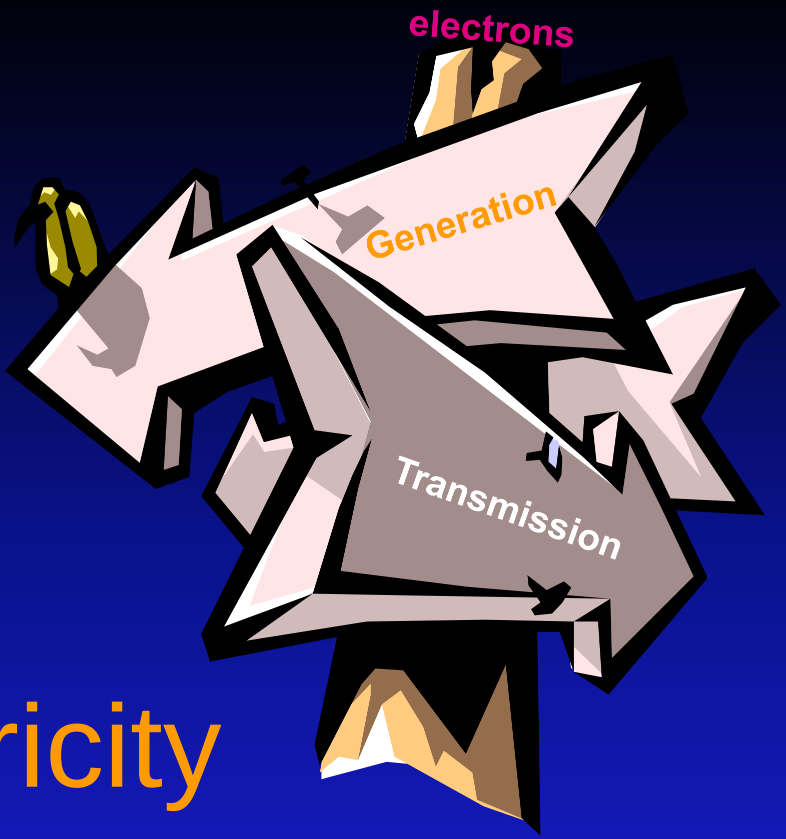


Basics of Electricity
and
Electrical Transmission

What is Electricity?

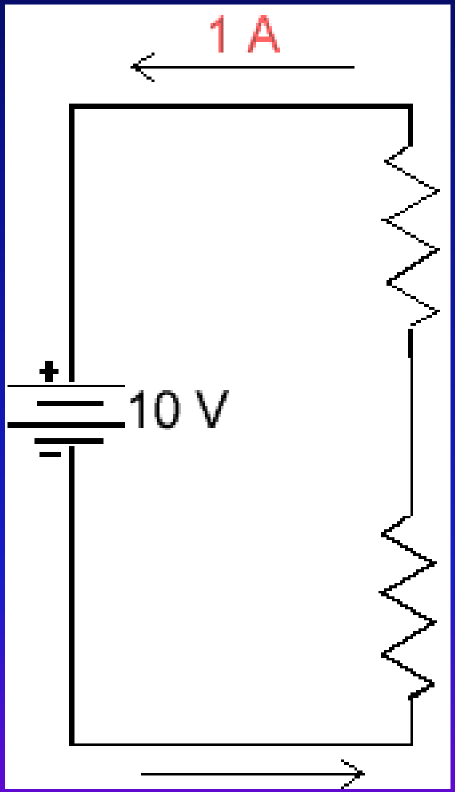
- Electricity is the movement of electrons

- Notice that electrons in materials do not move as much as they transfer their energy to the next electron

What kinds of electricity are there?

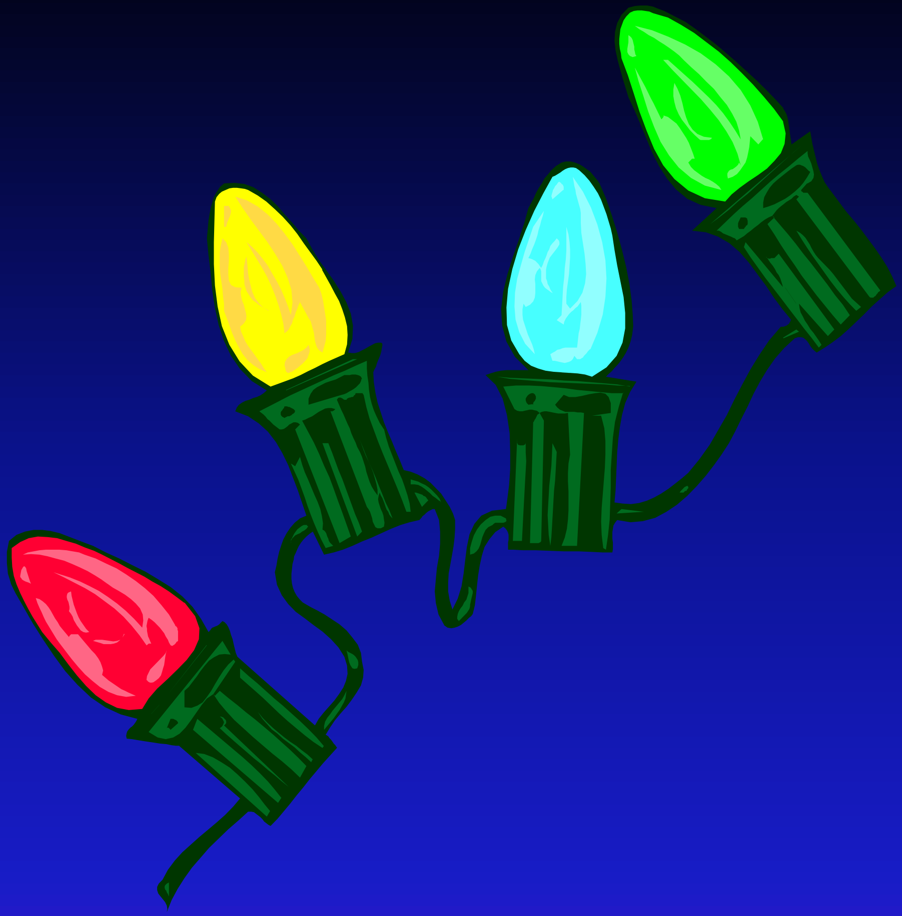
Static electricity occurs when charges build up and get transferred to the ground

- Electricity is often contained in "circuits" or closed loops of electrons flowing



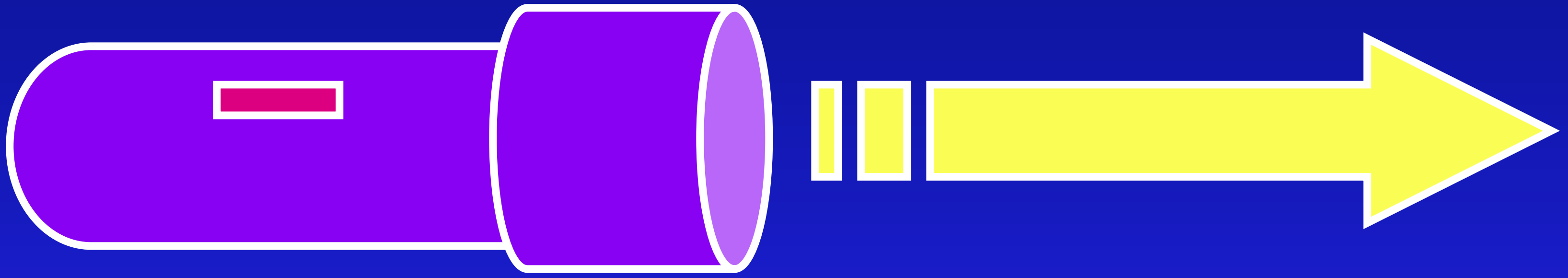
- A **series** circuit has only ONE loop of flowing electrons
- The same current flows throughout the circuit

Some types of Christmas lights use a series circuit



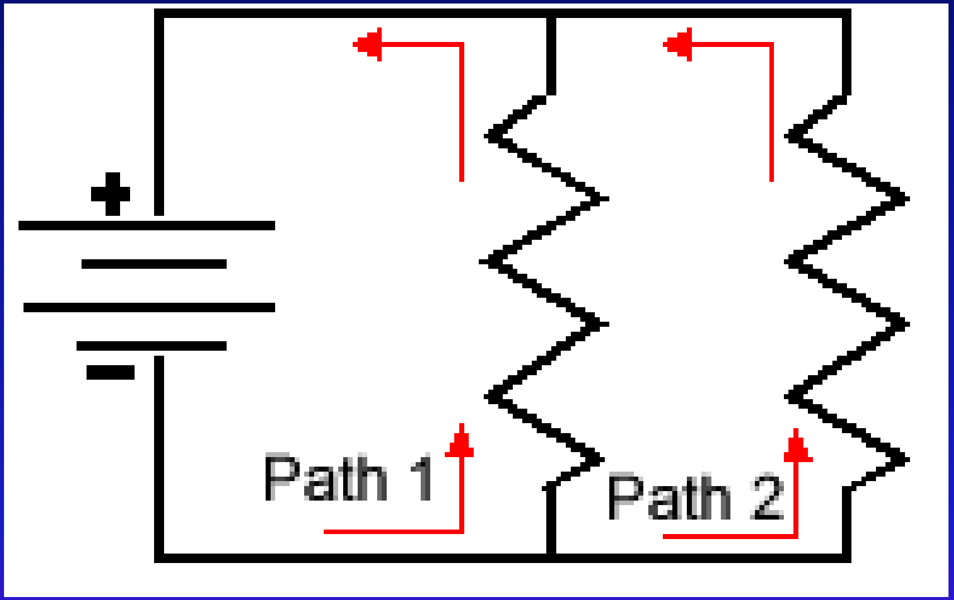
What is a major disadvantage of using devices with series circuits?

A flashlight is another example of an electrical device that uses a series circuit

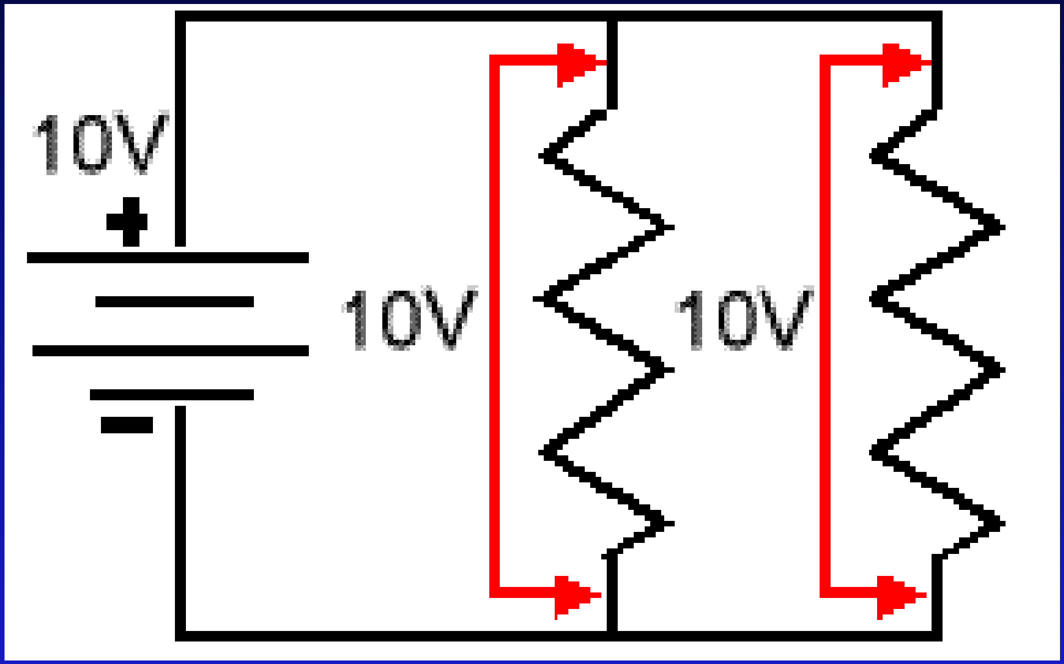


- Another kind of “circuit” or closed loop of flowing electrons is called parallel

- A **parallel** circuit has more than one loop of flowing electrons



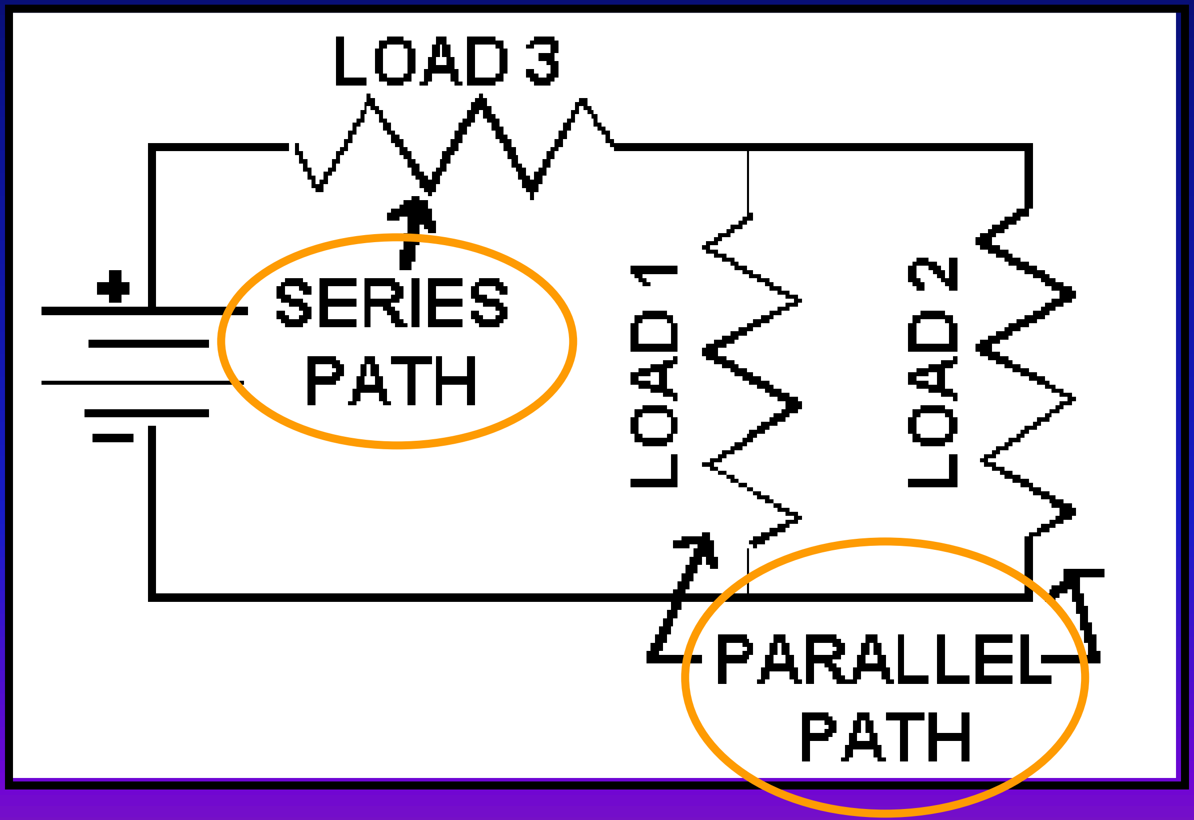
The same voltage flows throughout the parallel circuit



This means that any loop of the same parallel circuit can do the same amount of electrical work.

Most appliances and electrical devices used in industry and at home utilize parallel circuits

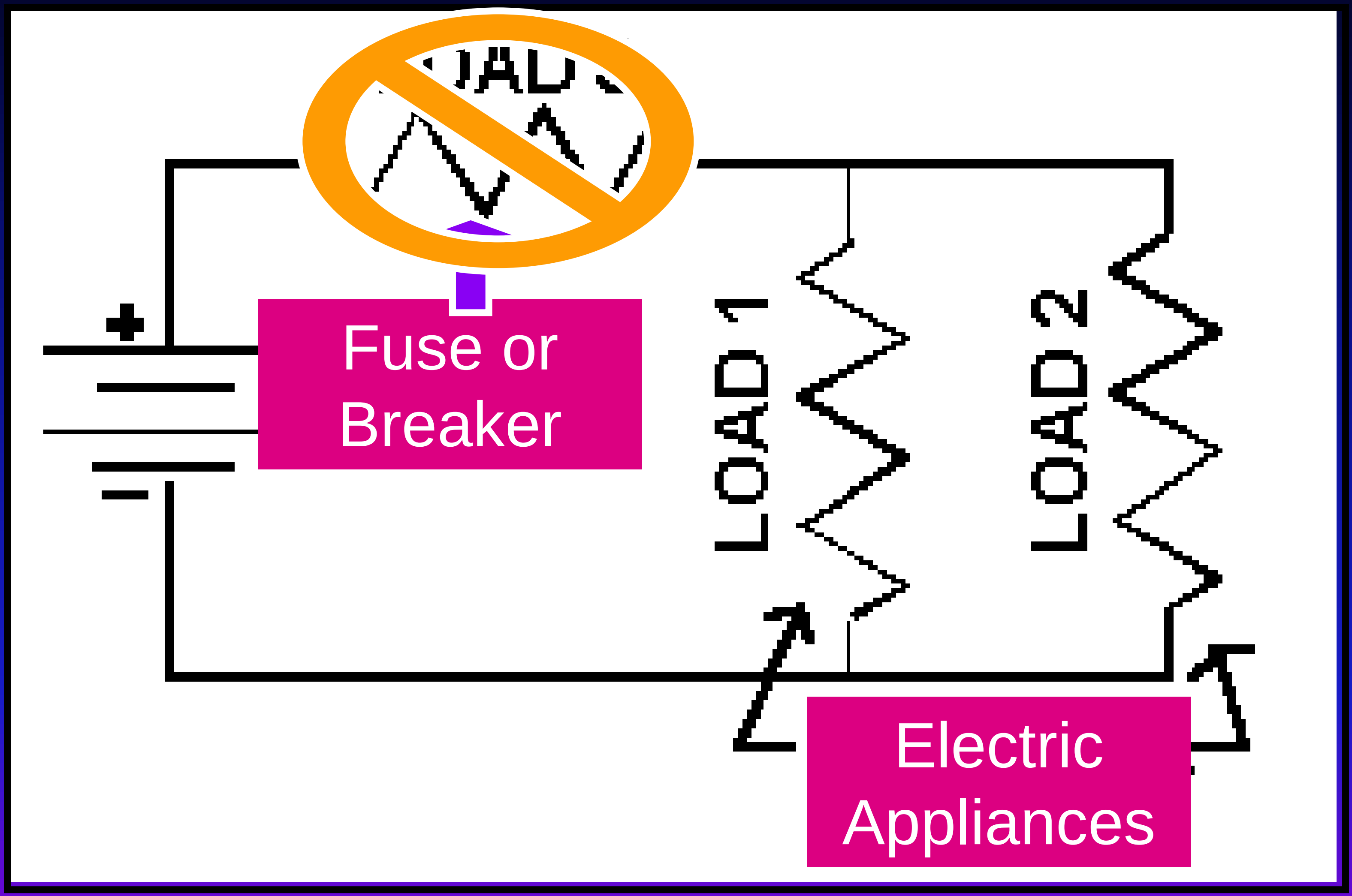
Combination circuits containing both series and parallel circuits are common in our homes and in industry



Combination Circuits are very important for electrical safety in our homes, schools and industry …

- Fuses and Circuit Breakers are connected in “series” to parallel circuits. Why?

If the fuse blows or the breaker trips, the entire circuit is “opened”



Current

- The amount of electrons moving within a circuit is called Current.
- Current is measured in "amps" … named after the scientist who worked with current (Ampere)
- Current or amps are designated by an "I" in the electrical equation (V = I R)

Components of Electricity

Basic Components of Electricity

Conductors,
Insulators

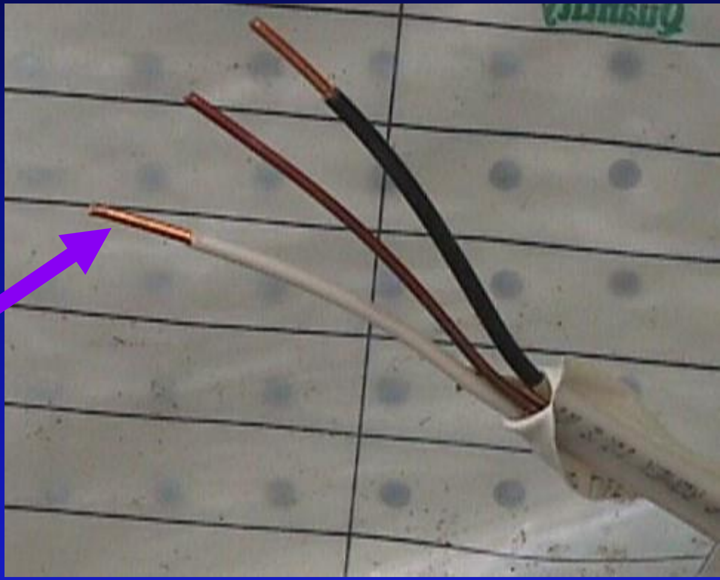
and

Resistors

Conductors

Electrons Can Move Through Materials

- If electrons move very easily in a material, that material is a “conductor”



Copper wire

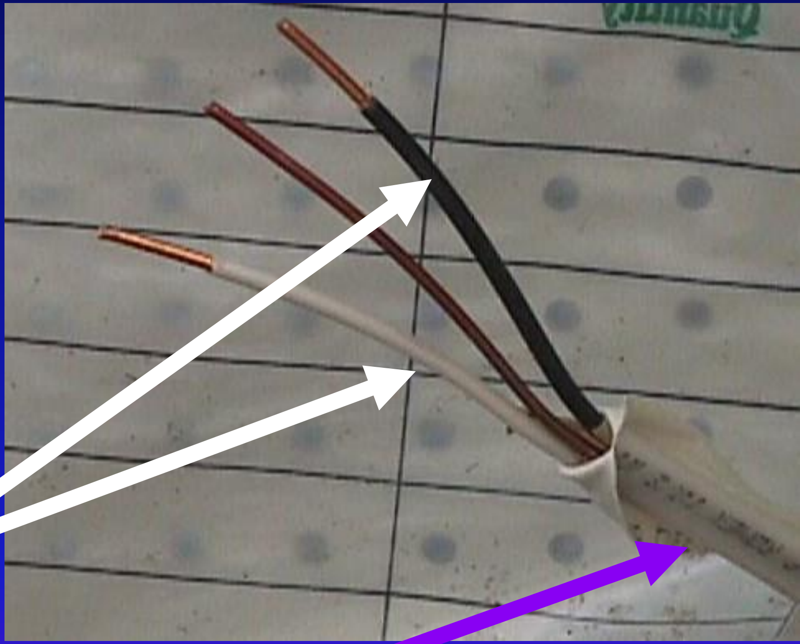
- Transmission wires are made of conductors like copper or aluminum

Insulators

- If the electrons do not move easily in a material, that material is an “insulator”
- Glass, wood, air and plastic are good insulators
- Insulators keep the current from touching other materials (or people)

Many Conductors are Covered with Insulators

- Wires are often coated with insulating material like plastic

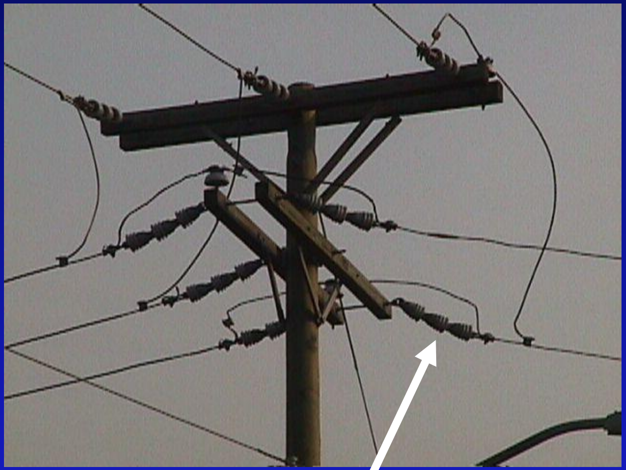


Plastic insulation on the white and black wires

Plastic insulation around all three wires

Insulating Transmission Wires

- High voltage transmission wires are coated to prevent corrosion but this doesn’t provide sufficient insulation
- They are suspended in the air by glass insulators
- Glass and air are good insulators



Glass insulator

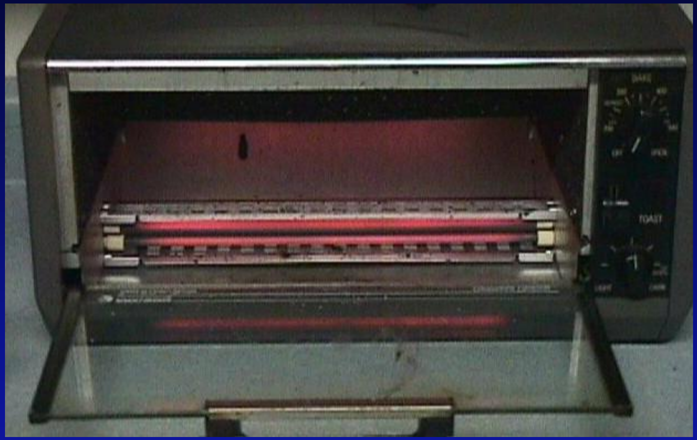
Resistance

- Some materials allow the electrons to move, but not easily. Such materials are called “resistors”

- Resistance is measured in ohms (named after George Ohm)

- Ohms are designated by an “R” in the electrical equation (V = I R)

Resistance Turns Electricity Into Heat and Light

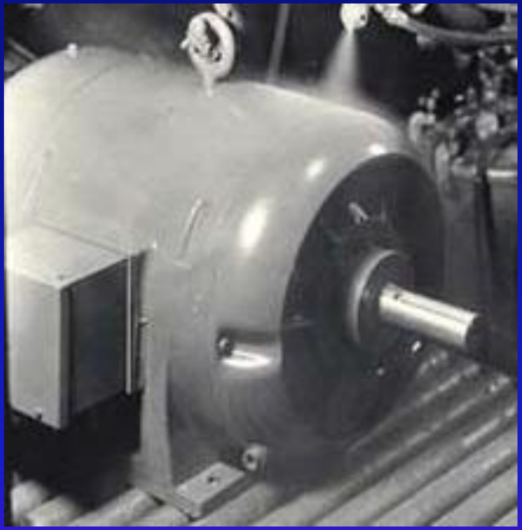


- Wires allow electrons to move through them but they resist the movement

- These wires produce useful heat and light

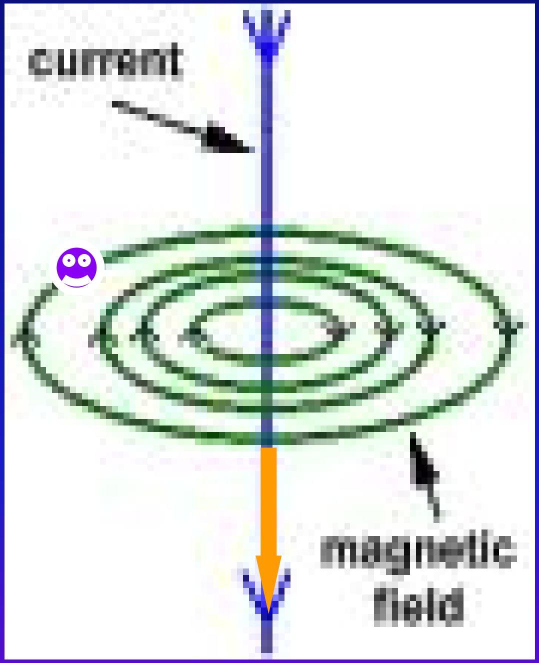
A common means to produce electricity for useful work is:

Magnetic Induction



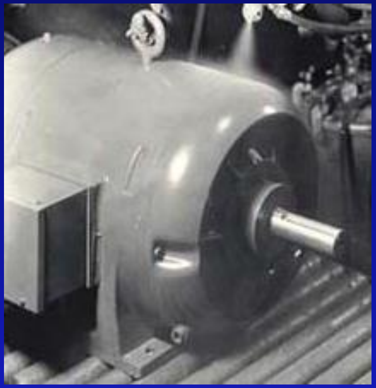
Magnetic Fields

- When current moves through a wire, a magnetic field is created around the wire
- The direction of the magnetic field is determined by the “right hand” rule



Magnetic Fields Can Do Work

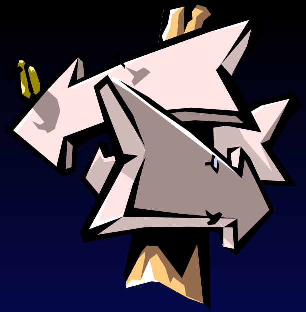
- When a magnetic field moves across a conductor (like a wire), electrical current is produced in that conductor



This is called "Induction"

- Induction causes motors to turn
- Induction is used to modify electrical potential and current in transformers

Summary



- Conductors allow current to flow easily
- Insulators do not

- Resistors will resist the current flow and get hot … this heat becomes useful for …
  - Heating elements
  - Lighting

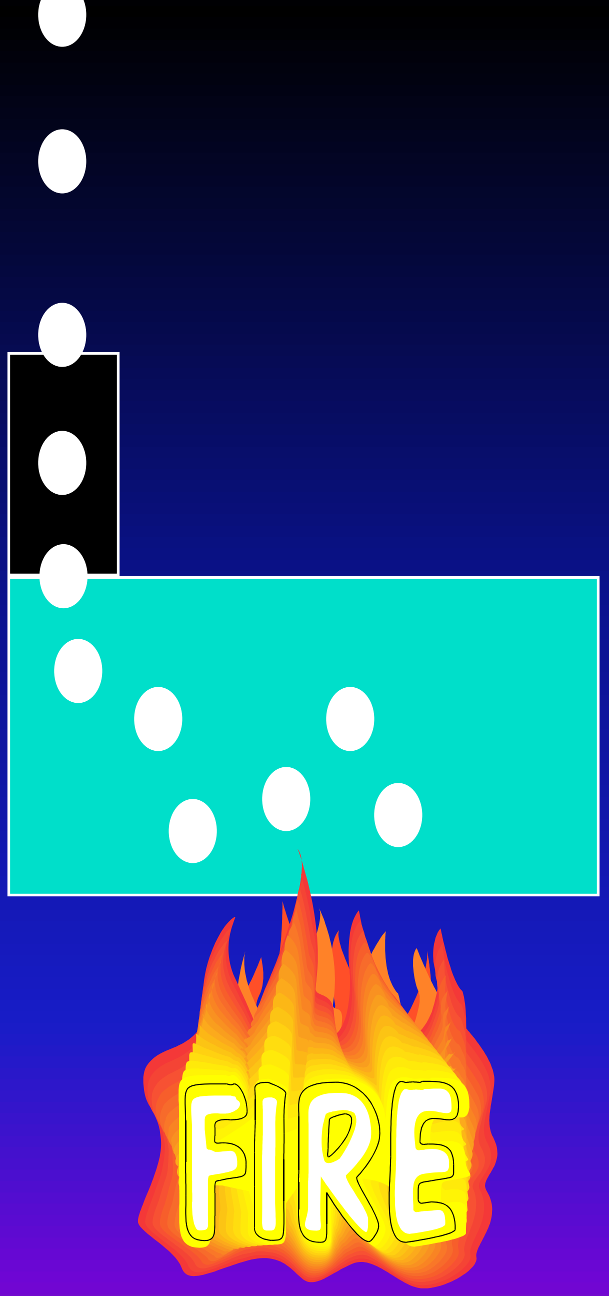
- Magnetic fields can "induce" a current in wires
  - Motors
  - Transformers

Generating Electricity

- Power plants (Utility Companies) force electrons to move through magnetic induction.
- There are several phases of electricity production, involving particular equipment and processes.

Boilers

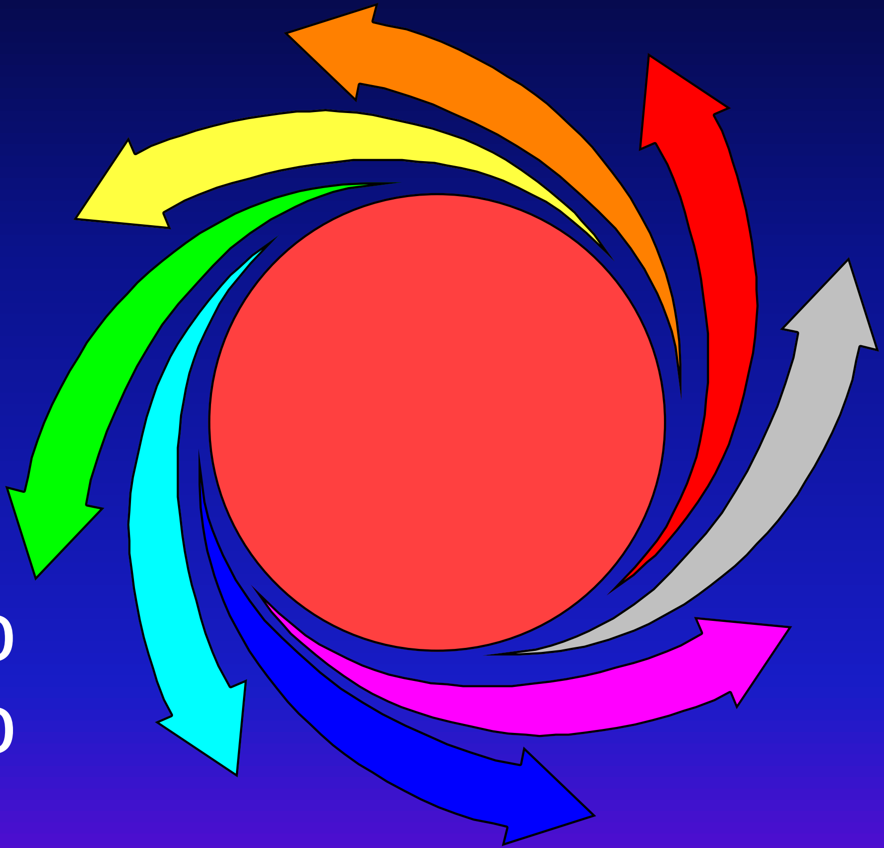
- Heat runs a reactor
- Boiling water expands 1000 times and rapidly escapes the boiler



Turbines

- Expanding & escaping steam from the boiler turns a turbine shaft

- Heat energy of the steam is converted to mechanical energy to generate electricity

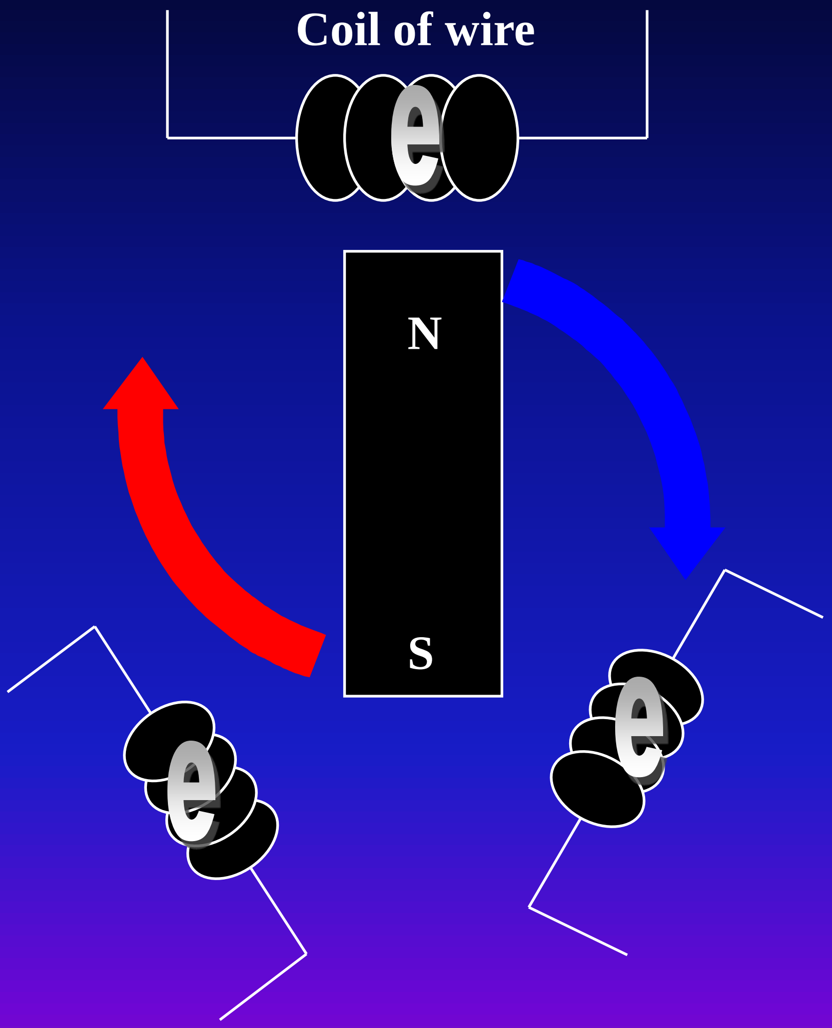


A Turbine in a Power Plant

Turbine

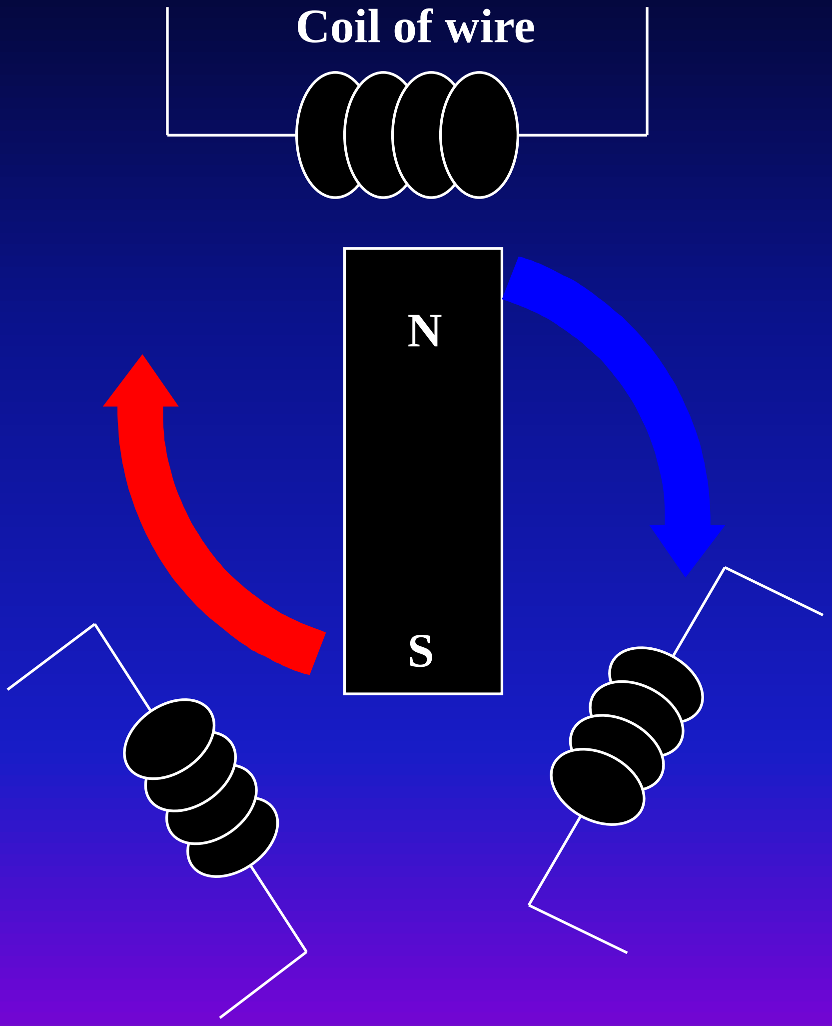
Generators

- A Shaft from a turbine is attached to an electromagnet
- Rotating the magnet produces electric current in nearby wires



Generators

- The Magnet rotates 60 times each second as the north pole and south pole pass by the coils of wire
- Alternating Current is produced at 60 hertz



Generators

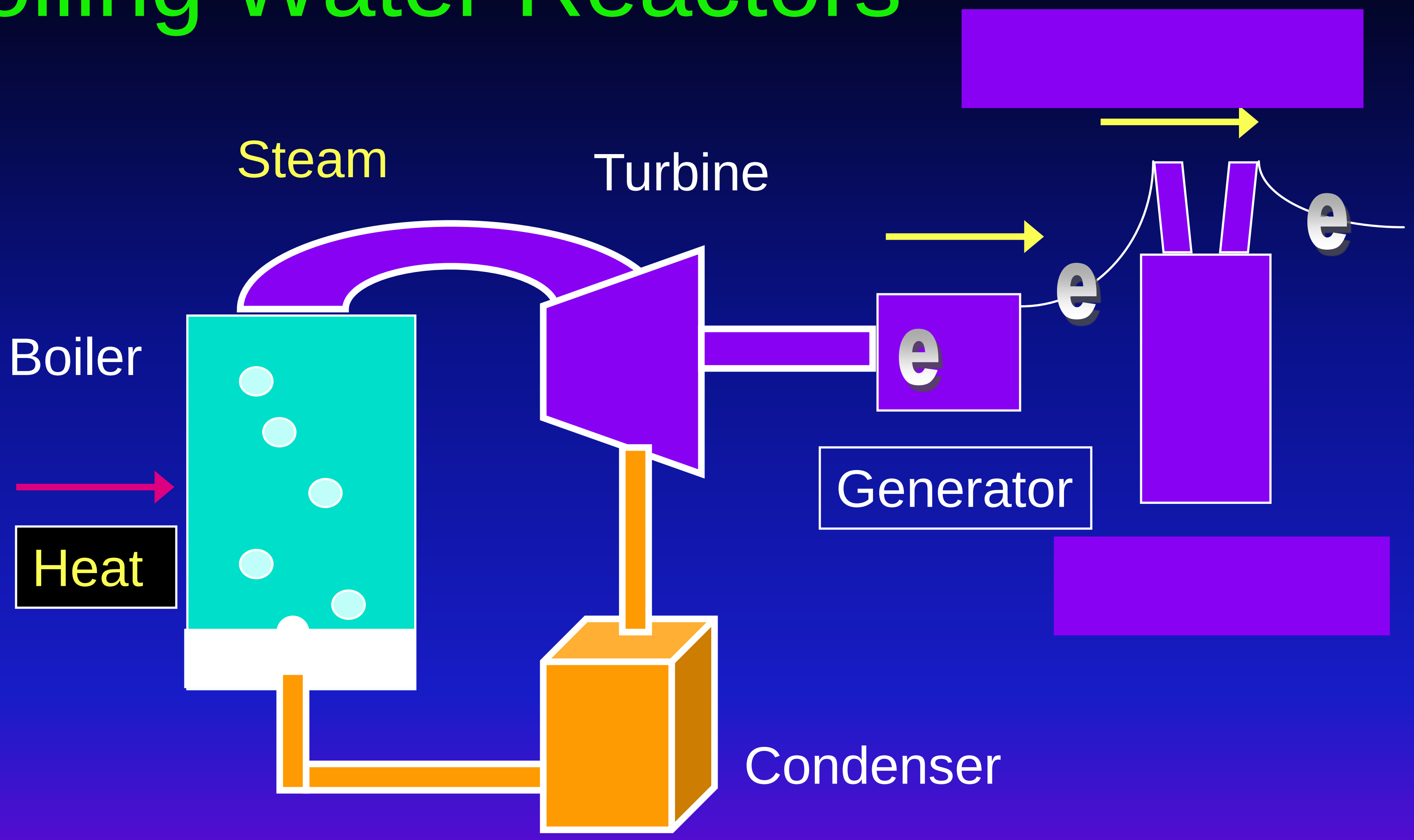
- Use Magnetic Induction
- Produce Alternating Current

- In our homes, this generation of 60 hertz alternating current yields a voltage of 120

Since this type of electrical generation uses heat, a cooling system is also required to restore normal temperatures

- This cooling system is called a condenser
- The condenser restores the temperature of the water from the hot steam

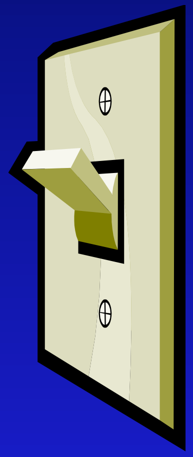
Boiling Water Reactors



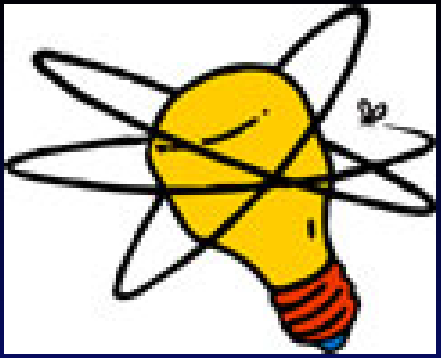
Transmitting Electricity

Transmission of Electricity

Now that we have generated electricity in a power plant, how do we get it to our fingertips?

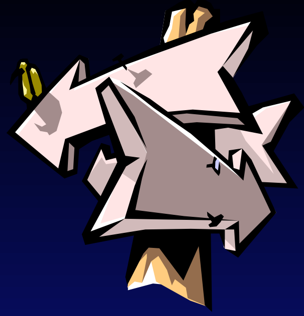


- We pay the power company to move the electrons back and forth to and from our homes when we flip on a switch
- Power plants are connected to our homes through a network of transmission wires



The electricity transmitted does <u>work</u> for us through electrical devices and appliances

Electricity’s potential to do work is measured in volts.



Examples of “voltage”:

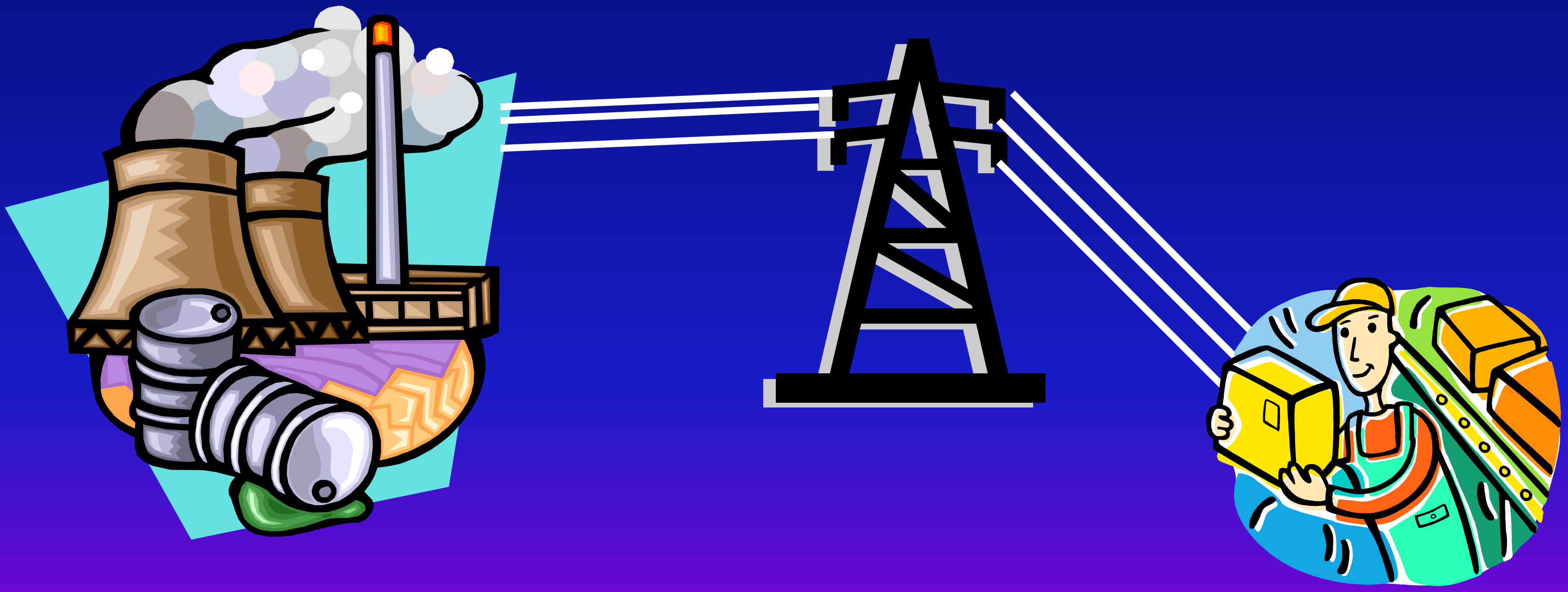
- Batteries (1.5 volts, 6 volts, 12 volts)
- Outlets (120 volts, 220 volts)

Voltage indicates how much work an electrical device can do. The higher the voltage, the more work per unit of charge that device can perform.

A power plant may produce 200,000 volts of electricity or more each second

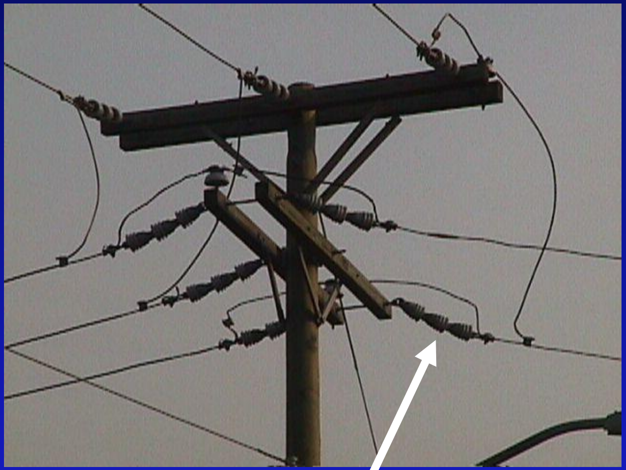
- This is enough to do work in thousands of homes and in industry

- How can we transport this huge amount of electrical potential to our homes without getting hurt and without huge electricity bills?



Safe & Cheaper Transmission

- Transmitting electricity using lower current is safer and utilizes smaller wires, saving weight and money
- Since the current is lower, the voltage (potential) can be very high
- Higher Potential is more dangerous so the high voltage wires are placed high in the air and suspended from the towers by glass insulators



Glass insulator

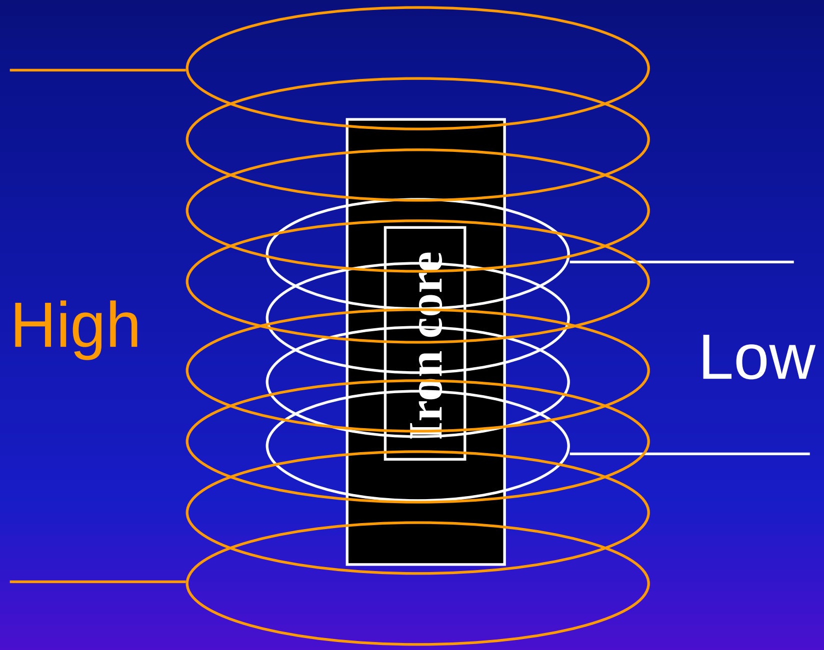
Electrical companies use Transformers to change the amount of voltage and current being transmitted

- A transformer keeps the electrical power the same while changing the voltage (potential) and current to make transmission safer and less costly
- Transformers use magnetic induction … producing alternating current
- This is one reason power plants produce "Alternating Current" rather than "Direct Current"

Transformers

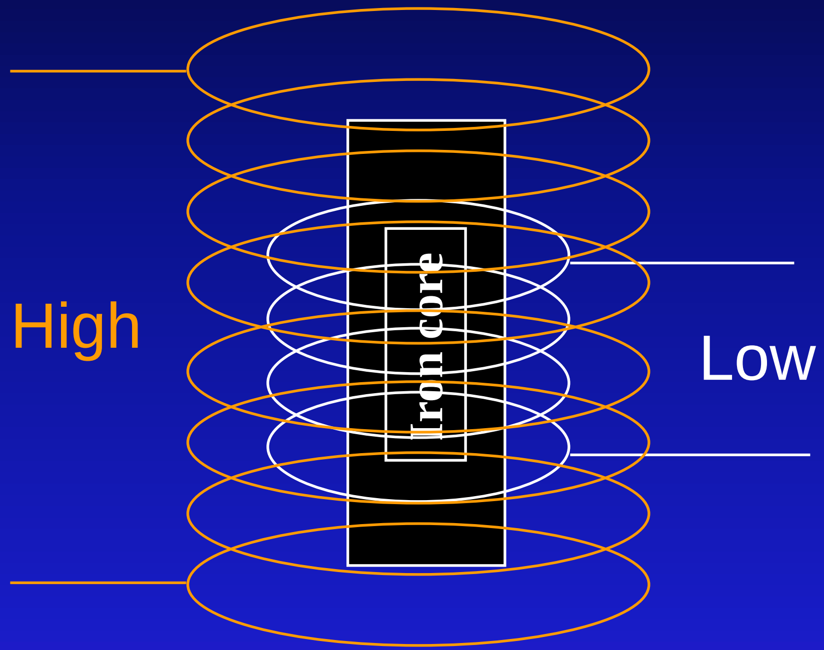
- Use Magnetic Induction

- An alternating current in one coil of wire will induce a potential and current in a coil next to it

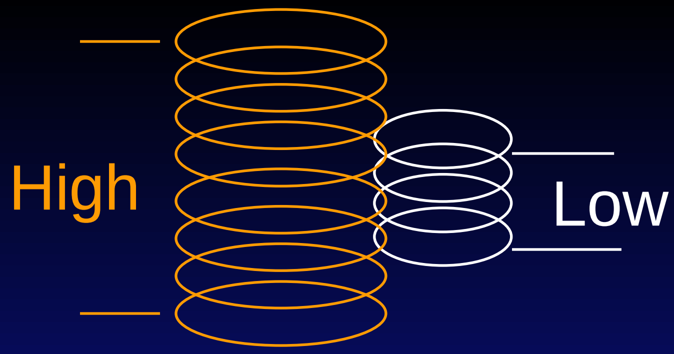


Transformers

- The ratio of coils in each loop determines the potential (voltage) in each loop



Example of Using A Transformer



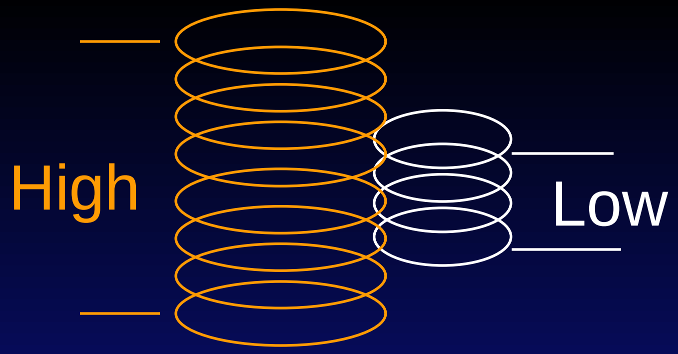
- If the Utlility Company generates 100 volts of electricity with 20 amps of current, 2000 watts of electric power are produced.

$$V \times I = P$$

$$(100 \text{ Volts}) \times (20 \text{ amps}) = 2000 \text{ W}$$

- A transformer changes the electricity to 2000 volts with 1 amp of current. This still represents 2000 watts of electrical power.

$$(2000 \text{ Volts}) \times (1 \text{ amp}) = 2000 \text{ W}$$



"Step up" transformers

increase the potential while decreasing the current

"Step down" transformers

decrease the potential while increasing the current

"Step Up" Transformers

Low current / high potential (voltage) electricity

Transformers reduce current (and increase potential)

“Step Up” Transformers

From the generator

To the consumer

"Step Down" Transformers

- exist near our homes and increase the current (reducing the potential)

Transformers

Reducing Amperage or Current

- Transformers are used at the power plant to decrease the current (therefore increasing the potential)
- This reduces transmission losses

One Last Thing

- Current is created when electricity is connecting to the earth. This is called the “ground”
- Wires are used to connect to the earth. These are called “ground wires”
- If part of an appliance is connected to the earth through the ground wire it is “grounded”