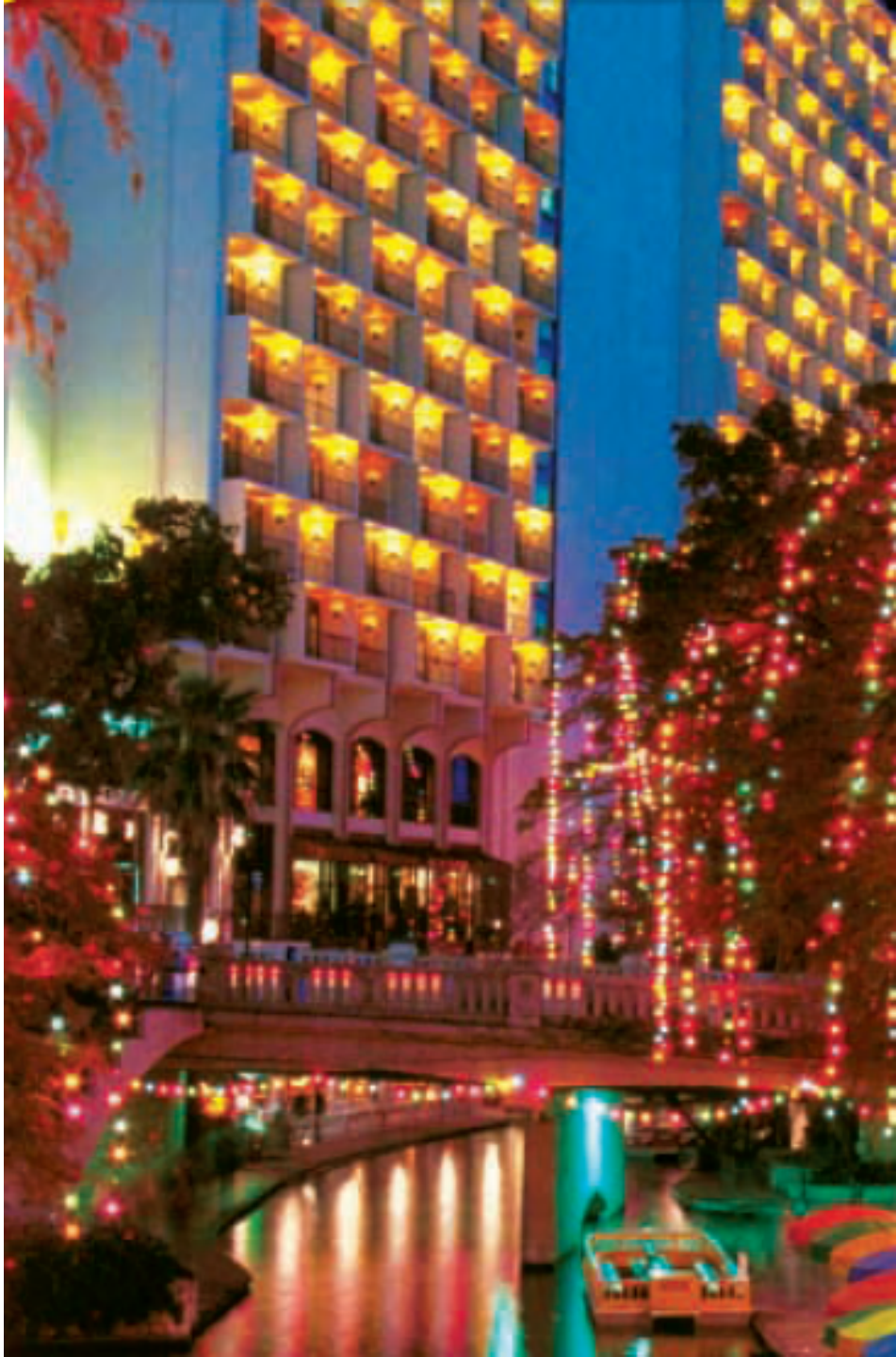
Electricity and Magnetism

Module 6

What is electricity?

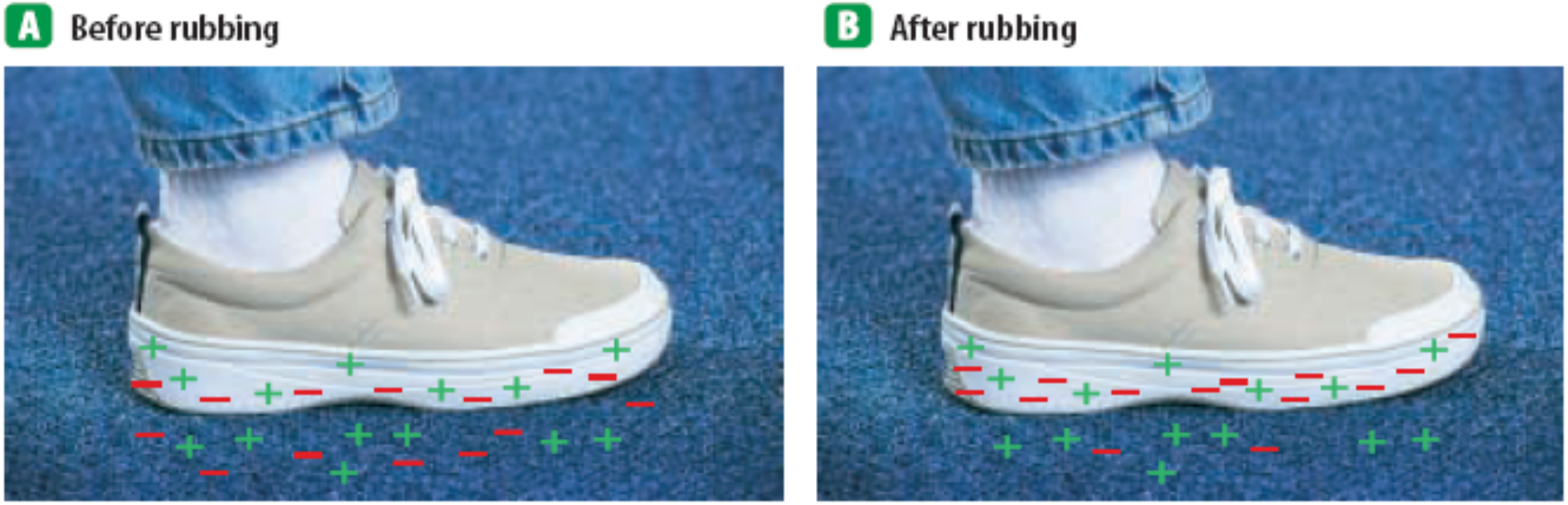
The collection or flow of electrons in the form of an electric charge



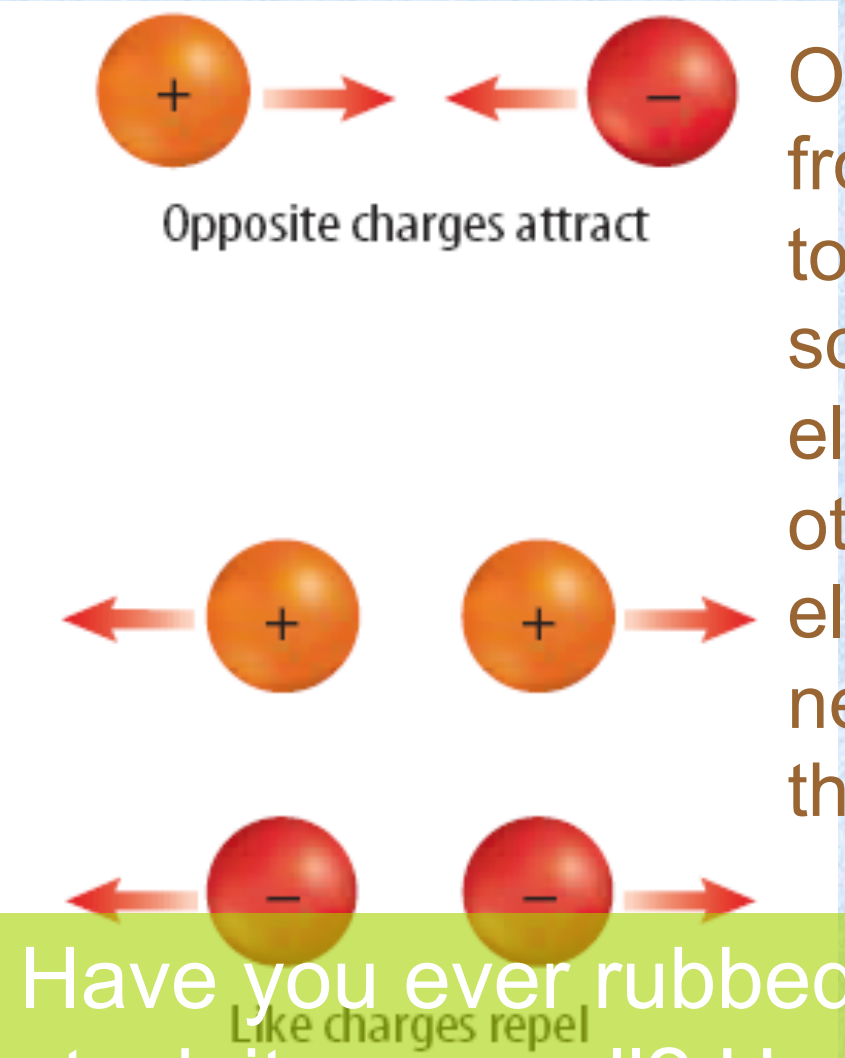
What is static electricity?

When two objects rub against each other electrons transfer and build up on an object causing it to have a different charge from its surroundings.

Like the shoes rubbing against the carpet. Electrons are transferred from the carpet to the shoes.

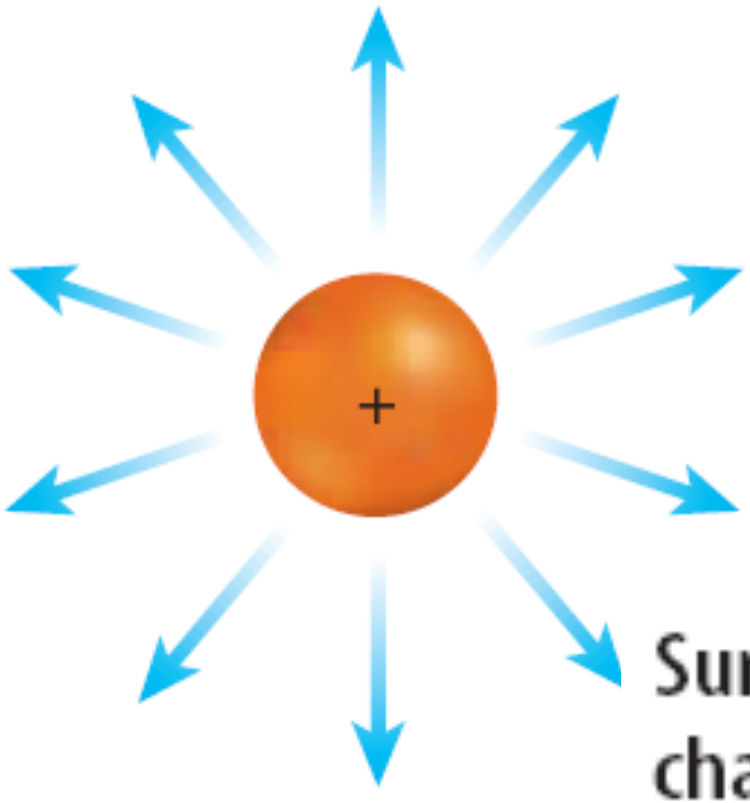


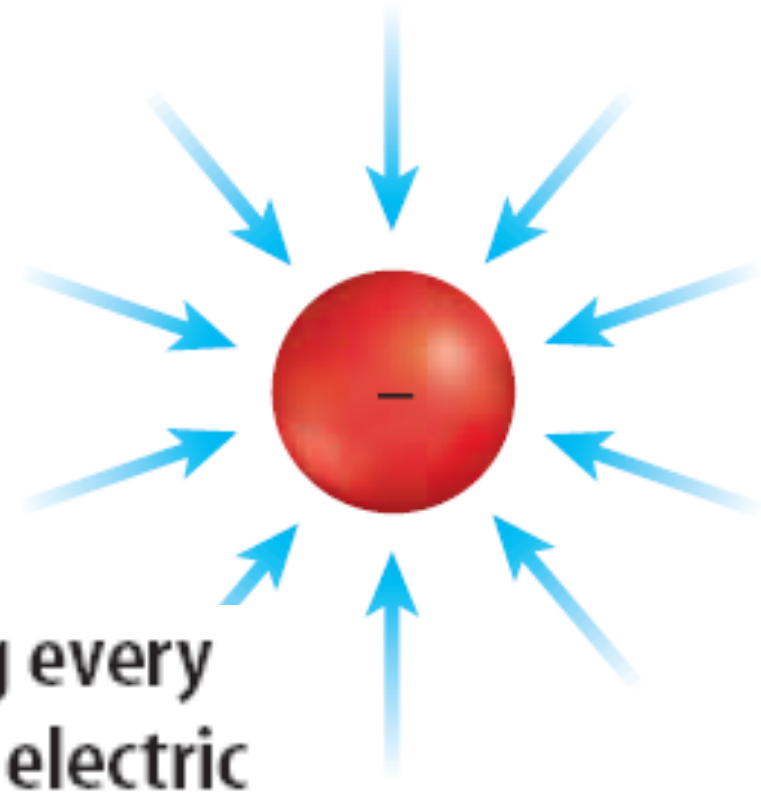
As electrons collect on an object, it becomes negatively charged. As electrons leave an object it attains a positive charges. Charges interact with each other:



Often when you remove clothes from the clothes dryer, they seem to stick together. This is because some of the clothes have gained electrons by rubbing against other clothes. The clothes losing electrons become positive. The negative clothes are attracted to the positive clothes.

Have you ever rubbed a balloon on your hair and stuck it on a wall? How do you think this works?



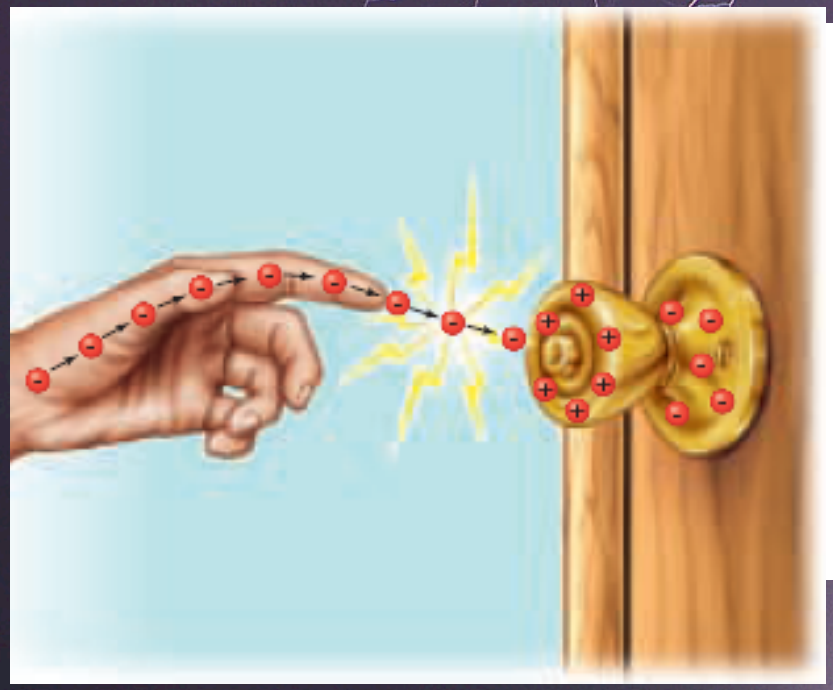


Surrounding every charge is an electric field. Through the electric field, a charge is able to push or pull on another charge.

The van de Graaf generator (large silver ball) deposits electrons on the ball. When a person places their hand on the ball and the machine is turned on, electrons are transferred to and collected on the person touching the silver ball.

Why do you think this machine affects the hair of the children in the picture?

What causes you to be shocked when you rub your feet across carpet?



As you walk across a carpeted floor, your body builds up a static charge. When you reach for a metal doorknob, the charges flow between your hand and the doorknob and you feel a shock.

An electrical discharge is the passing of an electric current through the air from a negatively charged object to a positively charge object. This is what causes lightning.

Check out these static electricity video clips

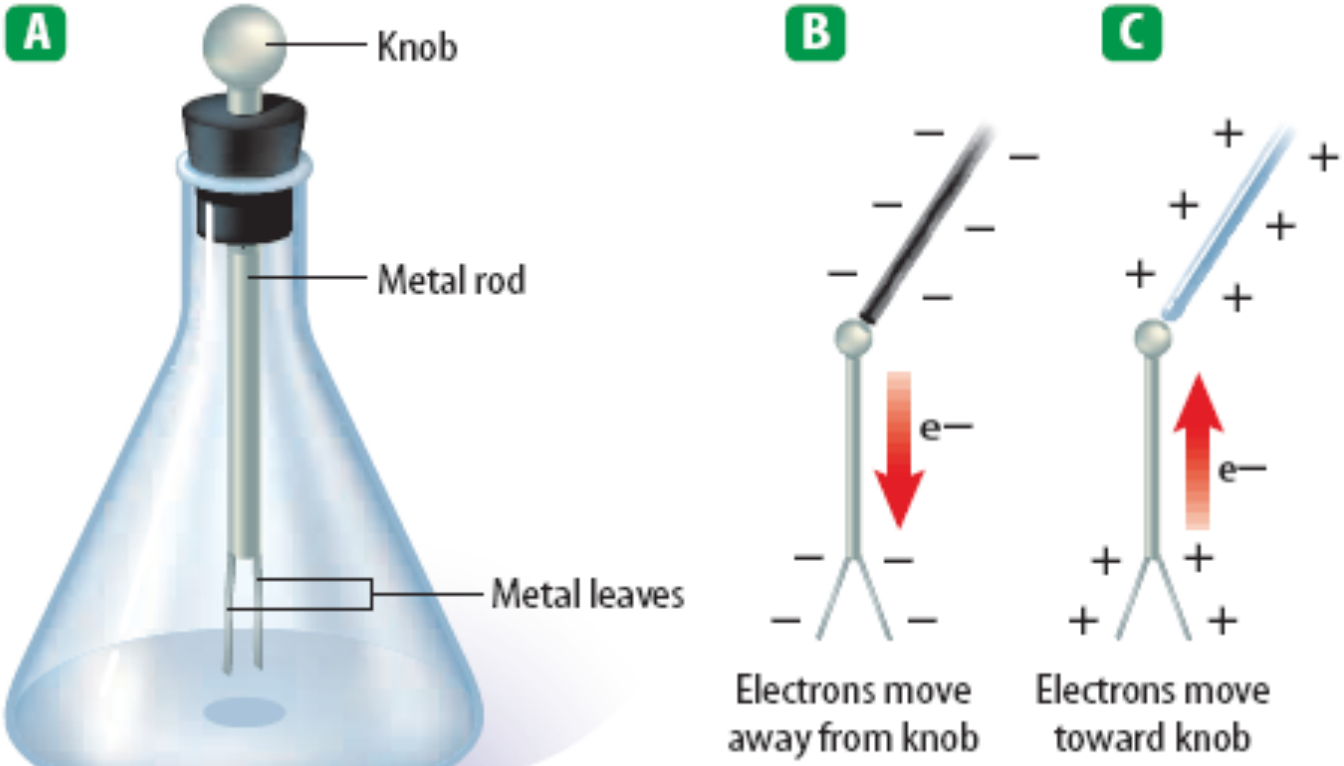
- Static electricity at a gas station
- Van de Graaf Generator's effect on human hair
- Static on Baby's hair
- Kid gets static going down a slide
- "Cat abuse" by static electricity

What is a conductor and insulator?

A conductor is a material which allows an electric current to pass. Metals are good conductors of electricity.

An insulator is a material which does not allow an electric current to pass. Nonmetals are good conductors of electricity. Plastic, glass, wood, and rubber are good insulators

How are static charges detected?

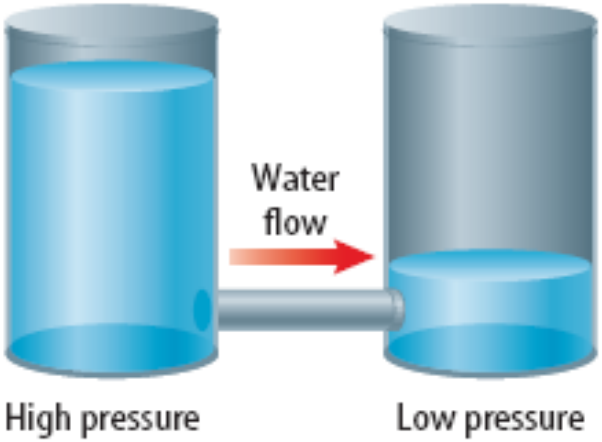


Notice the position of the leaves on the electroscope when they are A uncharged, B negatively charged, and C positively charged.

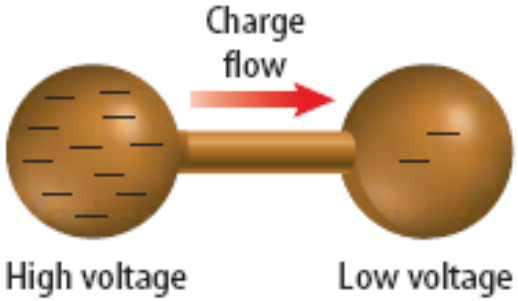
What is the difference between static electricity and current electricity?

Static electricity is stationary or collects on the surface of an object, whereas current electricity is flowing very rapidly through a conductor.

The flow of electricity in current electricity has electrical pressure or voltage. Electric charges flow from an area of high voltage to an area of low voltage.



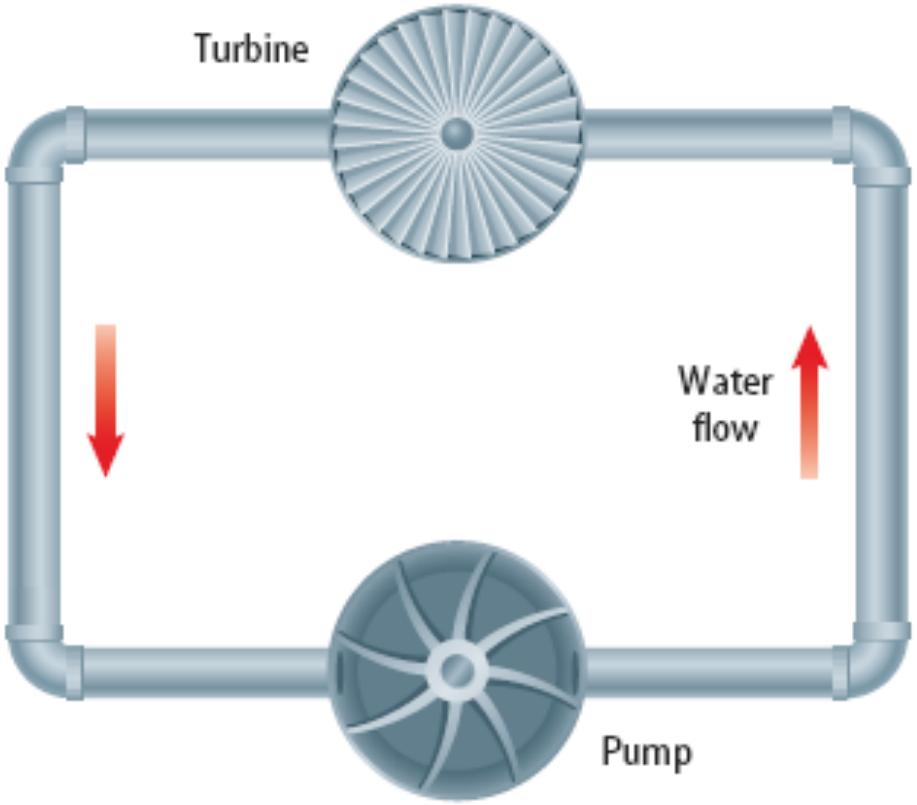
A A pressure difference causes water to flow.



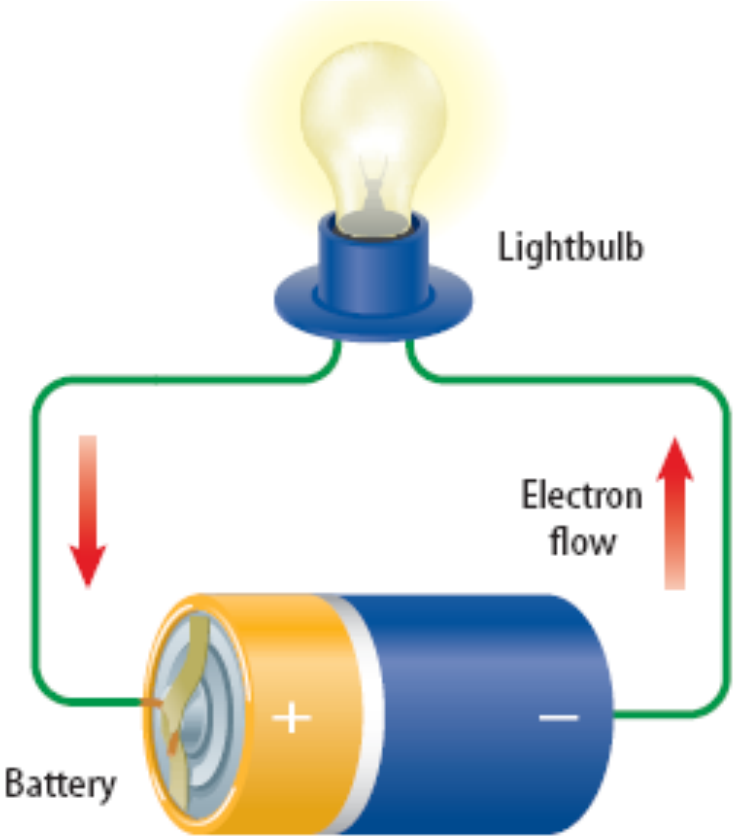
B A voltage difference causes charge to flow.

Water pressure and voltage behave in similar ways.

There are some similarities between the flow of water in a pipe and the flow of electric current through a circuit.



A Water flows only when the pipe makes a closed loop.



B Electric charge flows only when the wire makes a closed loop.

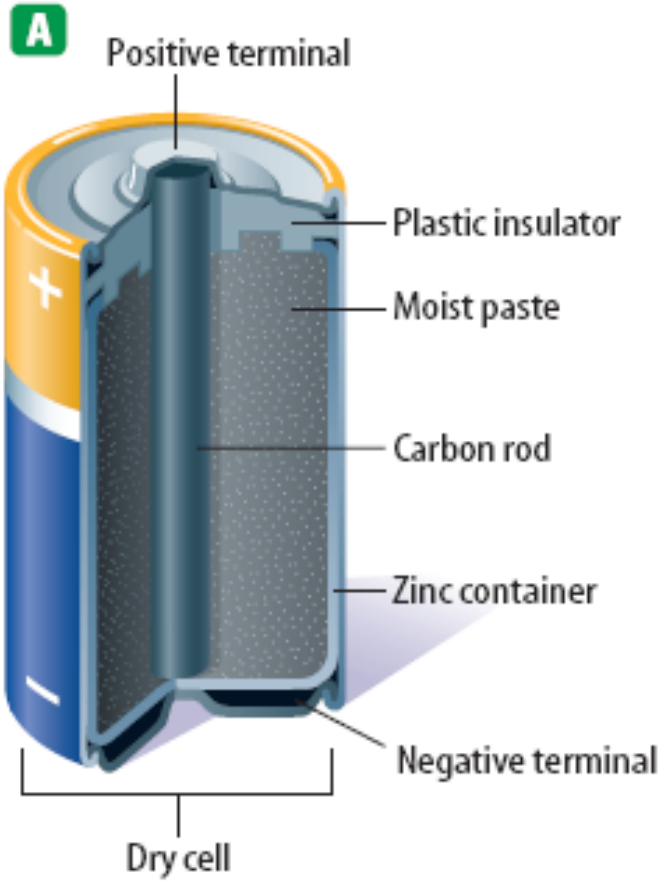
The pressure of the water flowing through the pipes on the last slide compare to the voltage (electric potential) flowing through the wires of the circuit. The unit used to measure voltage is volts (V).

The flow of charges in a circuit is called current. Current (I) is measured in Amperes (A).

What are batteries?

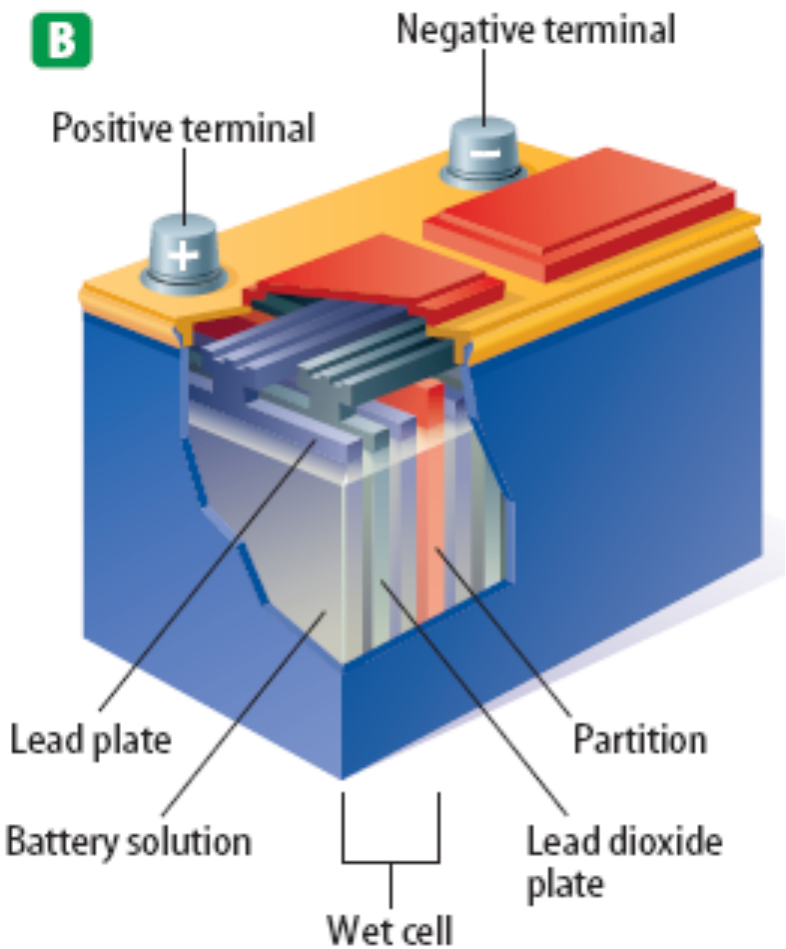
Batteries are composed of a chemical substance which can generate voltage which can be used in a circuit.

There are two kinds of batteries: dry cell and wet cell batteries. Below is an example of a dry cell.



The zinc container of the dry cell contains a moist chemical paste surrounding a carbon rod suspended in the middle.

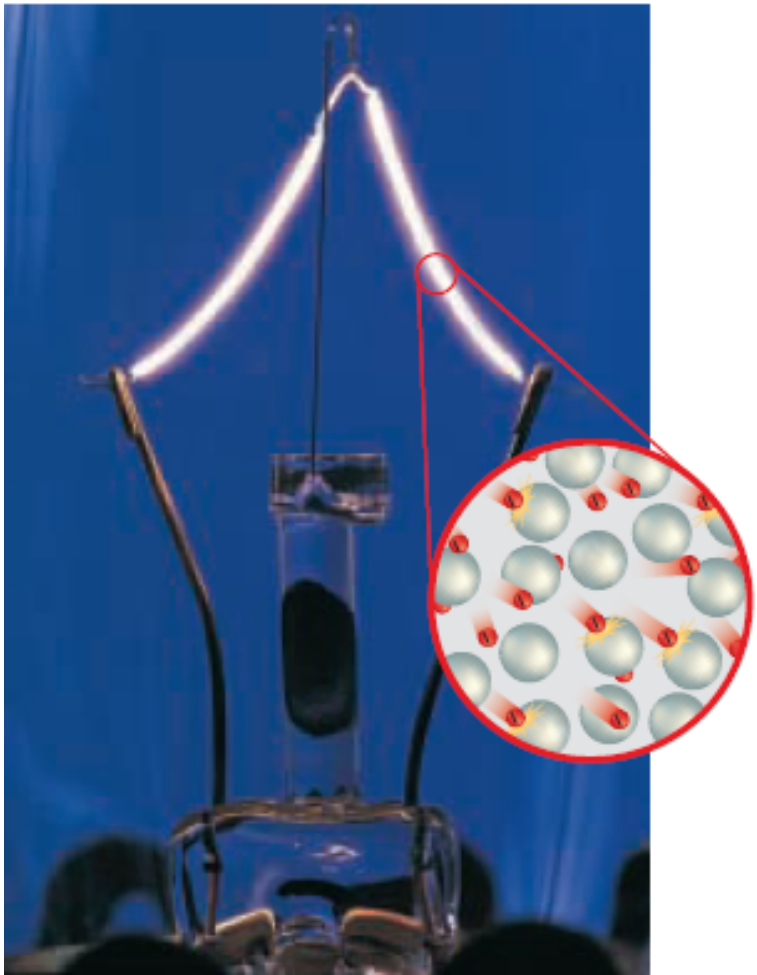
Wet cell batteries are most commonly associated with automobile batteries.



A wet cell contains two connected plates made of different metals or metal compounds in a conducting solution. Most car batteries have a series of six cells, each containing lead and lead oxide in a sulfuric acid solution.

What is electrical resistance?

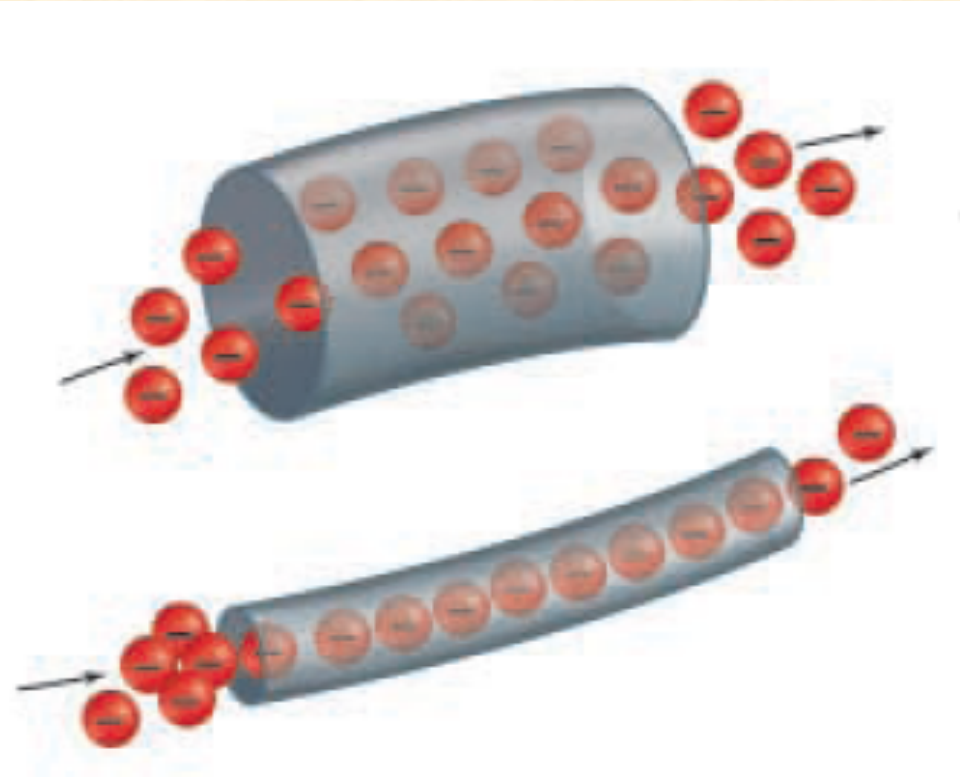
Resistance (R)is the opposition to the flow of an electric current, causing the electrical energy to be converted to thermal energy or light.



As electrons move through the filament in a lightbulb, they bump into metal atoms. Due to the collisions, the metal heats up and starts to glow.

The metal which makes up a light bulb filament or stovetop eye has a high electrical resistance. This causes light and heat to be given off.

The unit for measuring resistance is the **ohm (Ω).**



The resistance of a short, thick piece of wire is less than the resistance of a long, thin piece of wire.

Electrical Calculations – What is Ohm's Law?

$$\text{current} = \frac{\text{voltage difference}}{\text{resistance}}$$

$$I\,(\text{A}) = \frac{V\,(\text{V})}{R\,(\Omega)}$$

$$V = IR$$

A toy car with a resistance of 2 Ω is connected to a 3 V battery. How much current flows through the car?

$$I\,(\text{A}) = \frac{V\,(\text{V})}{R\,(\Omega)}$$

$$I = \frac{3\ \text{V}}{2\ \Omega}$$

I = 1.5 amps

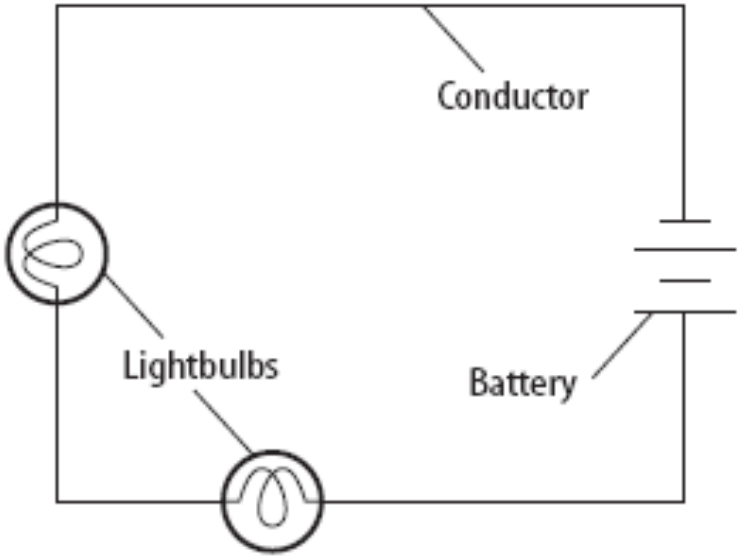
What are electric circuits?

Circuits typically contain a voltage source, a wire conductor, and one or more devices which use the electrical energy.

What is a series circuit?

A series circuit is one which provides a single pathway for the current to flow. If the circuit breaks, all devices using the circuit will fail.

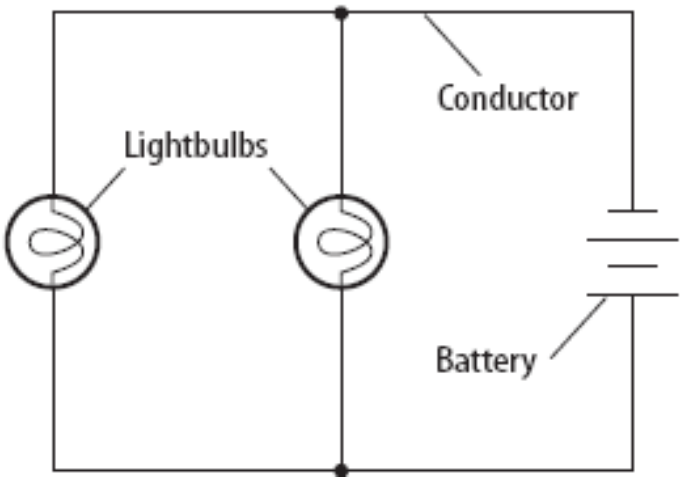
A series circuit provides only one path for the current to follow. *What happens to the brightness of each bulb as more bulbs are added?*

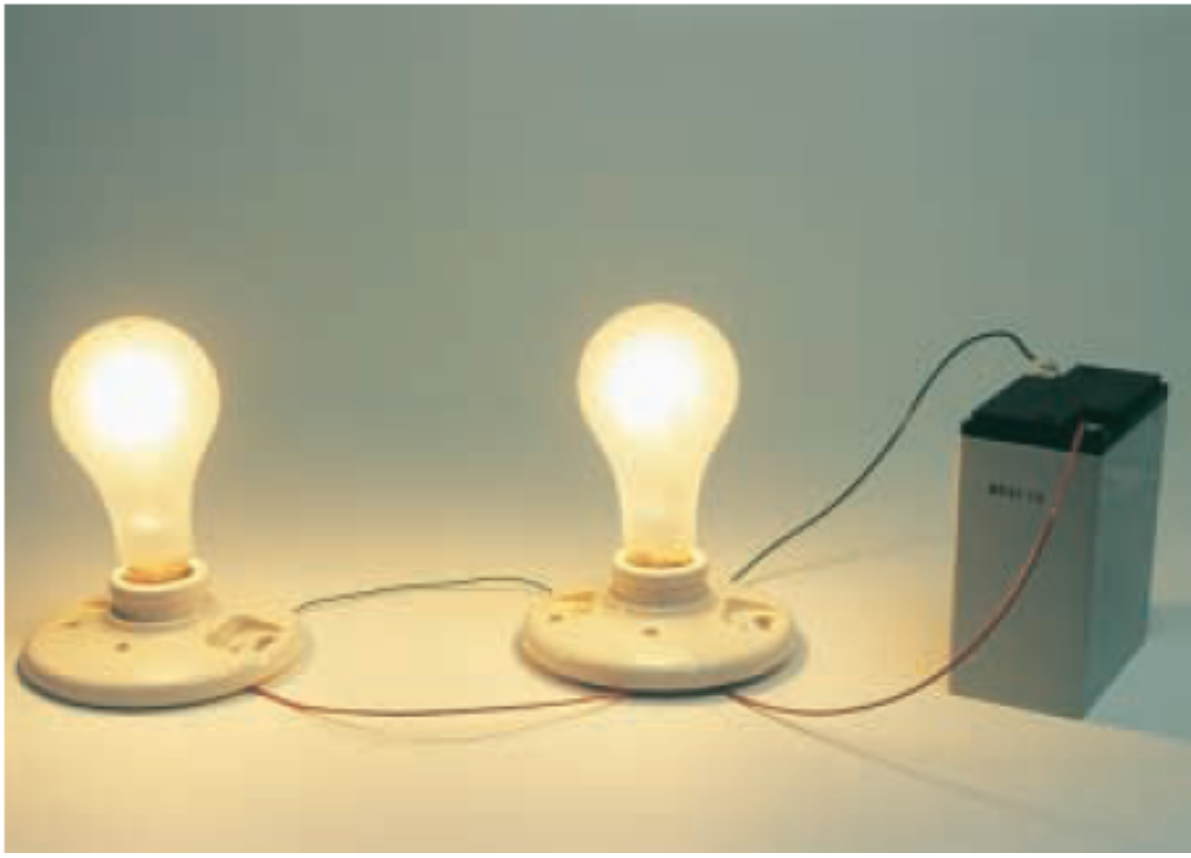


What is a **parallel** circuit?

A parallel circuit has multiple pathways for the current to flow. If the circuit is broken the current may pass through other pathways and other devices will continue to work.

Figure 18
In parallel circuits, the current follows more than one path. *How will the voltage difference compare in each branch?*





What is the difference between an open circuit and a closed circuit?

A closed circuit is one in which the pathway of the electrical current is complete and unbroken.

An open circuit is one in which the pathway of the electrical current is broken. A switch is a device in the circuit in which the circuit can be closed (turned on) or open (turned off).

How is household wiring arranged?

Most household wiring is logically designed with a combination of parallel circuits. Electrical energy enters the home usually at a **breaker box** or **fuse box** and distributes the electricity through multiple circuits. A **breaker box** or **fuse box** is a safety feature which will open

A

B

Two useful devices to prevent electric circuits from over-heating are A fuses and B circuit breakers.

How is Electrical Power calculated?

Electrical Power is the product of the current (I) and the voltage (v)

The unit for electrical power is the same as that for mechanical power in the previous module – the watt (W)

$$\text{power} = \text{current} \times \text{voltage difference}$$

$$P\,(\text{watts}) = I\,(\text{amperes}) \times V\,(\text{volts})$$

Example Problem: How much power is used in a circuit which is 110 volts and has a current of 1.36 amps?

P = I V

Power = (1.36 amps) (110 V) = 150 W

How is electrical energy determined?

Electrical energy is a measure of the amount of power used and the time of use.

Electrical energy is the product of the power and the time.

$$\text{energy} = \text{power} \times \text{time}$$

$$E\,(\text{kWh}) = P\,(\text{kW}) \times t\,(\text{h})$$

Example problem:

The current flowing through an appliance connected to a 120-V source is 2 A. How many kilowatt-hours of electrical energy does the appliance use in 4 h?

E = P X time

P = I V

P = (2A) (120 V) = 240 W

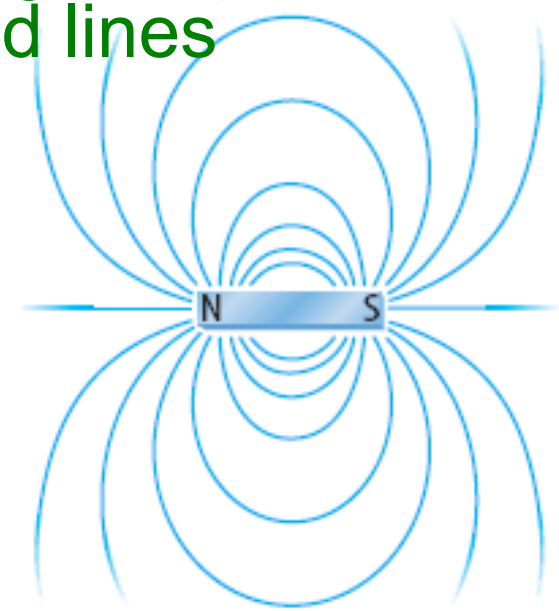
E = (240 W) (4 h) = 960Wh = **0.96 kWh**

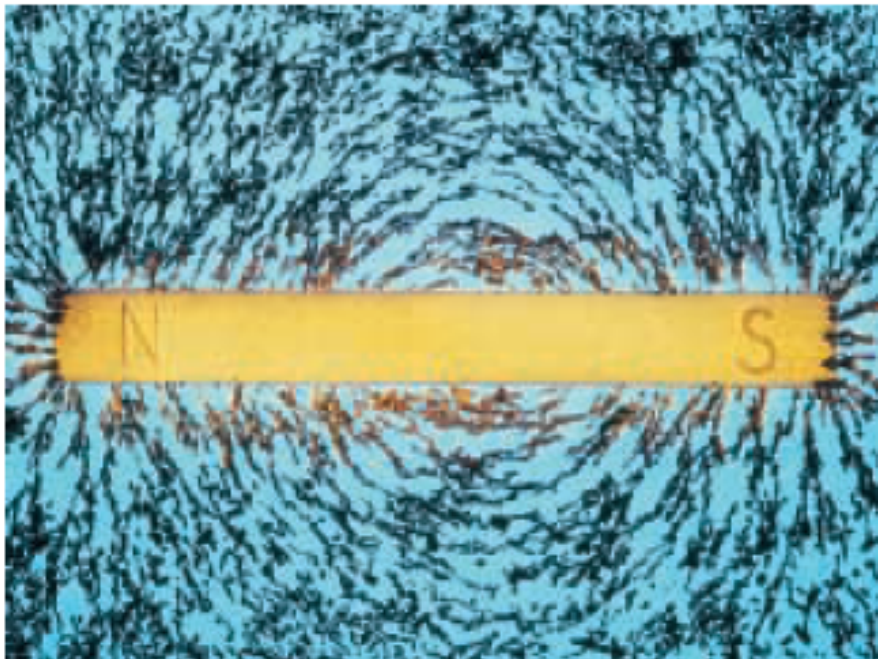
What is magnetism?

Magnetism is the properties
magnets

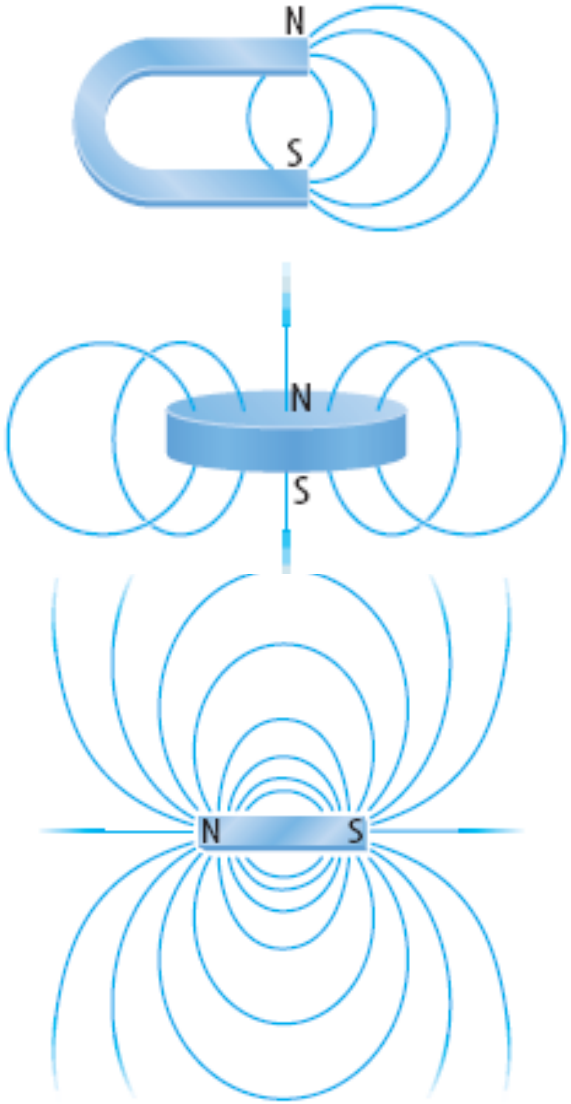
The earliest magnets were foun ineral *magnetite* which is abundant th *ne*. These magnets were used by th as compasses to guide sailing vessels.

Magnets produce magnetic forces and have magnetic field lines





Magnets have two ends or poles, called north and south poles. At the poles of a magnet, the magnetic field lines are closer together.

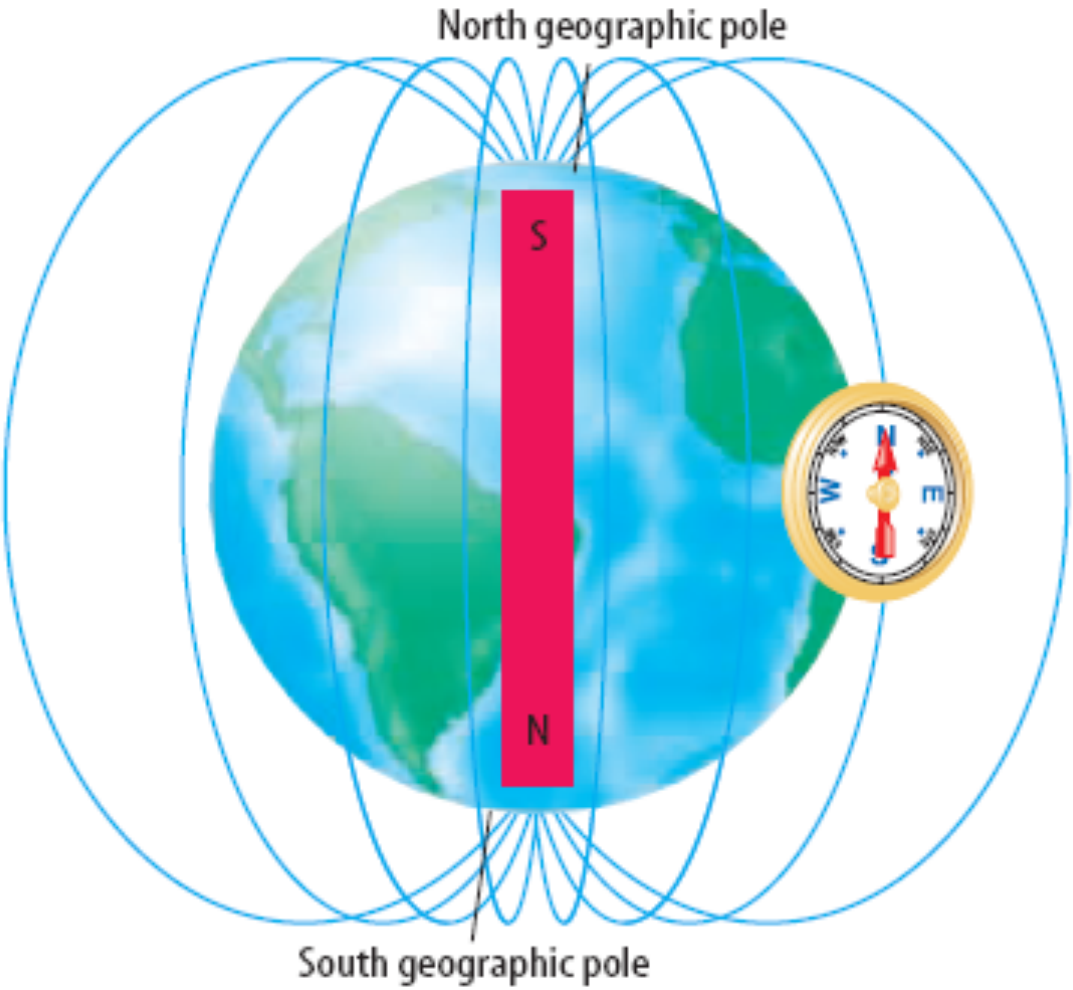


The magnetic field lines around horse-shoe and disk magnets are closest together at the magnets' poles.

Unlike poles of magnets attract each other and like poles of magnets repel.

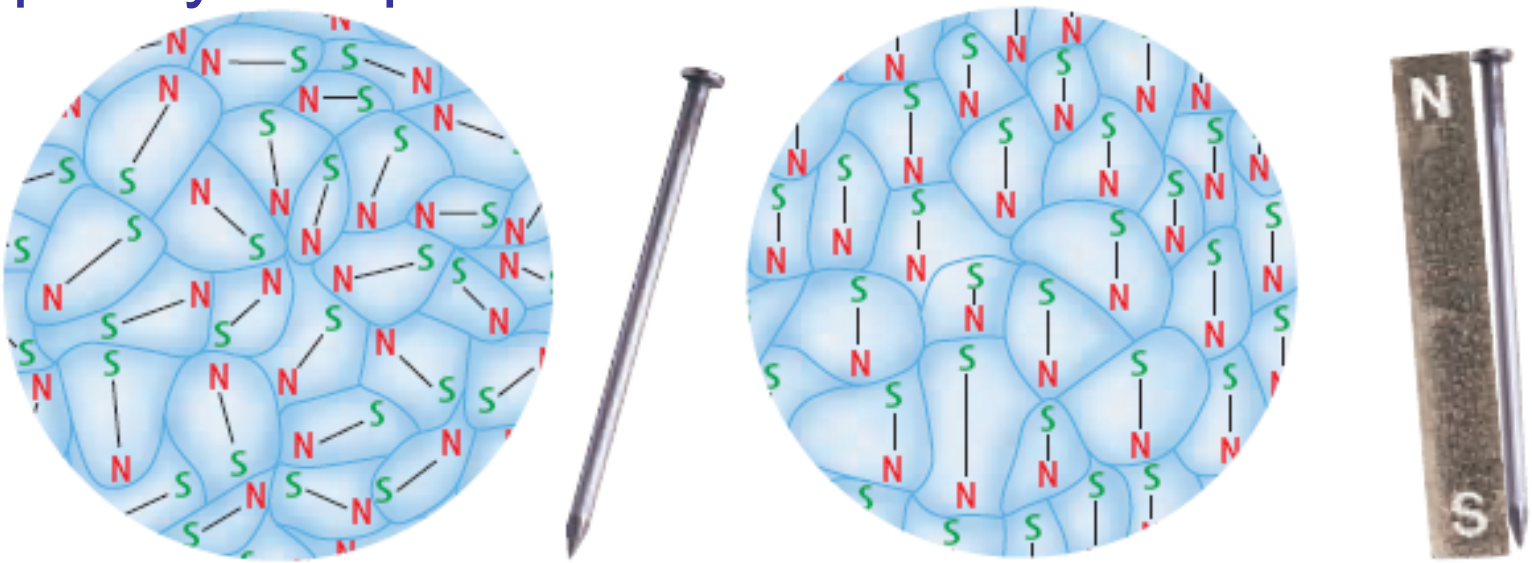
The earth is like a giant magnet!

The nickel iron core of the earth gives the earth a magnetic field much like a bar magnet.



What are magnetic domains?

Magnetic substances like iron, cobalt, and nickel are composed of small areas where the groups of atoms are aligned like the poles of a magnet. These regions are called domains. All of the domains of a magnetic substance tend to align themselves in the same direction when placed in a magnetic field. These domains are typically composed of billions of atoms.

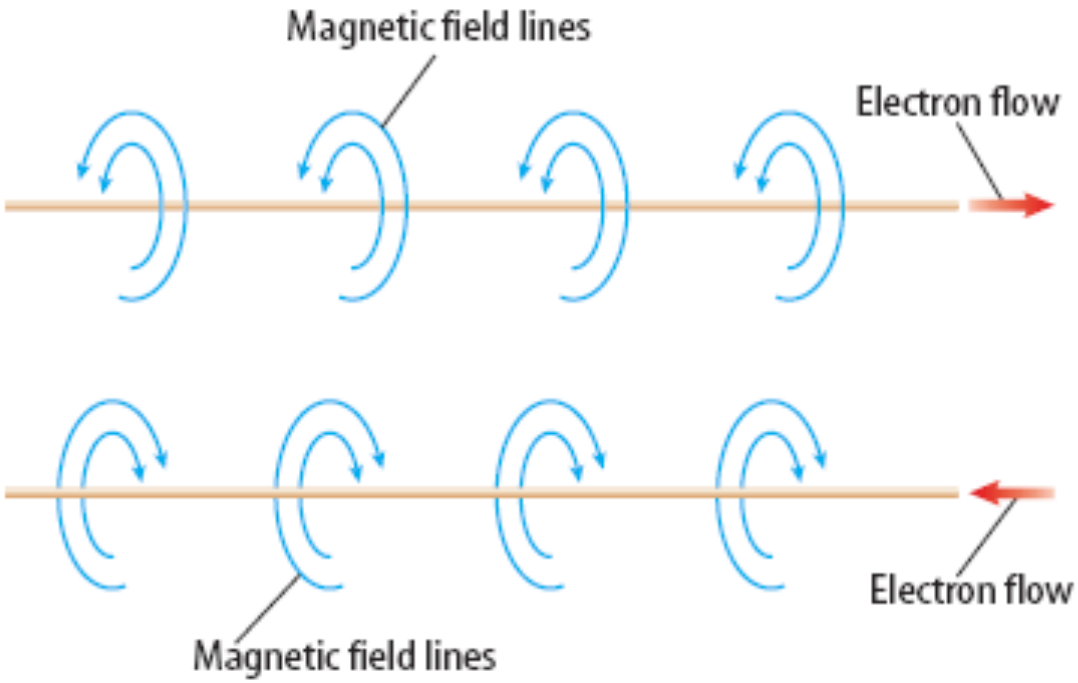


A A normal iron nail is made up of billions of domains that are arranged randomly.

B The domains will align themselves along the magnetic field lines of a nearby magnet.

Electricity and Magnetism – how are they related?

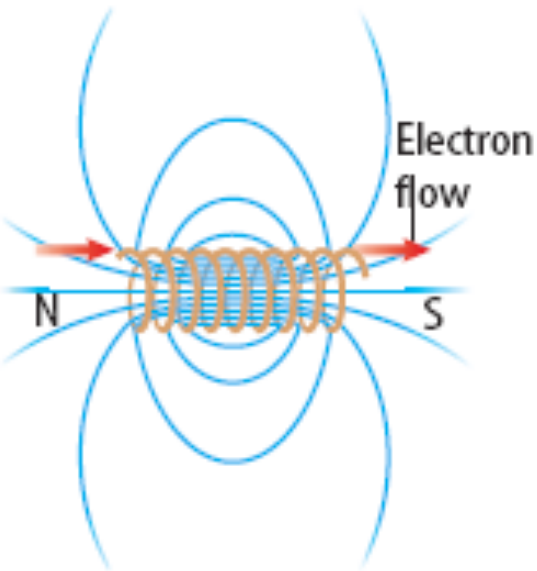
When an electric current passes through a wire a magnetic field is formed.

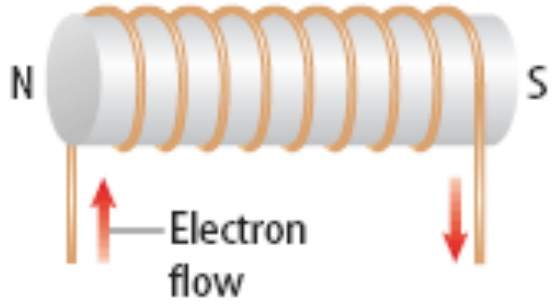


When electric current flows through a wire, a magnetic field forms around the wire. The direction of the magnetic field depends on the direction of the current in the wire.

What is an electromagnet?

When an electric current is passed through a coil of wire wrapped around a metal core, a very strong magnetic field is produced. This is called an electromagnet.



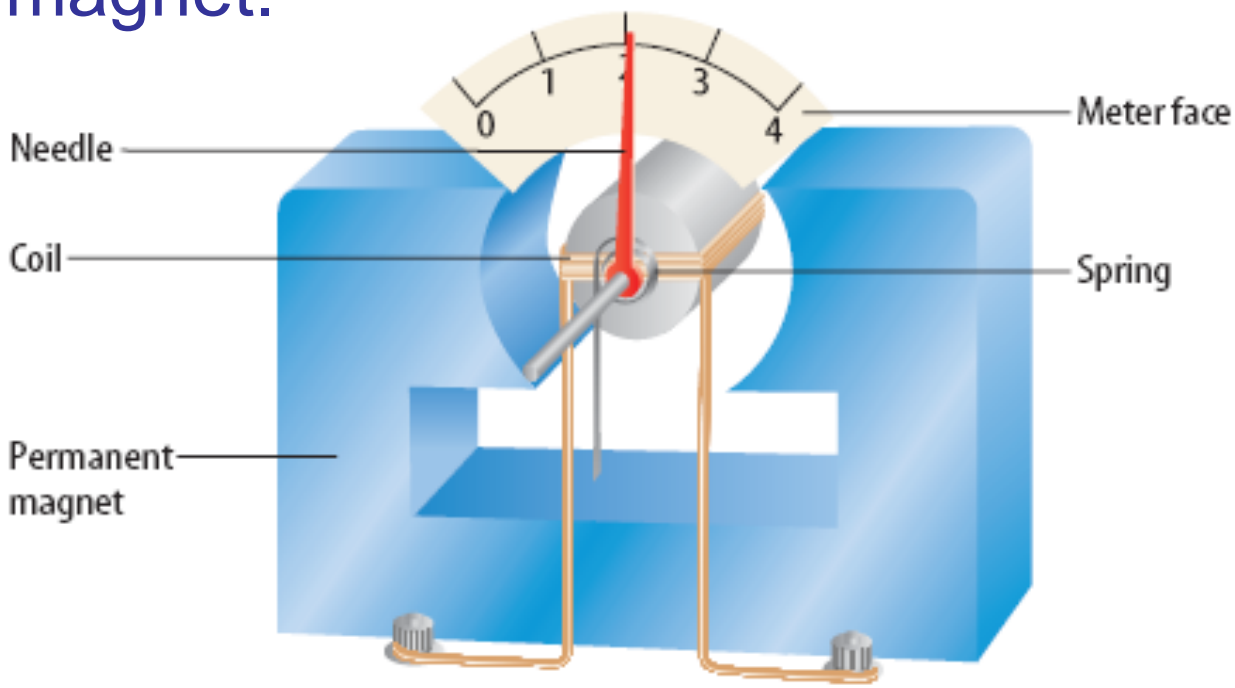


An iron core inserted into the coil becomes a magnet.

What is a galvanometer?

A galvanometer is an electromagnet that interacts with a permanent magnet. The stronger the electric current passing through the electromagnet, the more is interacts with the permanent magnet.

A galvanometer includes a permanent magnet, an electromagnet that rotates against a spring, and a scale that gives a measurement of the current.

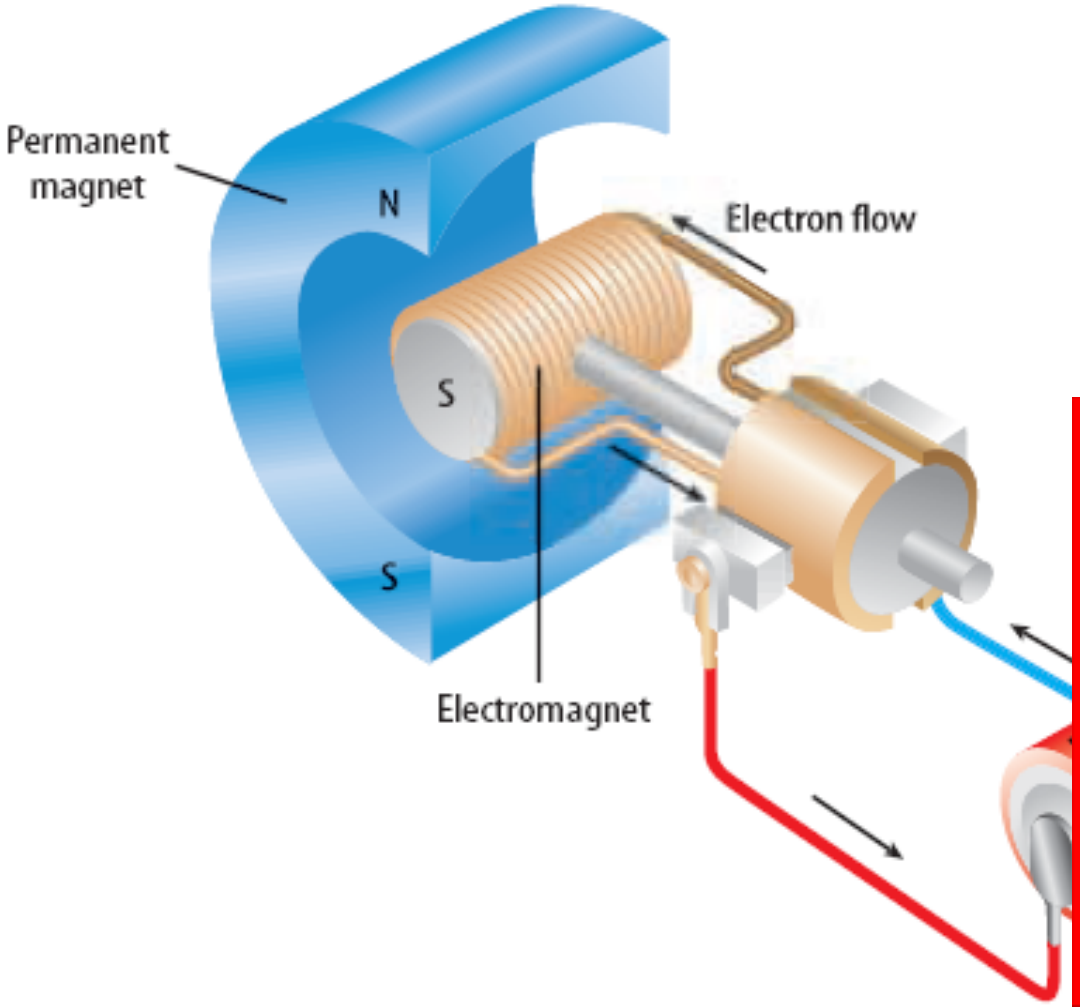


Galvanometers are used as gauges in cars and many other applications.

The greater the current passing through the wires, the stronger the galvanometer interacts with the permanent magnet.

What are electric motors?

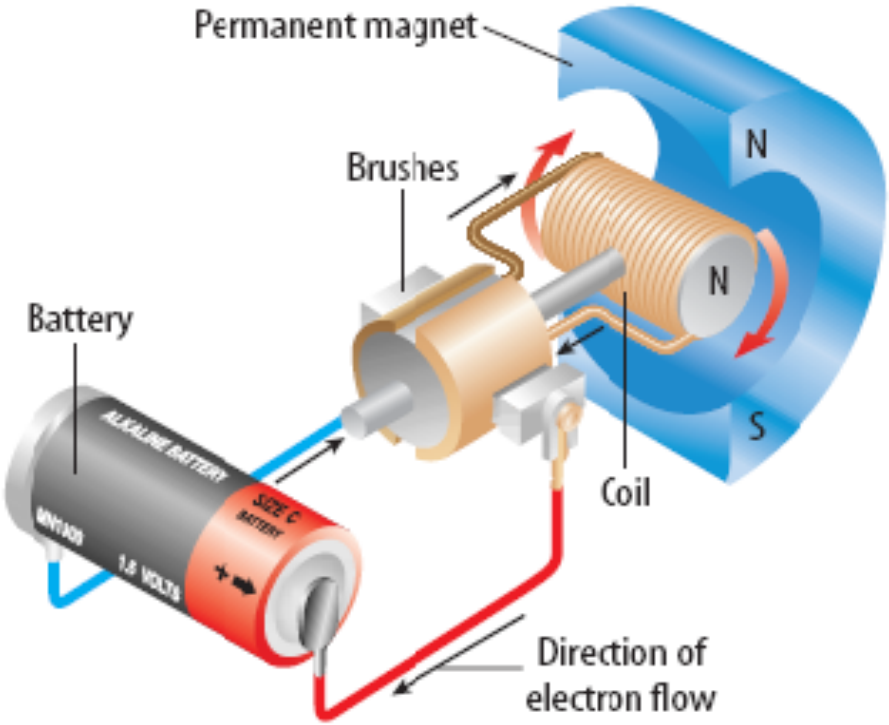
An electric motor is a device which changes electrical energy into mechanical energy.



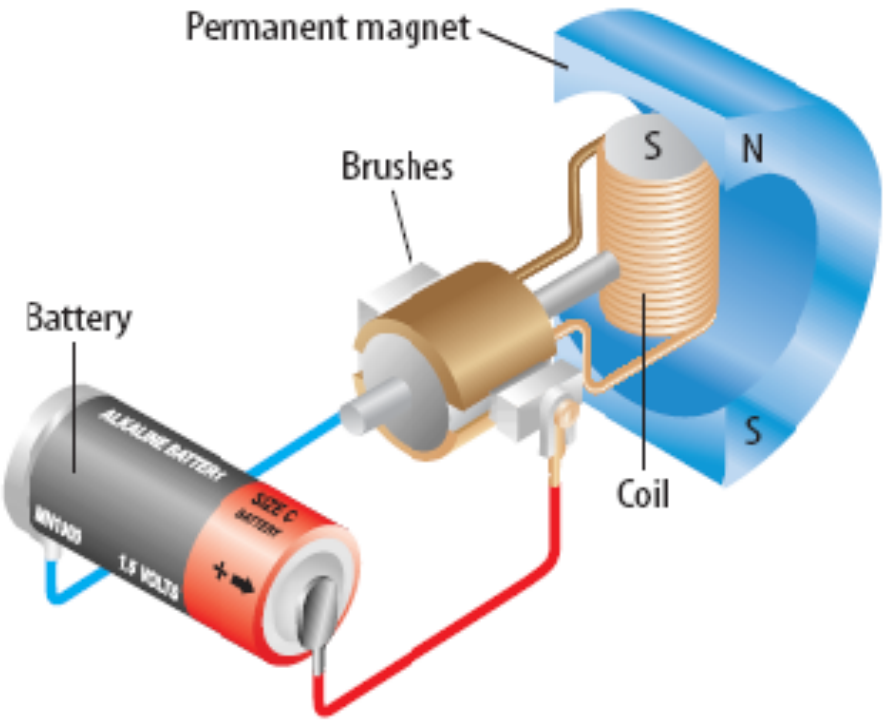
A basic electric motor has a power supply, a permanent magnet, and an electromagnet that can rotate.

Simplest Electric Motor

How does an electric motor work?

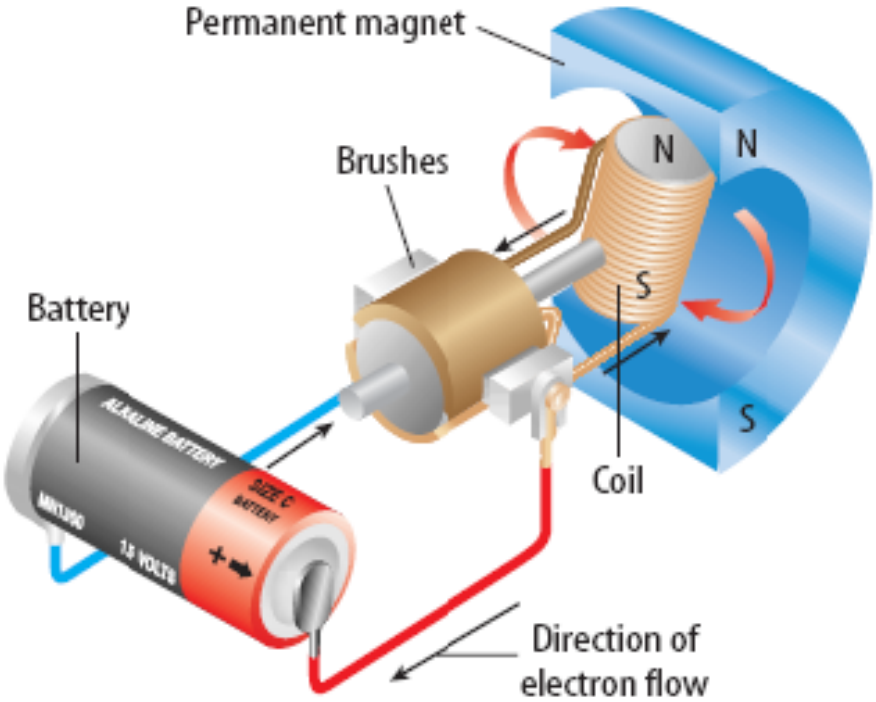


A A battery causes an electric current to flow through the coil of the electromagnet.

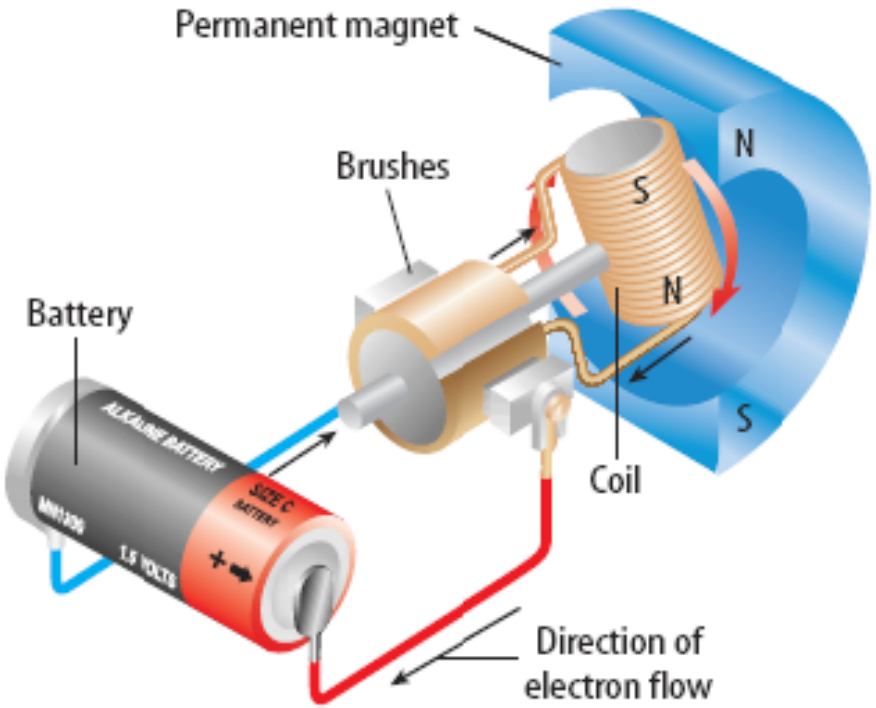


B Unlike poles of the two magnets attract each other, and the like poles repel. This causes the coil to rotate until the opposite poles are next to each other.

Go to the next slide →



C If the current in the coil is switched, the direction of the coil's magnetic field also switches. The north and south poles of the magnet trade places.



D The coil is repelled by and attracted once again to the poles of the permanent magnet. The coil rotates until it is again aligned with the permanent magnet's field.

Simple as that!!

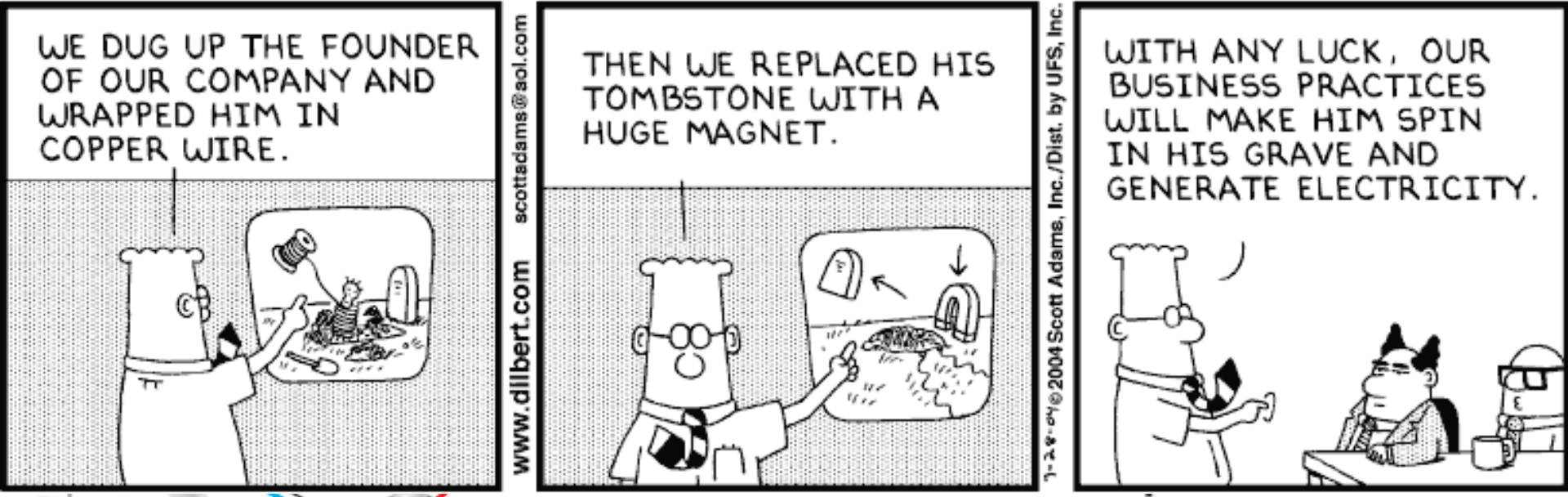
We have seen how electricity can produce a magnetic field, but a magnetic field can also produce electricity! How?

What is electromagnetic induction?

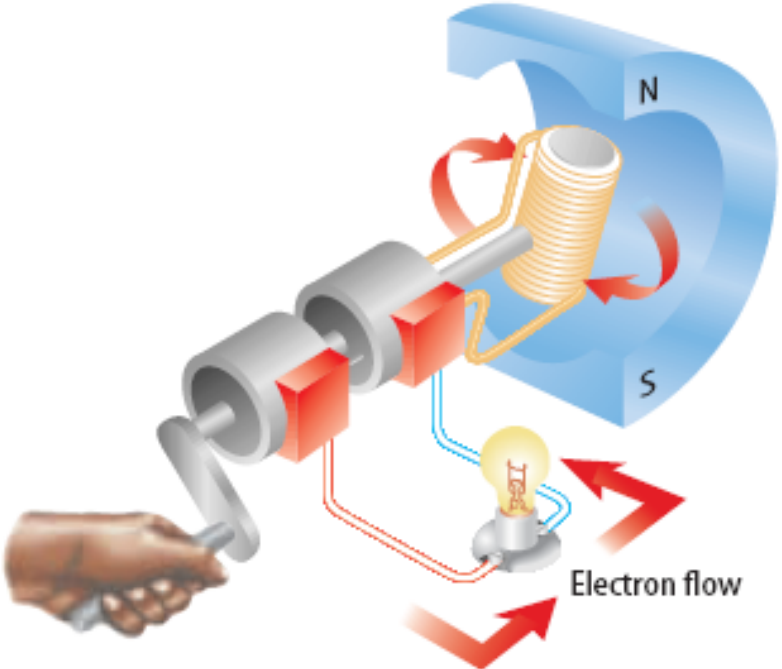
Moving a loop of wire through a magnetic field produces an electric current. This is electromagnetic induction.

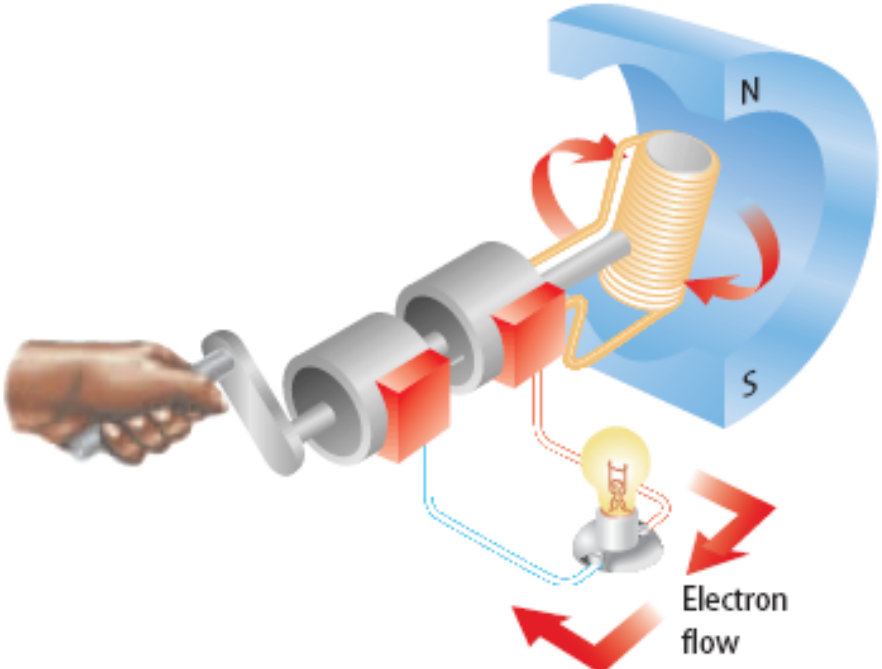
A generator is used to convert mechanical energy into electrical energy by electromagnetic induction.

Carefully study the next diagrams:



the wire coil is aligned with the permanent magnet.





Direct current versus alternating current –

AC vs DC : What's the difference?

Direct current is electrical current which comes from a battery which supplies a constant flow of electricity in one direction.

Alternating current is electrical current which comes from a generator. As the electromagnet is rotated in the permanent magnet the direction of the current *alternates* once for every revolution.

Go to this website and click the button for DC then for AC to visually see the difference between the two.

You can see that the DC source is a battery – current flows in one direction. The AC source is the generator and the current alternates once for each revolution.

This concludes Module 6!!!