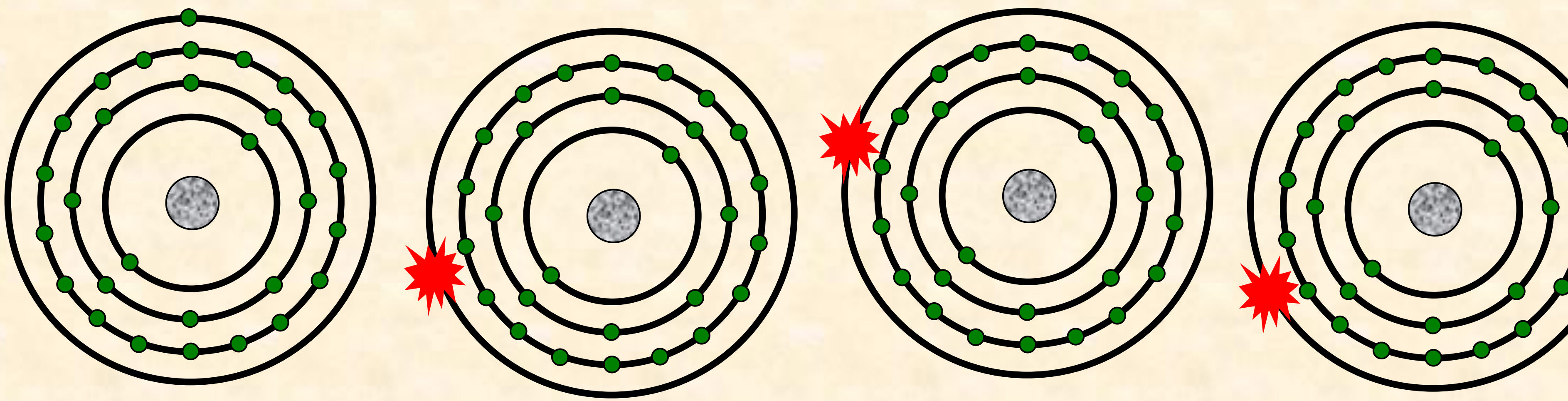
When an atom loses an electron, it seeks another to fill the vacancy.



Electricity at the Atomic Level

Electron Flow

Electricity is created as electrons collide and transfer from atom to atom.



Electricity at the Atomic Level

Conductors and Insulators

Conductors	Insulators
Electrons flow easily between atoms	Electron flow is difficult between atoms
1-3 valence electrons in outer orbit	5-8 valence electrons in outer orbit
Examples: Silver, Copper, Gold, Aluminum	Examples: Mica, Glass, Quartz

Introduction to Electricity

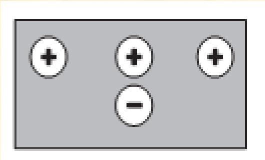
Electrical Charge

Electric charge is the basic physical property of matter that causes it to experience a force when kept in an electric or magnetic field. An electric charge is associated with an electric field and the moving electric charge generates a magnetic field.

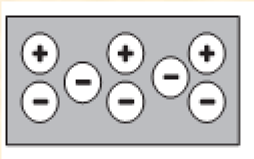
Atoms are composed of charge carrying particles: electrons (-) and protons (+), and neutral particles, neutrons.

basic types of charges

Positive charges



Negative charges



Unit of electrical charge Coulomb (C)

Symbol of electrical charge (q)

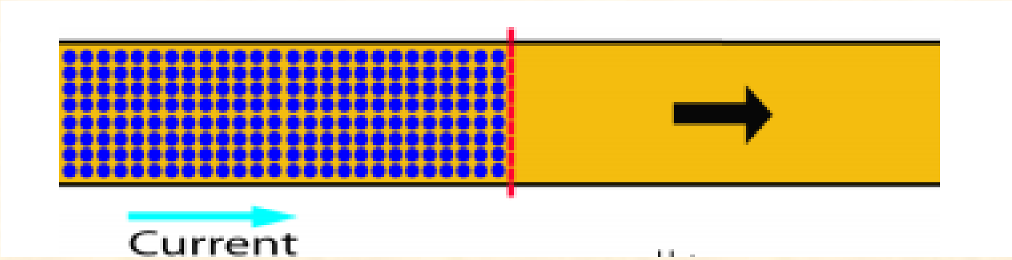
Charge in an electron:

$$q_e = -1.602 \times 10^{-19}\ C$$

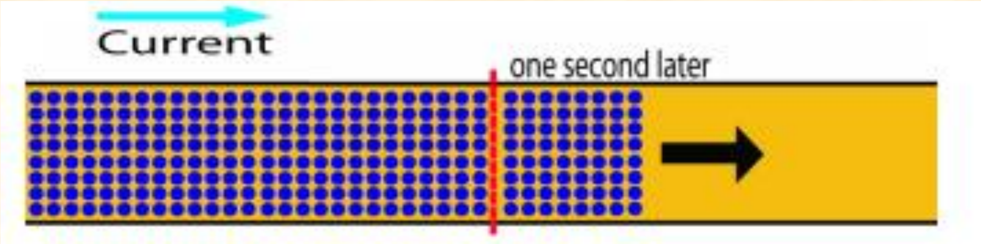
Introduction to Electricity

Electrical Current

Current is amount of electric charge passing a point in an electric circuit per unit time



Current is a rate of free electrons in a conductor from one atom to the next atom in the same general direction.

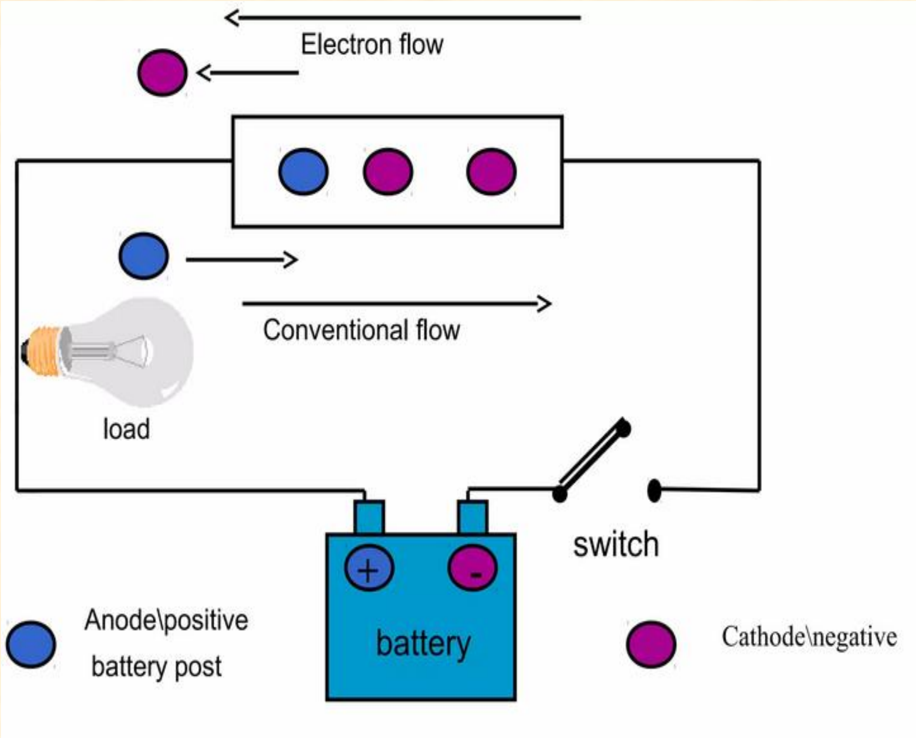


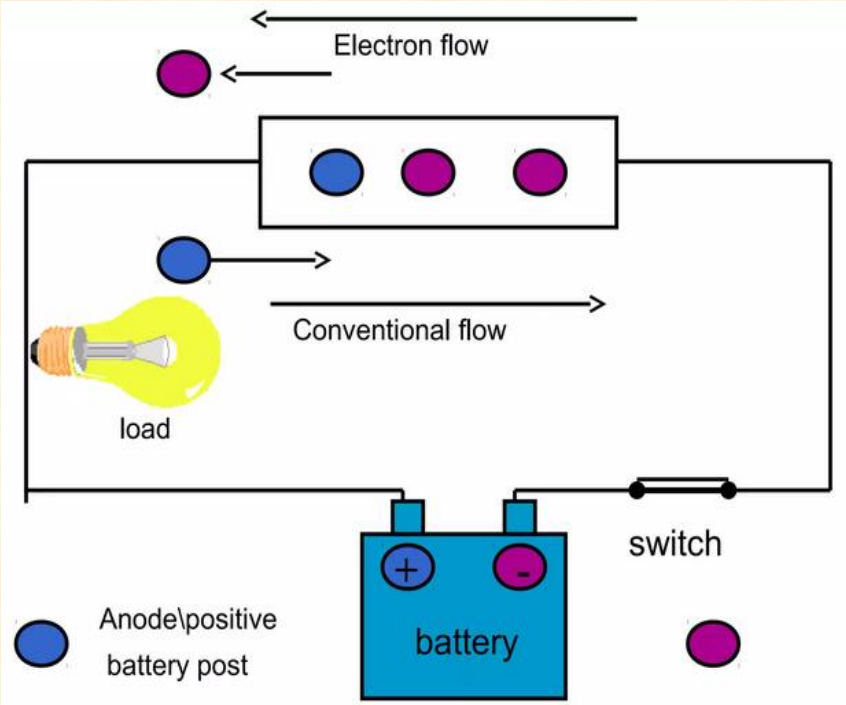
Unit of electrical Current Ampere

Symbol of electrical Current (I)

Introduction to Electricity

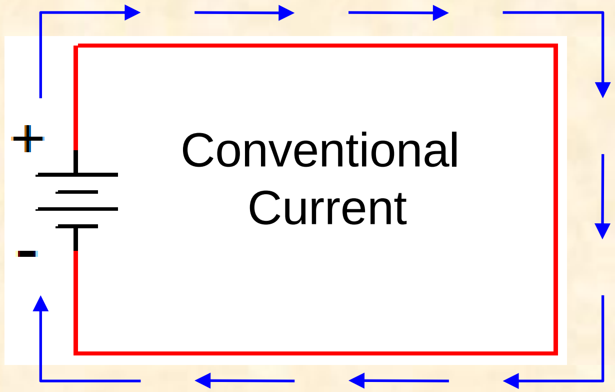
Direction of Flow



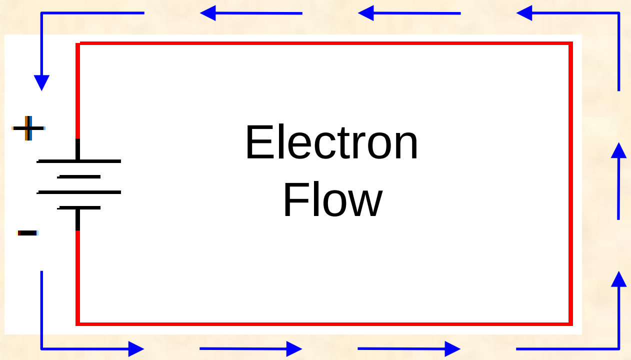


Introduction to Electricity

Conventional Current assumes that current flows out of the positive side of the battery, through the circuit, and back to the negative side of the battery. This was the convention established when electricity was first discovered, but it is incorrect!



Electron Flow is what actually happens. The electrons flow out of the negative side of the battery, through the circuit, and back to the positive side of the battery.



Introduction to Electricity

Essentially, flow of electrons in an electric circuit leads to the establishment of current.

$$I\,(t) = \frac{dq}{dt}$$

i = current in amperes

q = charge in coulombs

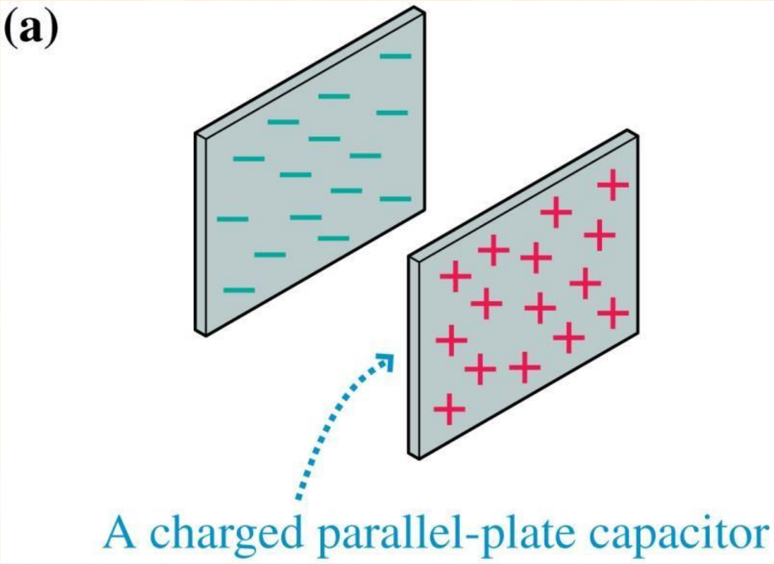
t = time in sec

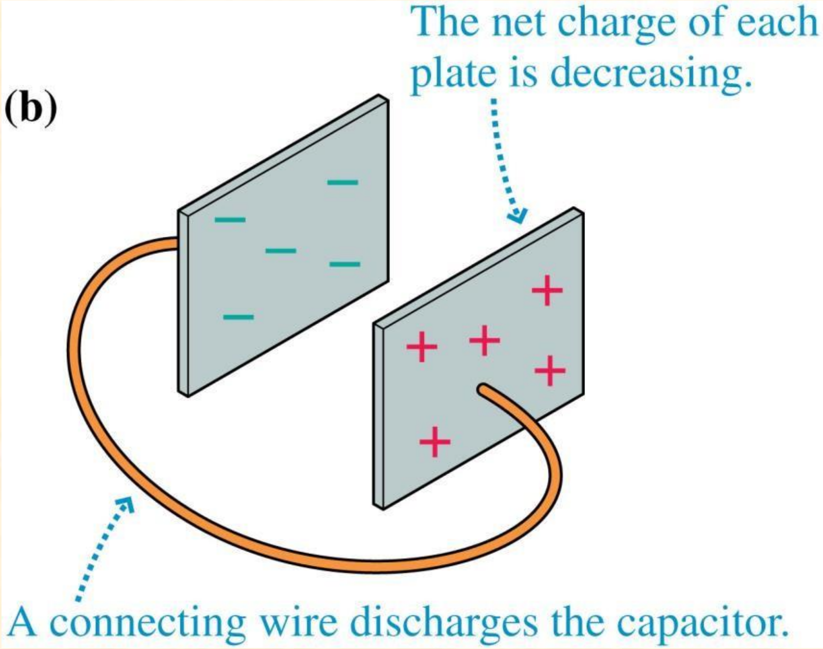
Unit of electric current: the ampere, A.

1 Ampere = 1 Coulomb per second (C/s)

A Model of a Current

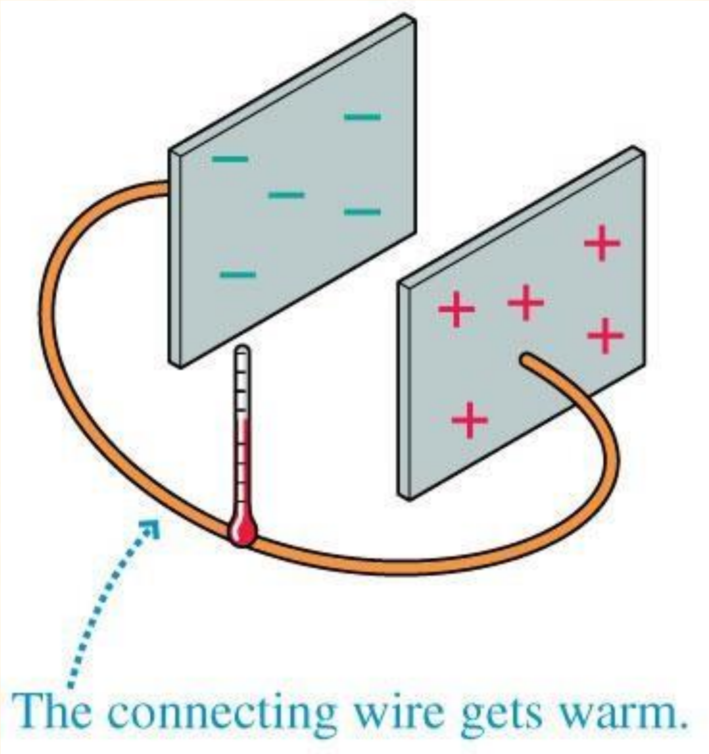
- If we connect the two capacitor plates of a parallel-plate capacitor with a metal wire, the plates become neutral. The capacitor has been *discharged.*





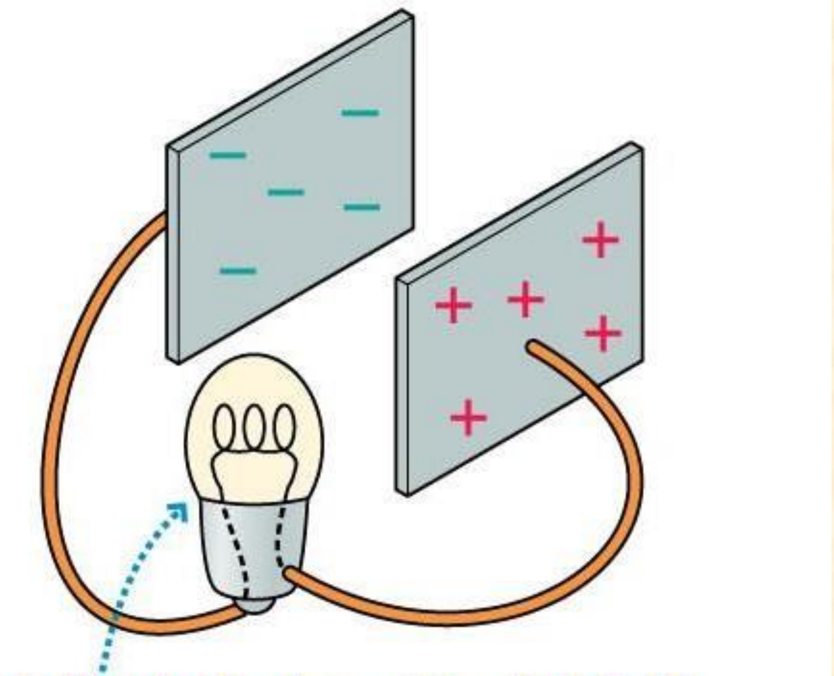
A Model of a Current

- The motion of charges through a material is called a *current*.
- If we observe a capacitor discharge, we see other effects. As the capacitor discharges, the connecting wire gets warmer.



A Model of a Current

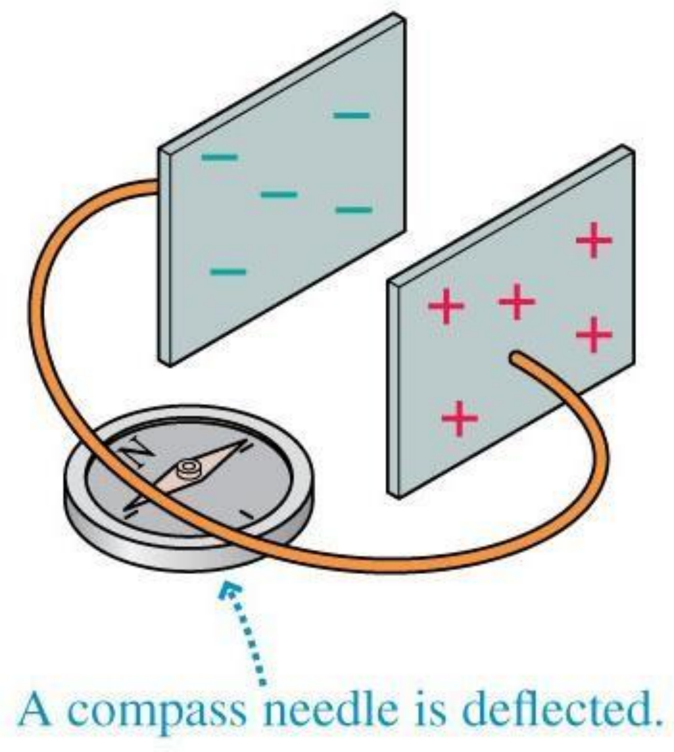
- As the capacitor discharges, if the wire is very thin in places like the filament of a lightbulb, the wire gets hot enough to glow.
- **More current means a brighter bulb.**



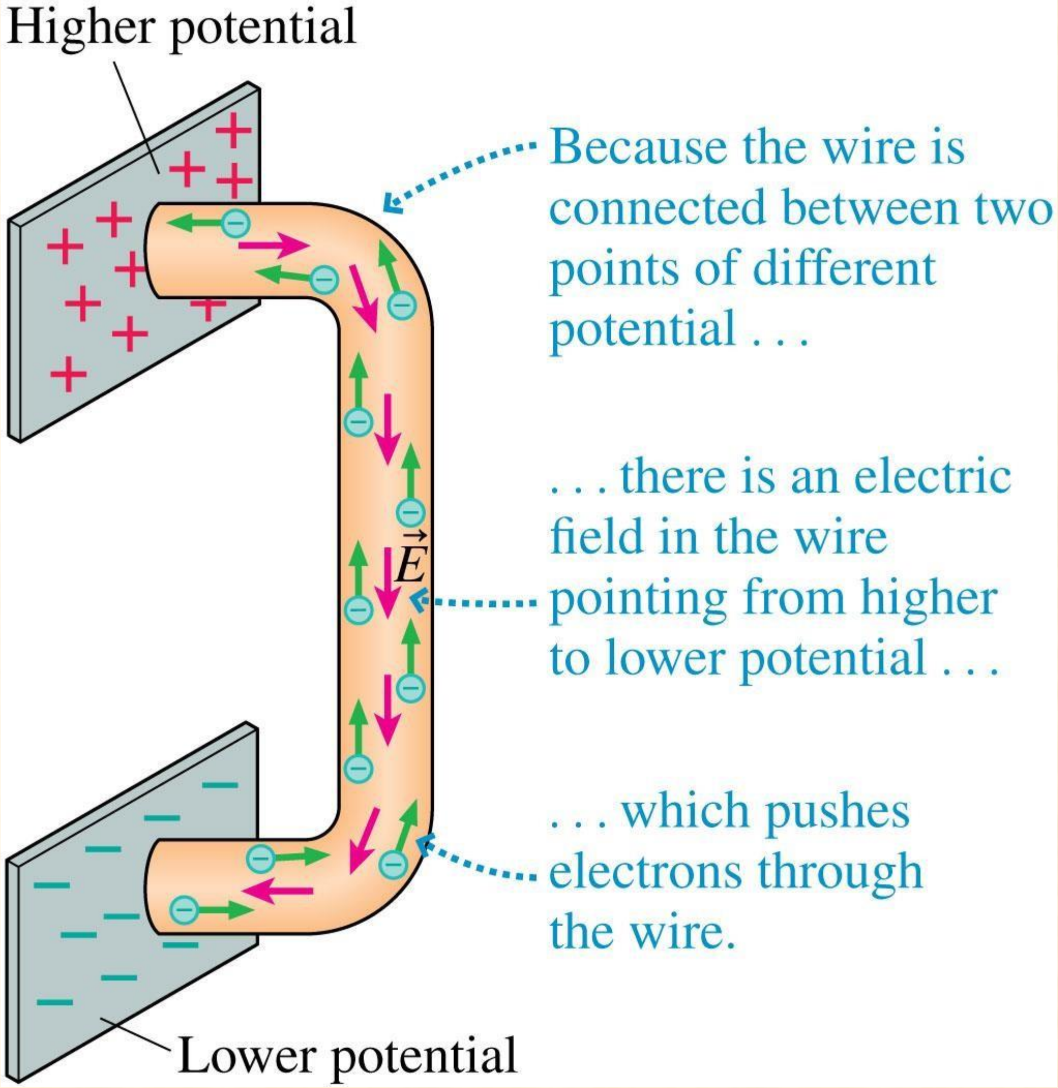
A lightbulb glows. The lightbulb filament is part of the connecting wire.

A Model of a Current

- As the capacitor discharges, the current-carrying wire deflects a compass needle.

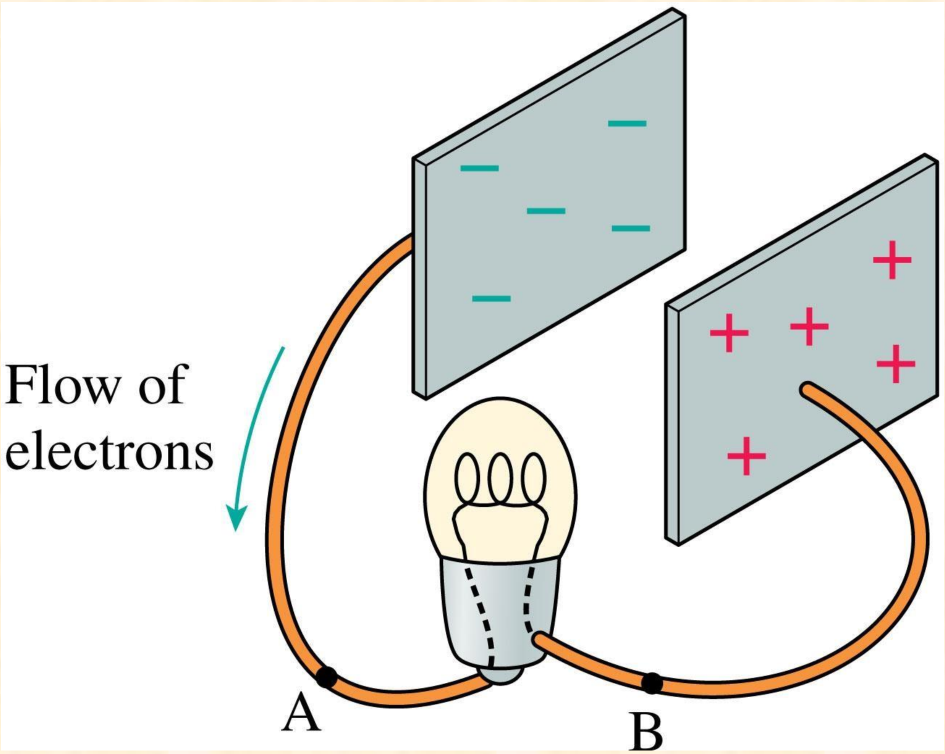


Creating a Current



Creating a Current

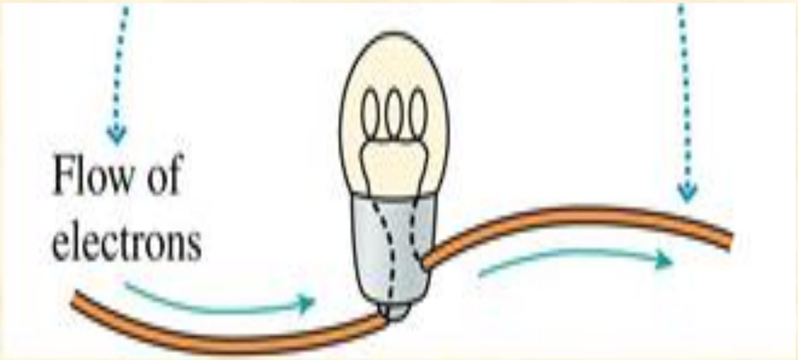
- The current at point B is *exactly equal* to the current at point A.
- **The current leaving a lightbulb is exactly the same as the current entering the lightbulb.**



Creating a Current

- The lightbulb cannot destroy electrons without violating the law of conservation of mass and the law of conservation of charge. Thus, the *number* of electrons is not changed by the lightbulb.
- The lightbulb cannot store electrons, or it would become increasingly negative until its repulsive force would stop the flow of new electrons and the bulb would go out.
- Every electron entering the lightbulb is matched by an electron leaving the lightbulb, and thus the currents on either side of a lightbulb are equal.

Creating a Current



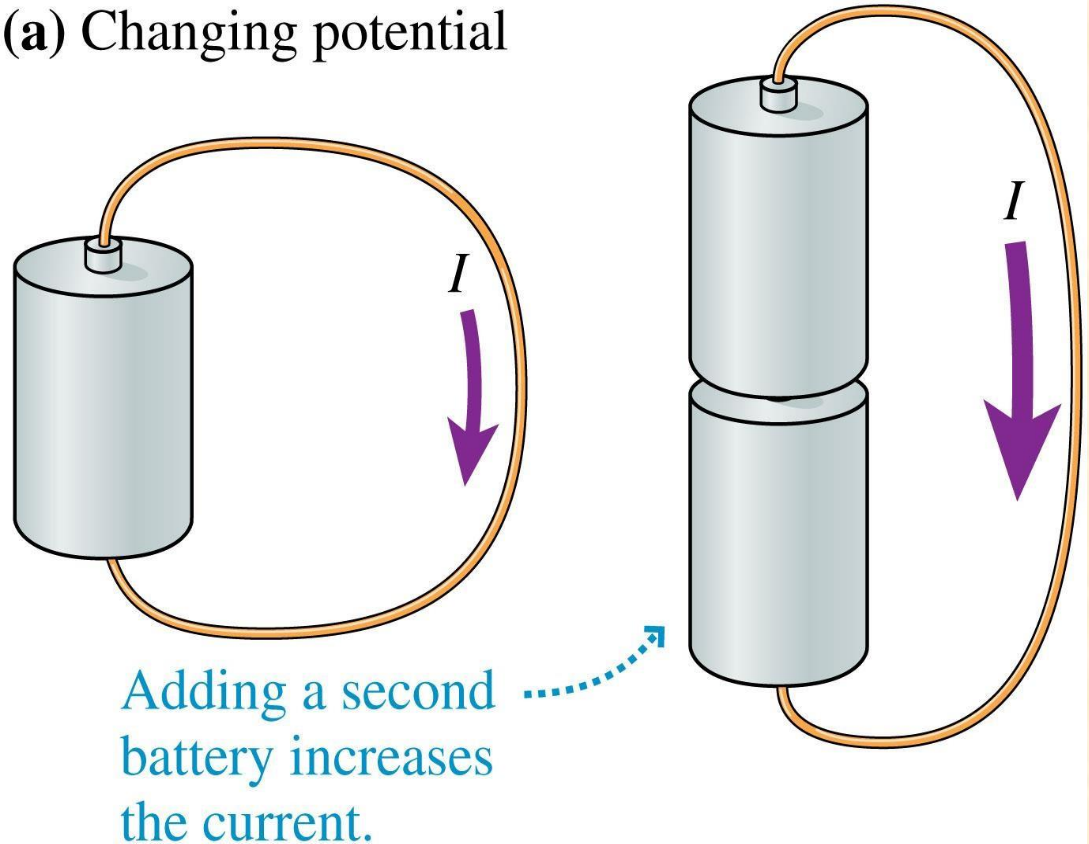
- In a lightbulb, the energy is dissipated by atomic-level friction as the electrons move through the wire, making the wire hotter until it glows.

Factors affect the current

Two factors determine the current

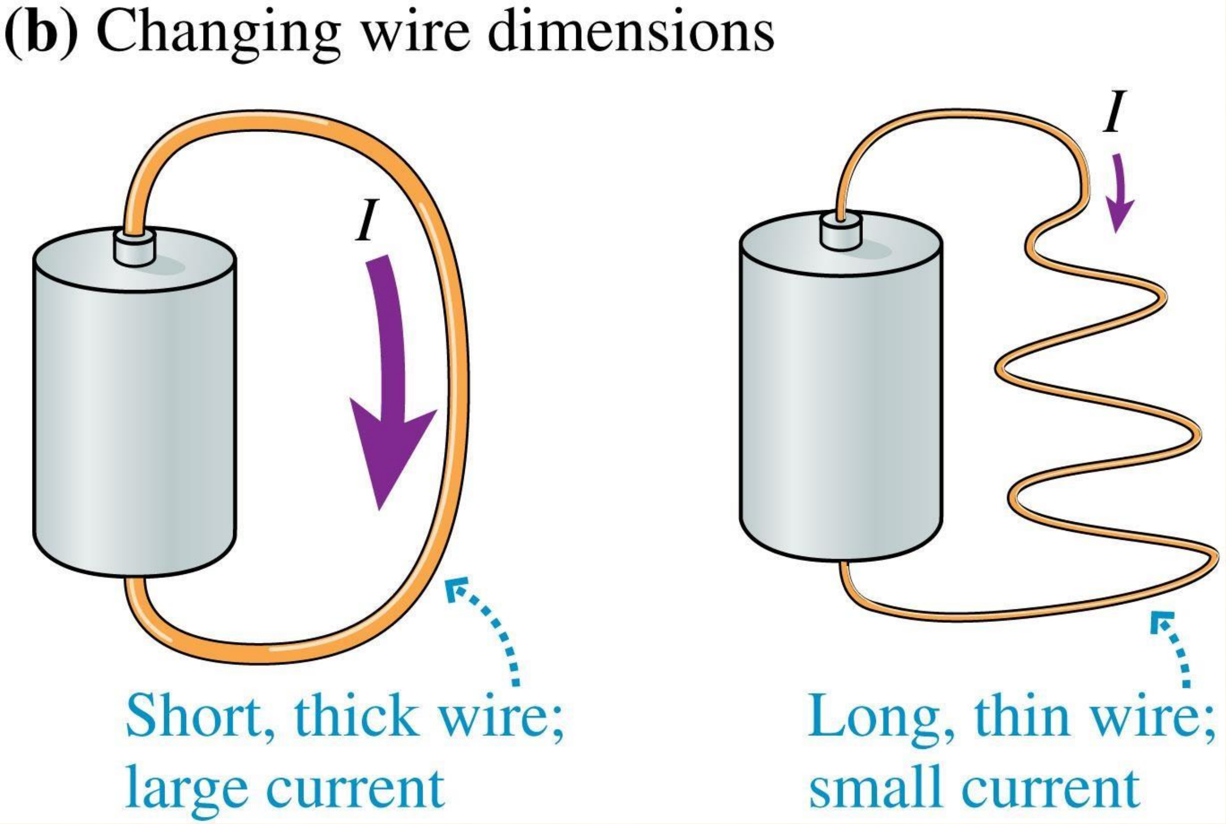
1- The potential difference

Adding a second battery increases the potential difference, which increases the electric field and therefore the current



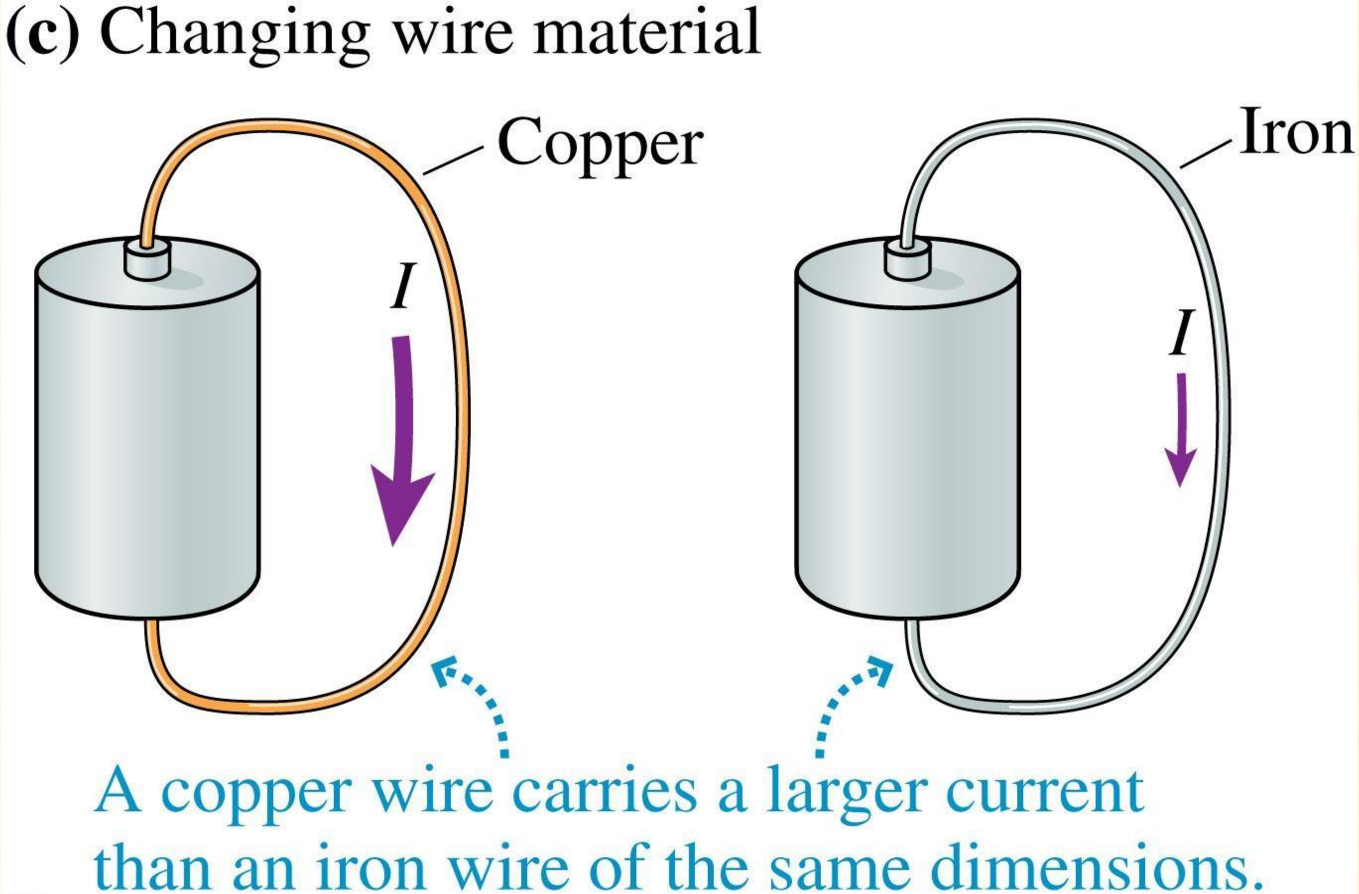
2- Properties of the wire

Increasing the length of the wire connecting a battery decreases the current, while increasing the thickness of the wire increases the current.



3- Material of the wire

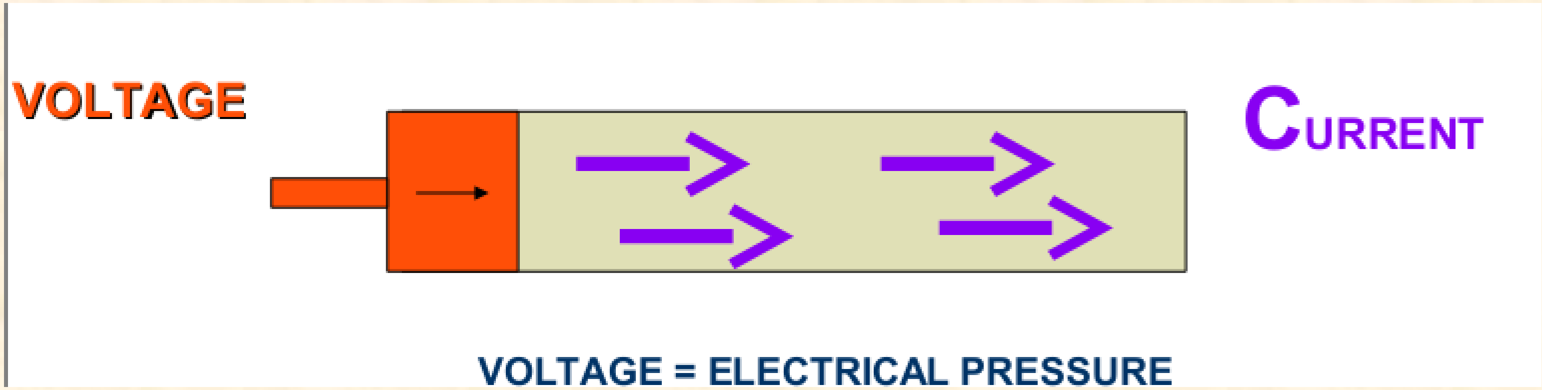
Wires of different material will carry different currents— some materials are better conductors than others.



Introduction to Electricity

Electrical Voltage

Voltage is the force that is applied to a conductor that causes electric current to flow.



Unit of electrical Voltage Volt

Symbol of electrical Voltage (V)

Introduction to Electricity

Voltage is the energy required to move a unit charge through an element

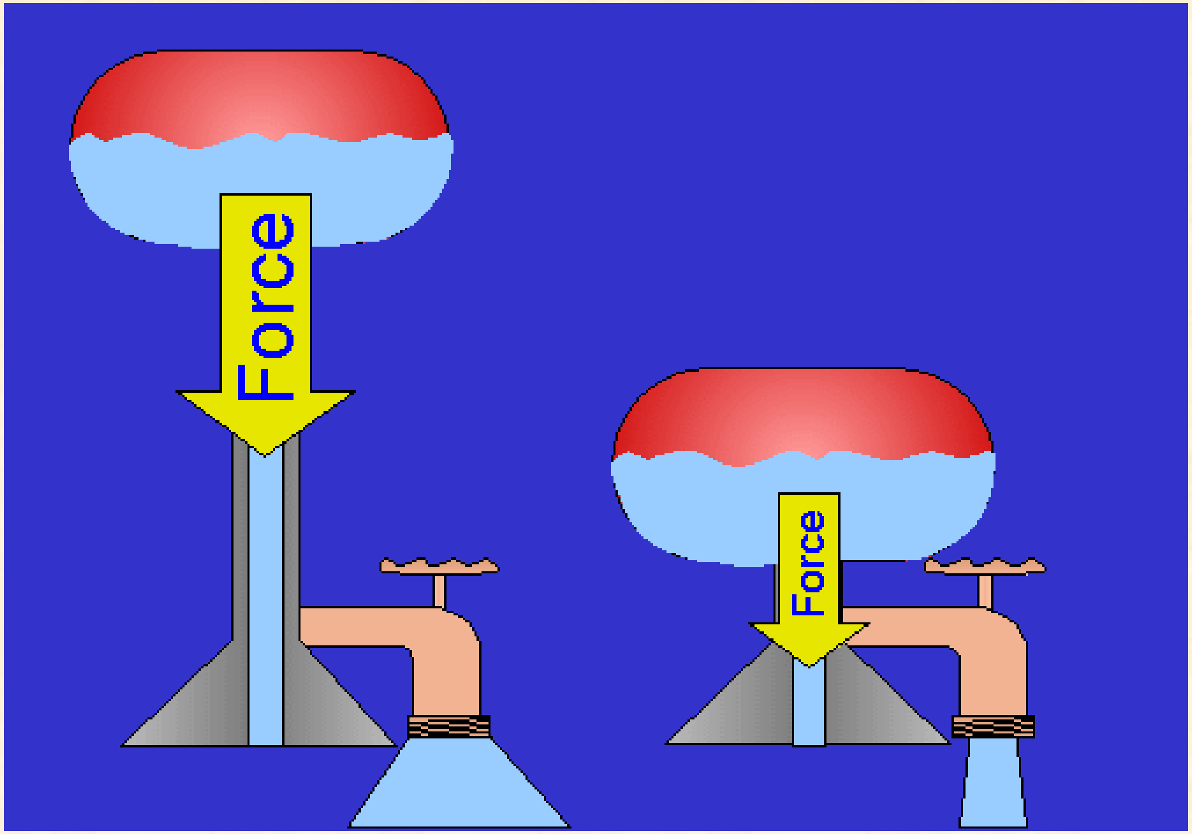
$$V = \frac{dw}{dq}$$

v = voltage in volts

q = charge in coulombs

ω= energy in Joules

Voltage-Water Analogy

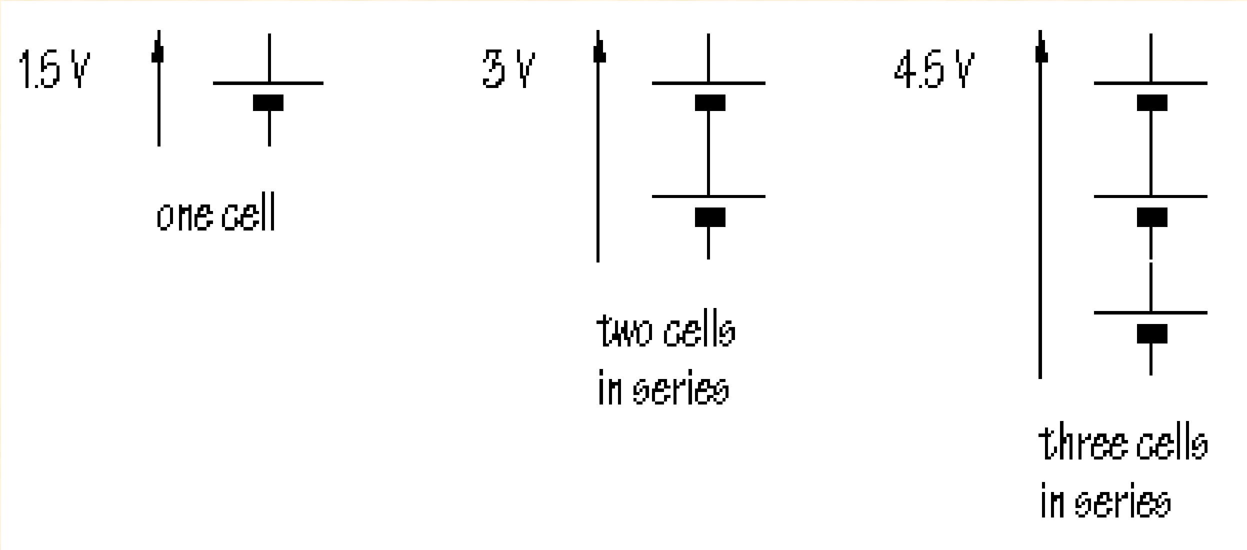


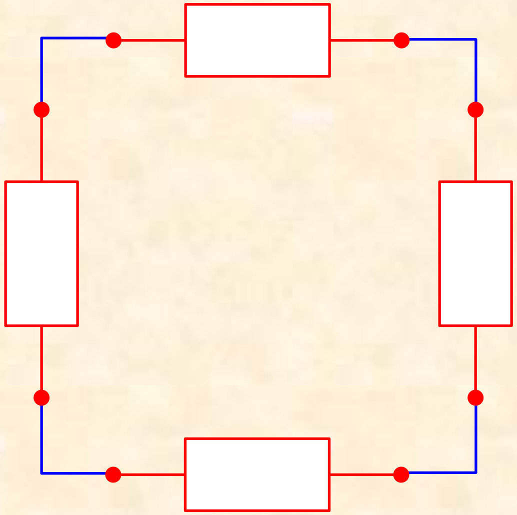
Circuit Configuration

Components in a circuit can be connected in one of two ways.

Series Circuits

Components are connected end-to-end.
There is only a single path for current to flow.

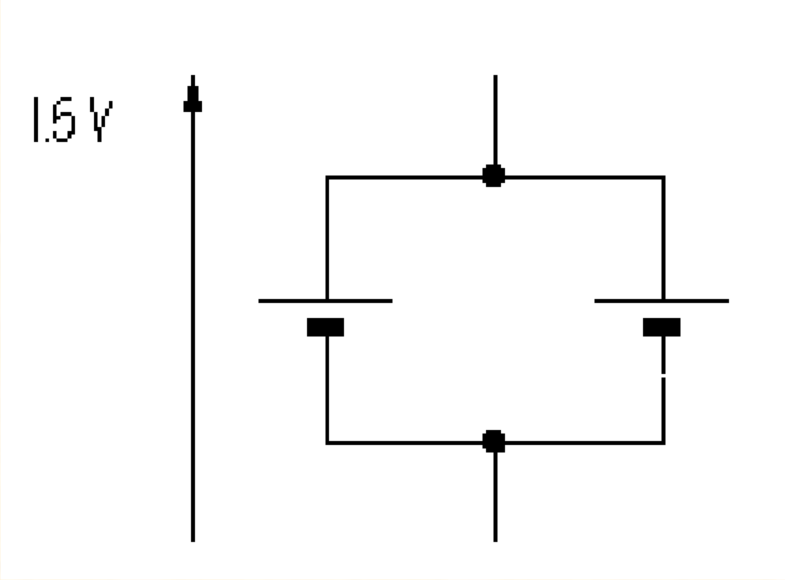


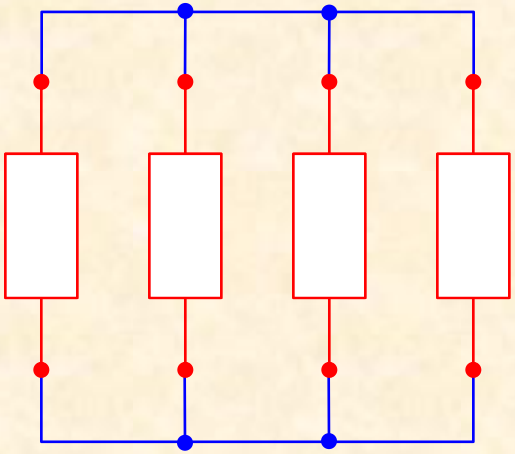


- Each cell provides 1.5 V
- Two cells connected one after another, **in series**, provide 3 V, while three cells would provide 4.5 V

Parallel Circuits

- Both ends of the components are connected together.
- There are multiple paths for current to flow.



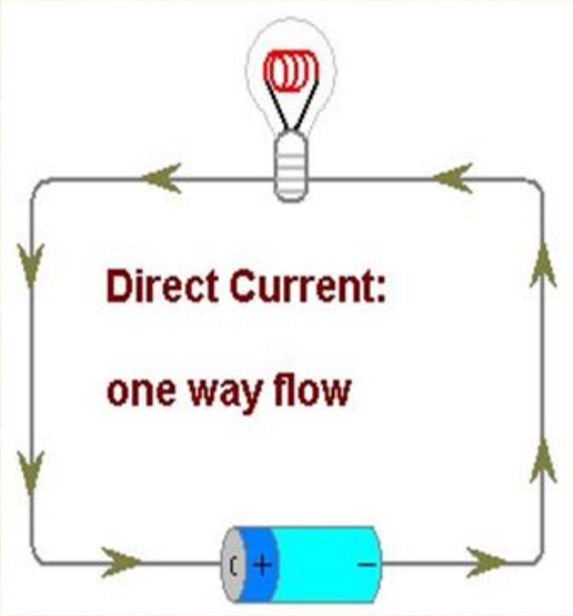


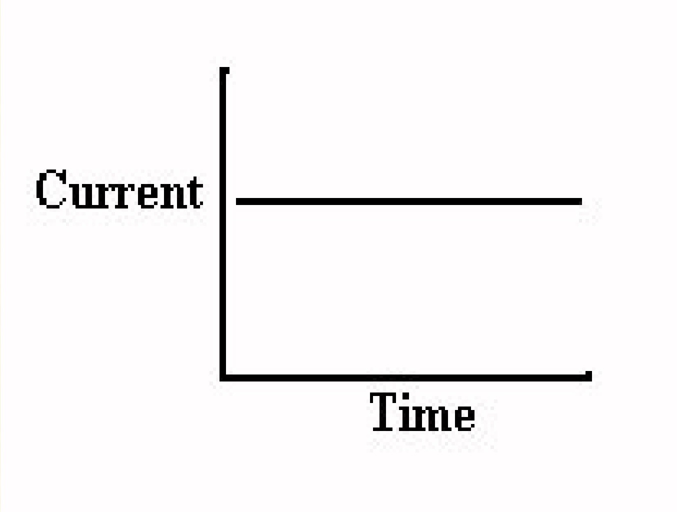
- If the cells are connected in parallel, the voltage stays at 1.5 V, but now a larger current can be drawn.

Types of Current

Direct current (DC)

Electrons always move through the circuit in the same direction from the negative terminal and toward the positive terminal

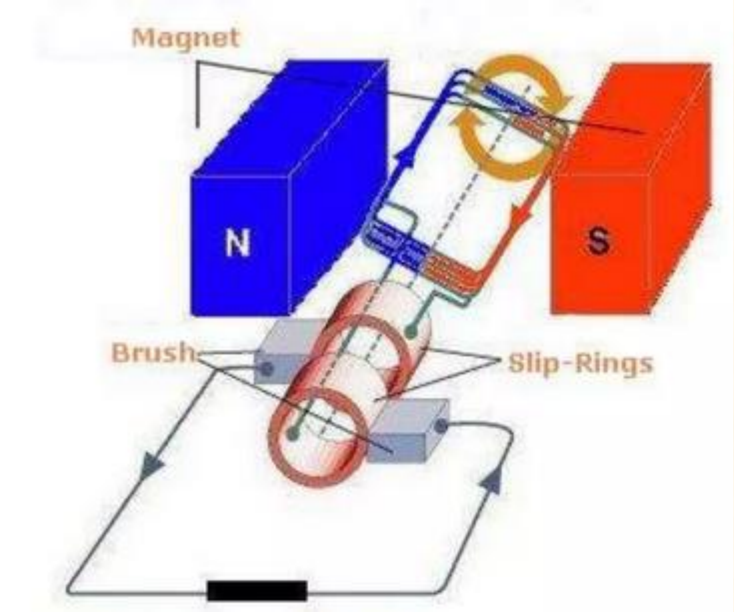


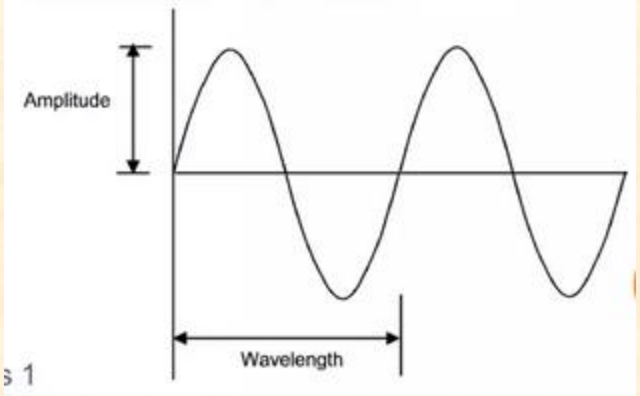


Types of Current

Alternating Current (AC)

Alternative current (AC) rapidly changes polarity and magnitude. The polarity constantly changes causing the current to alternately flow in both directions.





Types of Current

Direct Current

Alternating Current

Types of Current

T = time period

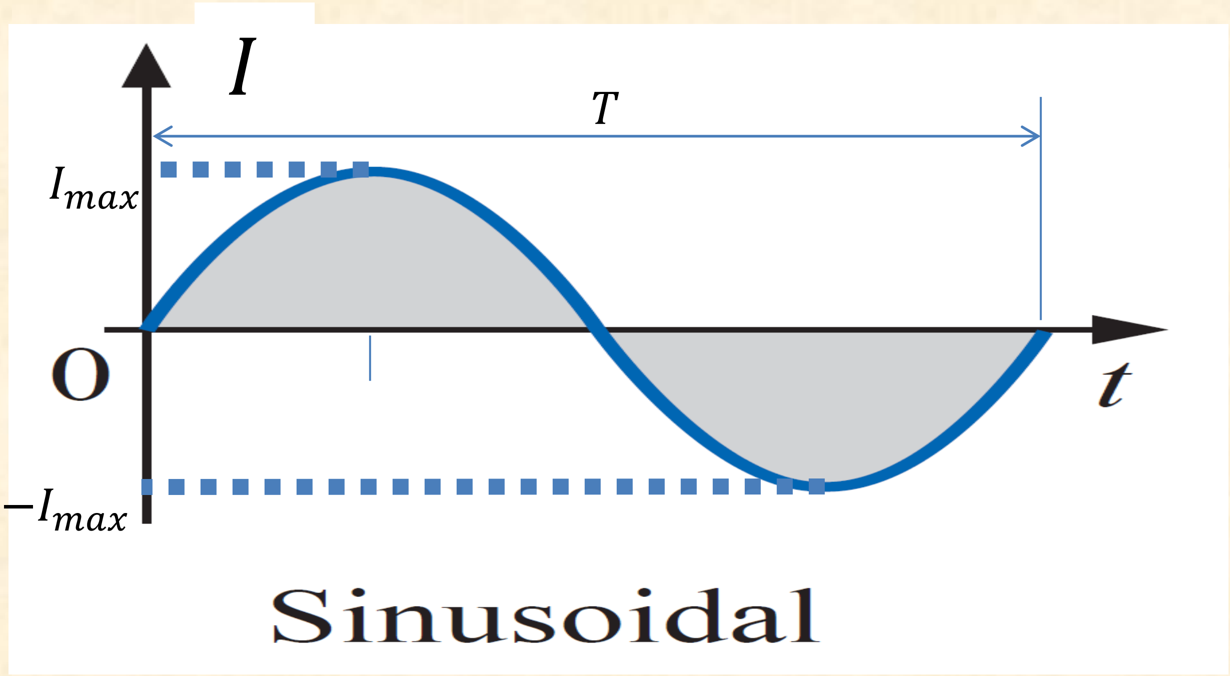
$$T = \frac{1}{frquency}$$

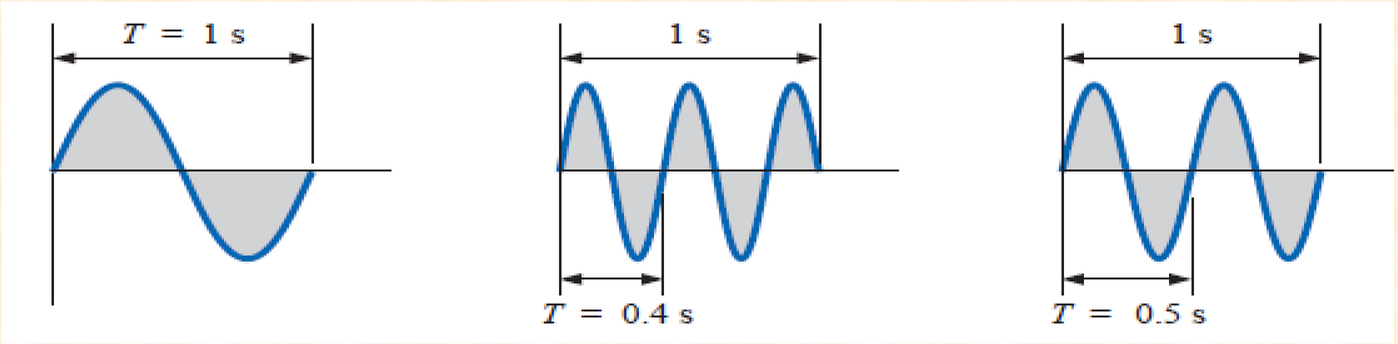
f = 60 Hz

$$T = \frac{1}{60} = 0.0166\ s$$

f = 100Hz

$$T = \frac{1}{100} = 0.01\ s$$





f = 1 Hz

f = 2.5 Hz

f = 2 Hz