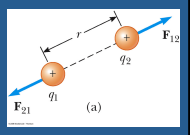
Chapter 7
Electricity

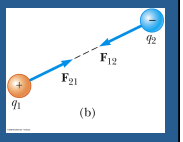
Section 7.1: Electric Charge

- Review:
  - protons have positive electric charge
  - electrons have negative electric charge
- a neutral atom contains the same number of protons and electrons
- objects with no net charge are electrically neutral

- Electrons are the main charge movers.
- **static electricity**
  - the accumulation of excess electric charge on an object
- **law of conservation of charge**
  - charge can be transferred from object to object, but it cannot be created or destroyed
  - whenever an object becomes charge, electric charges have moved from one place to another

- unlike charges (positive and negative) attract
- like charges (positive, positive or negative, negative) repel
- force of attraction depends on
  - distance between charges
  - amount of charge on each object
    - as this increases, so does the electrical force





- an electric field surrounds every electric charge
  - it exerts the force that causes other electric charges to be attracted or repelled
  - any charge placed in the field will be pushed or pulled by the field

Conductors and Insulators

- **conductor**
  - material in which electrons are able to move easily
- **metals** are the best electrical conductors
  - atoms in metals have electrons that are able to move easily through the material
  - copper (Cu), silver (Ag), and gold (Au)
- common nonmetal conductors
  - graphite
  - salt solutions (electrolytes)

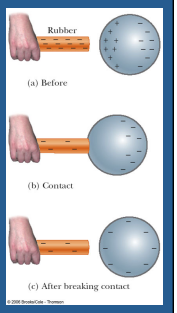
- **insulator**
  - material in which electrons are not able to move easily
  - electrons are held tightly
- examples
  - plastics
  - glass
  - wood
  - rubber

Transferring Charge

- compared to electrons in carpet atoms, electrons are bound more tightly to the soles of your shoes
- when you walk on the carpet, electrons are transferred from the carpet to the soles of your shoes
- the soles of your shoes have an excess of electrons and become negatively charged
- the carpet has lost electrons and has an excess of positive charge

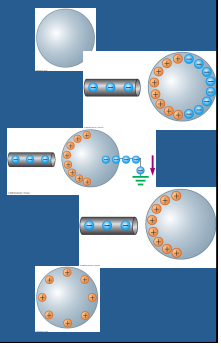
Charging Objects - Conduction

- rubbing two materials together can result in a transfer of electrons
- one material would have a positive charge, and the other a negative charge
- **charging by contact (conduction)**
  - the process of transferring charge by touching or rubbing



Charging Objects - Induction

- electrical forces act at a distance
- charged objects brought near a neutral object will cause electrons to rearrange their positions on the neutral object
- **charging by induction**
  - process of rearranging electrons on a neutral object by bringing a charged object close to it



Lightning

- lightning is a large static discharge
- a static discharge is a transfer of charge between two objects because of a buildup of static electricity
- a thundercloud is a mighty generator of static electricity
- as air masses move and swirl in the cloud, areas of positive and negative charge build up

- eventually, enough charge builds up to cause a static discharge between the cloud and the ground
- as the electric charges move through the air, they collide with atoms an molecules
- these collisions cause the atoms and molecules to emit light

Thunder

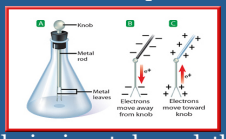
- lightning generates powerful sound waves
- the electrical energy in a lightning bolt rips electrons off atoms in the atmosphere and produces great amounts of heat
- the heat causes air in the bolt's path to rapidly expand, producing sound waves that you hear as thunder

Grounding

- a discharge can occur any time that charge builds up in one area
- providing a path for charge to reach Earth prevents any charge from building up
- Earth is a large, neutral object that is also a conductor of charge
  - any object connected to Earth by a good conductor will transfer any excess electric charge to Earth
  - connecting an object to Earth with a conductor is called grounding

Detecting Electric Charge

- **electroscope**
  - device used to detect the presence of electric charge



  - when the device is not charged, the leaves hang straight down
  - notice the position of the leaves on the electroscope when they are A uncharged, B negatively charged, and C positively charged

Section 7.2: Electric Current

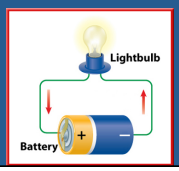
- **electric current**
  - the net movement of electric charges in a single direction
- when an electric current flows in the wire, electrons continue their random movement and drift in the direction that the current flows
- electric current is measured in amperes (A)

Voltage Difference

- when a current flows, the net movement of electric charges is caused by an electric force acting on the charges
- electric charge flows from higher voltage to lower voltage
- **voltage difference**
  - related to the force that causes electric charges to flow; measured in volts (V)

Electric Circuits

- **circuit**
  - closed connecting loop through which an electric current can flow
- if the circuit is broken by removing the battery, or the lightbulb, or one of the wires, current will not flow



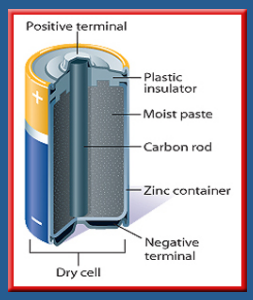
Batteries

- to keep an electric current continually flowing in the electric circuit a voltage difference needs to be maintained in the circuit
- a battery can provide the voltage difference that is needed to keep current flowing in a circuit
- current flows as long as there is a closed path that connects one battery terminal to the other battery terminal

Dry Cell Batteries

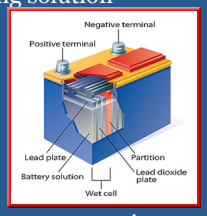
- a cell consists of two electrodes surrounded by a material called an electrolyte
- the electrolyte enables charges to move from one electrode to the other
- one electrode is the carbon rod, and the other is the zinc container
- the electrolyte is a moist paste containing several chemicals
- the cell is called a dry cell because the electrolyte is a moist paste, and not a liquid solution

Dry Cell Battery



Wet Cell Battery

- a wet cell contains two connected plates made of different metals or metallic compounds in a conducting solution



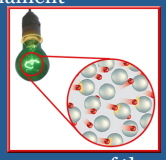
- a wet-cell battery contains several wet cells connected together

Lead and Acid Batteries

- most car batteries are lead-acid batteries
- a lead-acid battery contains a series of six wet cells made up of lead and lead dioxide plates in a sulfuric acid solution
- the chemical reaction in each cell provides a voltage difference of about 2 V, giving a total voltage difference of 12 V

Resistance

- as the electrons flow through the filament in a light bulb, they bump into the metal atoms that make up the filament



- in these collisions, some of the electrical energy of the electrons is converted into thermal energy
- eventually, the metal filament becomes hot enough to glow, producing radiant energy that can light up a dark room

Resisting the Flow of Current

- **resistance**
  - the tendency for a material to oppose the flow of electrons, changing electrical energy into thermal energy and light
  - resistance is measured in ohms (Ω)
- **Ohm's Law**
  - the current in a circuit equals the voltage difference divided by the resistance

$$V = IR$$

V = voltage (volts)
I = current (amperes)
R = resistance (ohms)

Complete Problems:

Pg 205 #6

Pg 205 #7

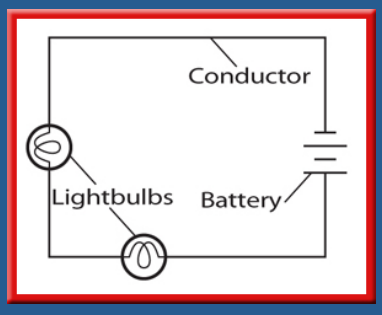
Section 7.3: Electrical Energy

- circuits contain three components
  - one source of voltage difference
  - one or more devices that uses electrical energy
  - conductors, such as wires, that connect the devices to the source of voltage difference to form a closed path

Series Circuit

- **series circuit**
  - circuit in which electric current has only one path to follow
  - used in flashlights and some holiday lights
- How can one faulty bulb cause a whole string of lights to go out?
  - when any part of a series circuit is disconnected, no current flows through the circuit
  - this is called an open circuit
  - the burned-out bulb causes an open circuit in the string of lights

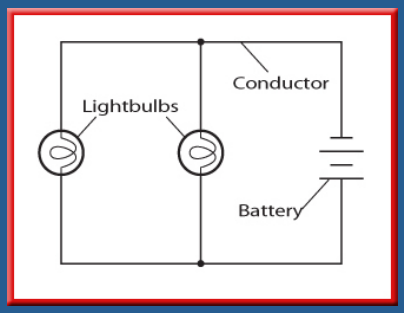
Series Circuit



Parallel Circuit

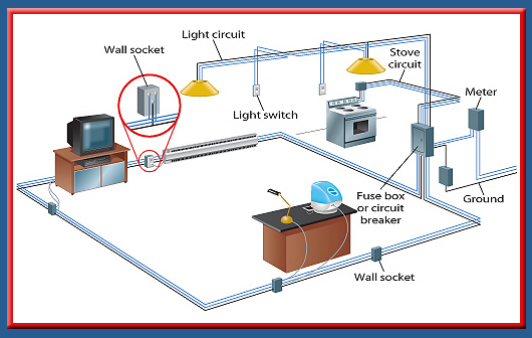
- **parallel circuit**
  - circuit in which electric current has more than one path to follow
- the current can flow through both or either of the branches
- parallel circuits have several advantages
- when one branch of the circuit is opened, such as when you turn a light off, the current continues to flow through the other branches

Parallel Circuit



Household Circuits

- wiring is mostly a combination of parallel circuits connected in an organized and logical network
- the main switch and circuit breaker or fuse box serve as an electrical headquarters for your home
- parallel circuits branch out from the breaker or fuse box to wall sockets, major appliances, and lights
- to protect against overheating of the wires, all household circuits contain either a fuse or a circuit breaker



Fuses

- an electrical fuse contains a small piece of metal that melts if the current becomes too high
  - it causes a break in the circuit, stopping the flow of current through the overloaded circuit
  - to enable current to flow again in the circuit, you must replace the blown fuse with a new one

Circuit Breaker

- a circuit breaker contains a piece of metal that bends when the current in it is so large that it gets hot
  - the bending causes a switch to flip and open the circuit, stopping the flow of current
  - circuit breakers usually can be reset by pushing the switch to its "on" position

Electrical Power

- electrical energy is converted easily to other types of energy
- **electric power**
  - the rate at which electrical energy is converted to another form of energy

$$P=IV$$

P = electric power (W)

I = current (A)

V = voltage difference (V)

Electrical Energy

- electric companies charge by the amount of electrical energy used, rather than by the electric power used
- electrical energy usually is measured in units of kilowatt hours (kWh)

$$E = Pt$$

E = electrical energy (kWh)

P=electric power (kW)

t = time (h)