Lecture (01) Introduction to Electric Charges and Electric Field (1)

By:

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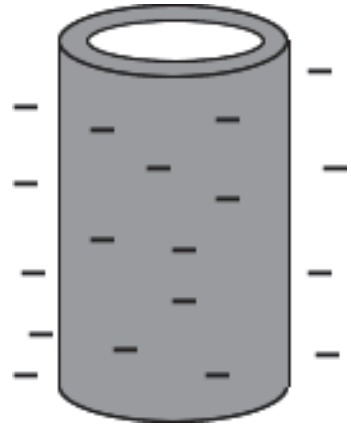
Agenda

- Basics of Static Electricity
- Cause of static electricity
- Electric Charge in the Atom
- Electrostatic Induction
- Electrostatic Conduction
- Grounding
- Static Electricity Forces

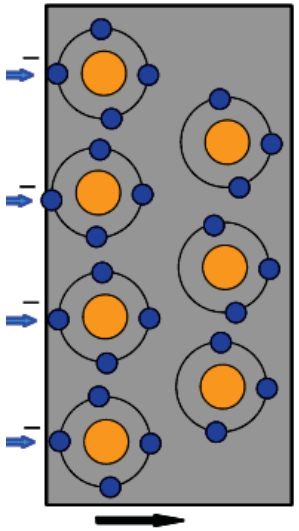
Basics of Static Electricity

- Static electricity is the buildup of electrical charges on the surface of some object or material.
- Static electricity is usually created when materials are pulled apart or rubbed together, causing positive (+) charges to collect on one material and negative (−) charges on the other surface.
- Results from static electricity may be sparks, shocks or materials clinging together.

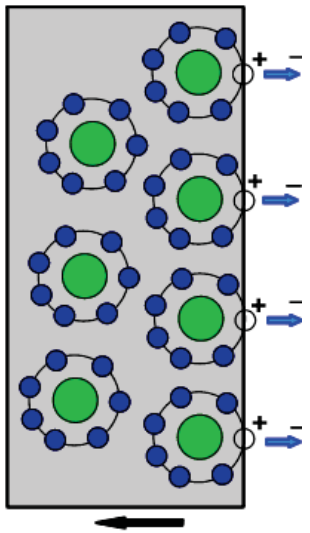
- Static electricity is the accumulation of electrical charges on the surface of a material, usually an insulator or non-conductor of electricity.
- It is called "static" because there is no current flowing,
- Typically, two materials are involved in static electricity, with one having an excess of electrons or negative (−) charges on its surface and the other material having an excess of positive (+) electrical charges.



- Atoms near the surface of a material that have lost one or more electrons will have a positive (+) electrical charge.



- If one of the materials is an electrical conductor that is grounded, its charges will drain off immediately, leaving the other material still charged.

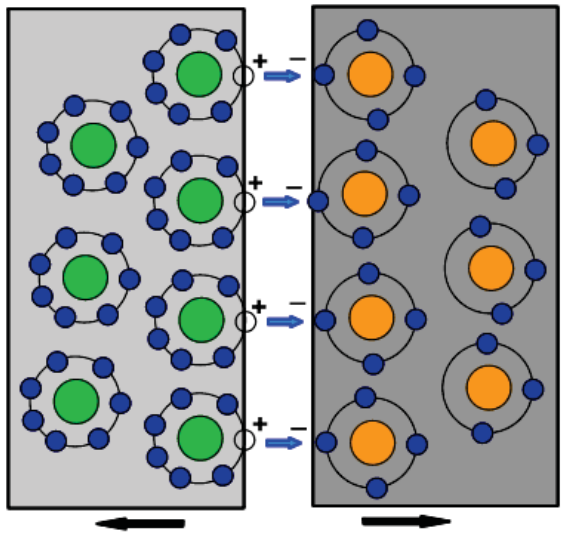


Cause of static electricity

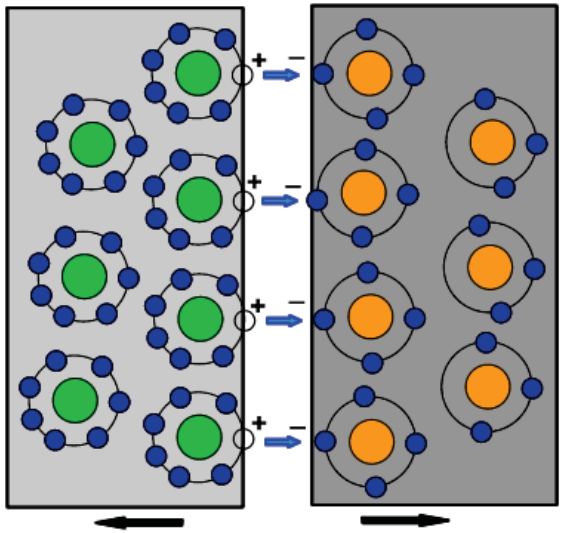
- triboelectric charging
- electrostatic induction
- Special pressure and heating causes

triboelectric charging

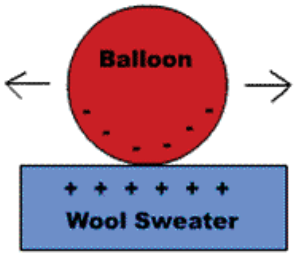
- Static electricity is usually caused when certain materials are rubbed against each other
- The process causes electrons to be pulled from the surface of one material and relocated on the surface of the other material.



- It is called the triboelectric effect or triboelectric charging.
- The material that loses electrons ends up with an excess of positive (+) charges.
- The material that gains electrons ends up an excess of negative (−) charges on its surface.



- Certain combination of materials work better than others in creating static electricity.
- Dry human skin and rabbit fur have the greatest tendency to give up electrons when rubbed on something and become positively (+) charged.
- Teflon and vinyl have the greatest tendency to become negatively charged (−) when rubbed.
- If you want to create static electricity, rubbing fur on Teflon should give the best results.



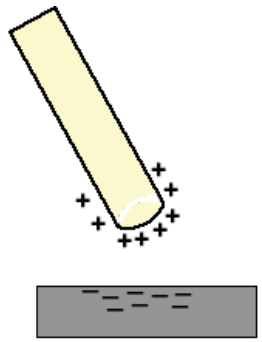
Materials that gain a positive (+) electrical charges (Tend to give up electrons)
Dry human skin
Leather
Rabbit fur
Glass
Human hair
Nylon
Wool
Cat fur
Silk
Aluminum
Paper

Materials that are relatively neutral
Cotton
Steel

Materials that gain a negative (−) electrical charges (Tend to attract electrons)
Wood
Hard rubber
Nickel, Copper
Silver
Gold, Platinum
Polyester
Vinyl (PVC)
Silicon
Teflon

electrostatic induction

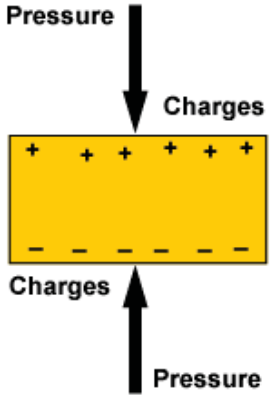
- Another way that static electricity commonly seen is when a charged material is brought near a neutral material.
- This is called electrostatic induction.



Special pressure and heating causes

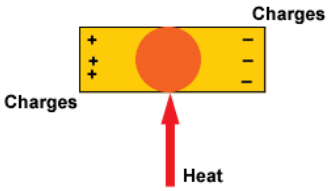
Piezoelectric effect

- When pressure or stress is applied to certain crystals, opposite electric charges collect on the ends of the crystal. By maintaining the pressure on the crystal, the static electric effects can be demonstrated.
- Piezoelectric effect creates charges near surfaces
- piezoelectric effect is used in creating an electrical current for numerous applications.



Pyroelectric effect

- Likewise, when heat is applied to certain materials, positive and negative charges move to opposite ends of the material.
- By maintaining the heat on the material, the static electric effects can be demonstrated.
- Pyroelectric effect creates charges near surfaces
- Although the separation of charges is considered static electricity, the usual applications of the pyroelectric effect is to create electric current for various devices.



MCQs

1. How does rubbing materials together cause static electricity?

A. Friction from rubbing causes electrons to deposit on the other material
B. The adhesive force between the materials separates the electric charges
C. Rubbing creates friction that shoots off sparks

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2. Do all materials cause static electricity equally?

A. Yes, since all materials have positive and negative charges
B. Materials have nothing to do with static electricity
C. No, certain combinations of materials work best to cause static electricity

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A. Yes, since all materials have positive and negative charges
B. Materials have nothing to do with static electricity
C. No, certain combinations of materials work best to cause static electricity

3. How could the piezoelectric effect used to show static electricity?

A. Show that opposite charges are attracted to end of pressed crystal
B. Press on the crystal until it explodes, sending off charged particles
C. The piezoelectric effect has nothing to do with static electricity

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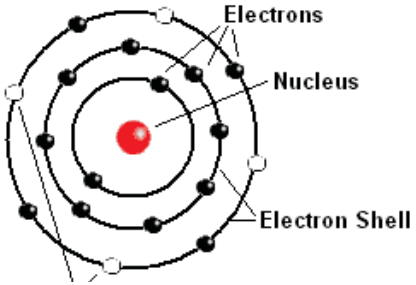
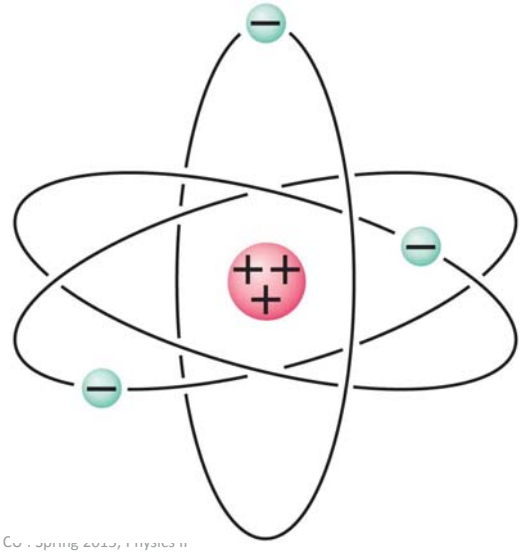
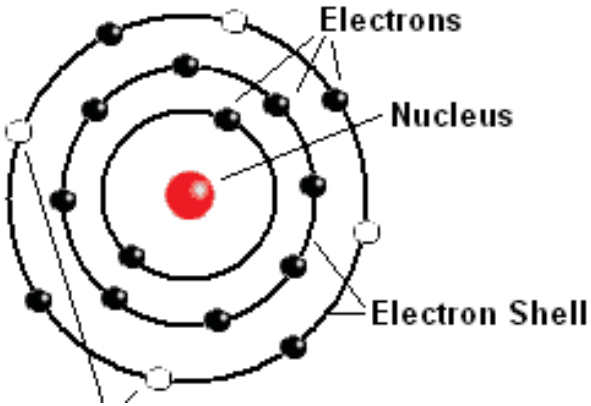
Electric Charge in the Atom

Atom:

- Nucleus (small, massive, positive charge)
- Electron cloud (large, very low density, negative charge)







Elementary charge

- Charge on the electron:

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

- Electric charge is quantized in units of the electron charge.

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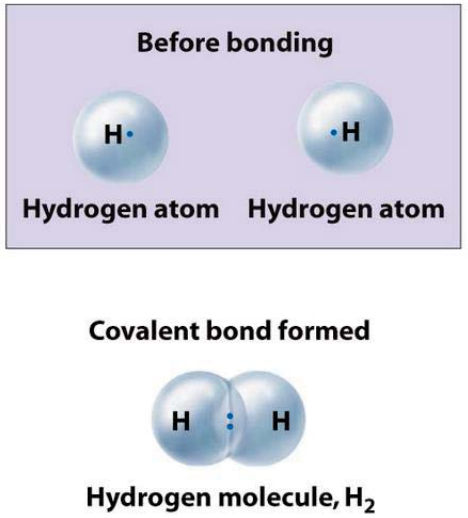
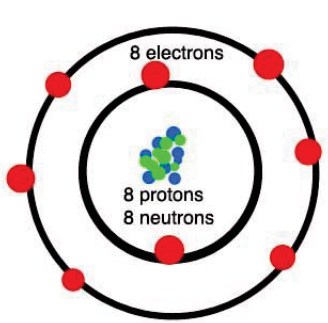
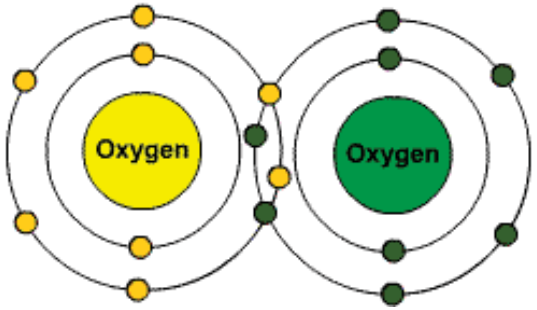


- Possible Number of Electrons in shells 1-6

Shell	Electrons
1	2
2	8
3	18
4	32
5	50
6	72



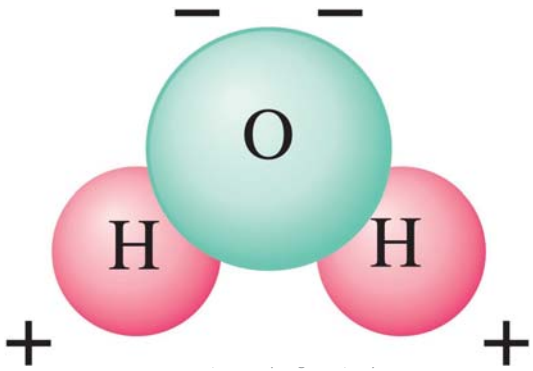
Oxygen atom



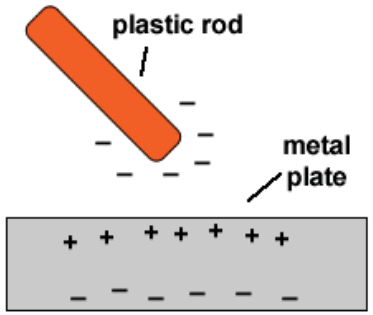
Oxygen molecule

covalent bond

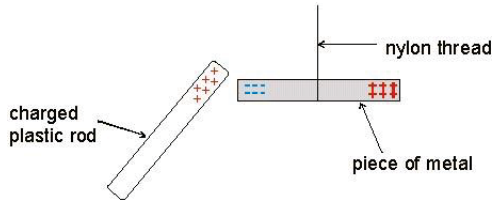
- Polar molecule: neutral overall, but charge not evenly distributed
- Diagram of a water molecule. Because it has opposite charges on different ends, it is called a “polar” molecule.



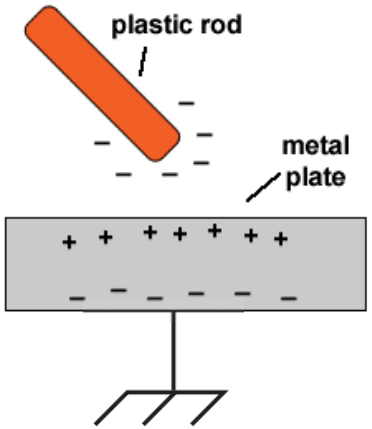
Electrostatic Induction



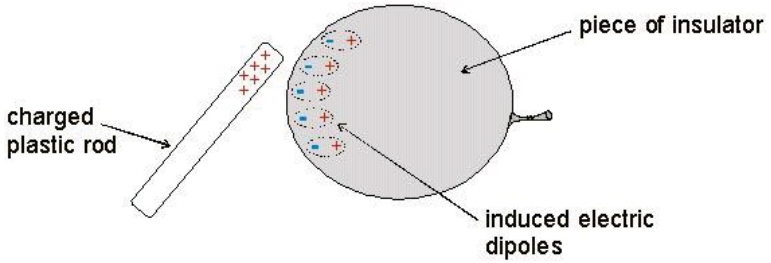
- Electrostatic induction is a method to create or generate static electricity in a material by bringing an electrically charged object near it.
- This causes the electrical charges to be redistributed in the material, resulting in one side having an excess of either positive (+) or negative (−) charges.



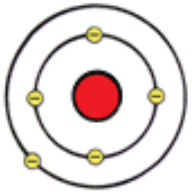
- This phenomenon is most effective when the objects are conducting materials, such as a metals.
- The only drawback is that, once the electrically charged object is removed, the conductor loses its charge.
- This can be solved by temporarily grounding the conductor.



- Certain non-conducting materials can also be given a static electric charge by electrostatic induction.
- In these cases, it is caused by polarization of their molecules.



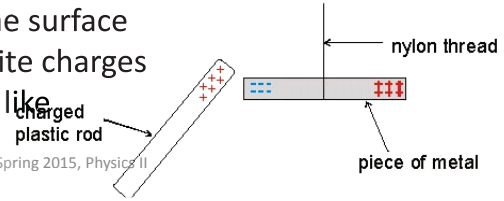
CONDUCTORS



1-3 ELECTRONS IN OUTER RING

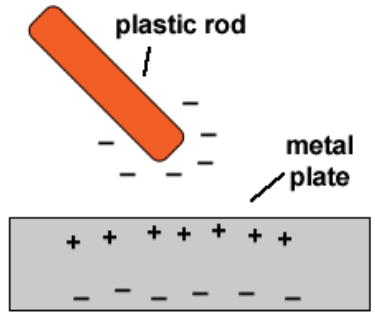
Induction in a conducting material

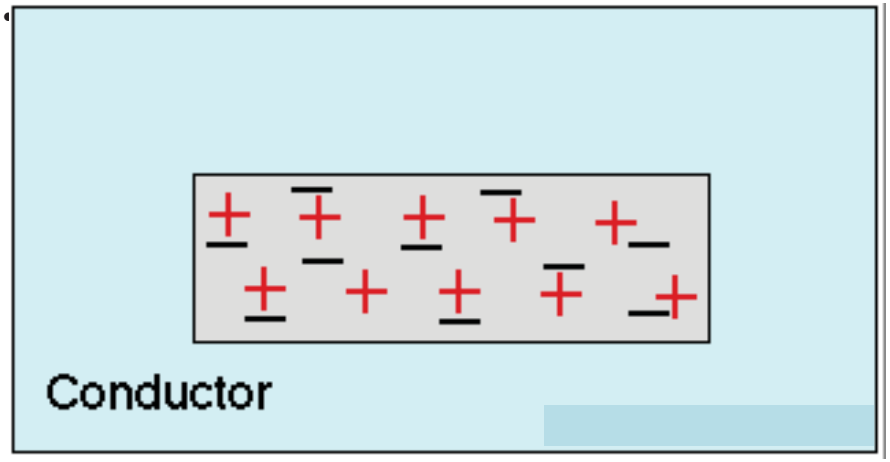
- In its normal, neutral state, an electrically conducting object typically has an equal number of positive (+) and negative (−) electrical charges—such as positive ions, negative ions and electrons—intermingled within the material.
- When an static electrically charged object is brought near this conductor, the electrical charges on or near the surface of the object attract the opposite charges in the conductor and repel the like charges.



Plastic rod near metal plate

- As an example, if a charged plastic rod is brought near a metal plate, the negative charges on the rod attract the positive charges in the plate and repel its negative charges.
- This creates a redistribution of electrical charges in the plate.

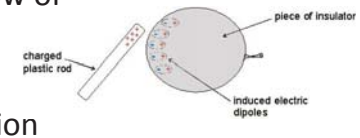




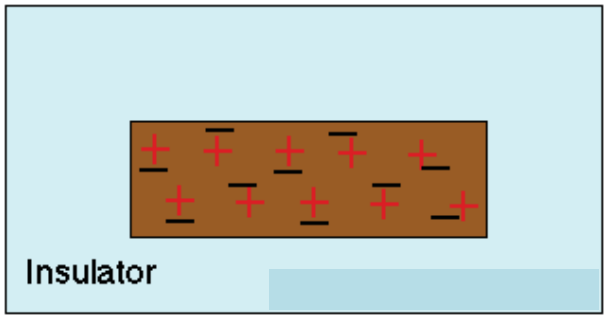
- As long as the electrically charged rod is near the metal plate, the electrical charges in the plate will be redistributed.
- But once the charged object is removed, thermal motion of the atoms in the metal will cause the charges to intermingle again.

Induction in nonconducting materials

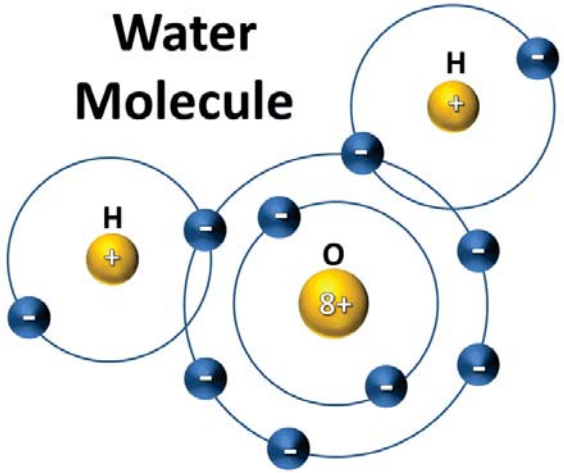
- Electrostatic induction can also work in nonconducting or dielectric materials.
- However, movement of electrical charges is much more constrained in nonconductors than in conductors.
- Electrons are allowed to move about in a conductor, and that is what allows the flow of electricity in a metal wire.
- In a nonconductor, the electrons are constrained within the atoms, so separation of charges particles does not work.



- However, if the nonconductor consists of polar molecules—that is, molecule that have one side more positive than the other side—then electrostatic induction will cause those molecules to be aligned with positive charges on one side and negative charges on the other side.



- For example, the water molecule has more positive charges on one side of the molecule and negative charges on the other side.
- Thus, water can be slightly attracted to a static electric charge.



- A demonstration of that can be seen in bending a stream of water with a charged plastic comb.
- Or pending of water stream over charged ballon

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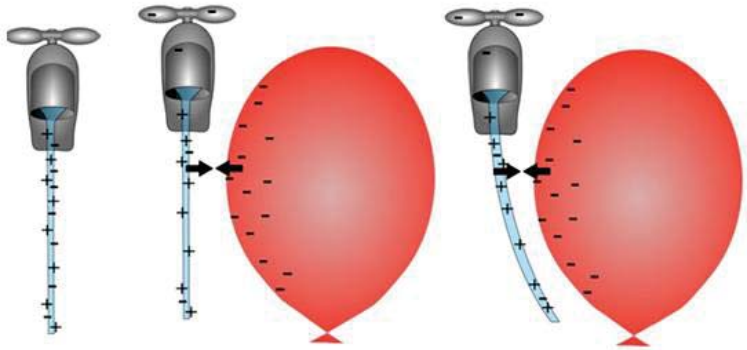

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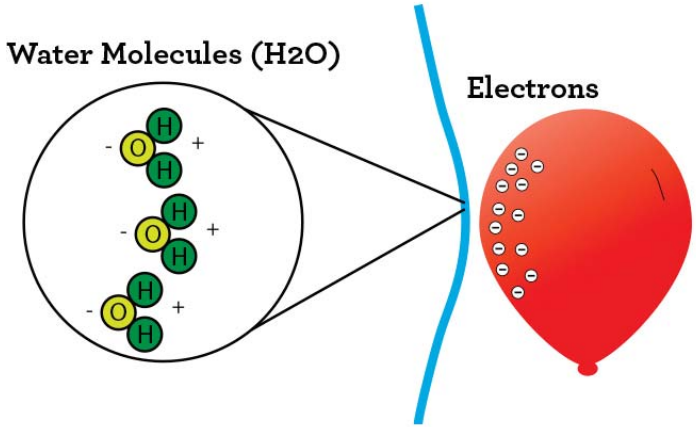
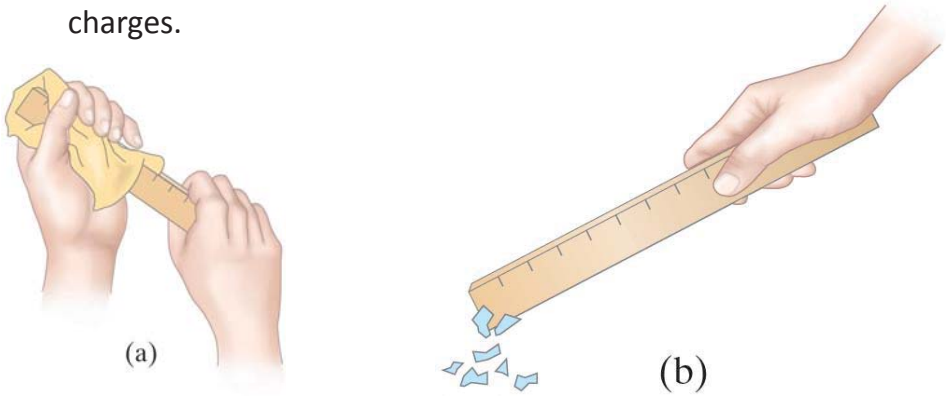


- Other examples can be seen in the attraction of lightweight nonconductive objects like pieces of tissue paper or small pieces of Styrofoam to an object that has static electric charges.



(a) Rub a plastic ruler and (b) bring it close to some tiny pieces of paper.

MCQs

1. What allows electrical charges to be redistributed in a conductor?

A. Conductors often have free electrons and positive and negative ions
B. Static electricity is so strong that it rips the charges apart
C. Negative charges are heavier, so they often sink to the bottom

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2. What does temporarily grounding a charged conductor do?

A. It prevents getting electrical shocks
B. It draws off one charge and leave the opposite charged particles in place
C. You should always permanently ground conductors

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3. How does a charged object attract a neutral nonconductor?

A. You cannot attract an electrically neutral object
B. Free electrons in the nonconductor flow toward the charged object
C. Nonconductor molecules become aligned to attract the opposite charge

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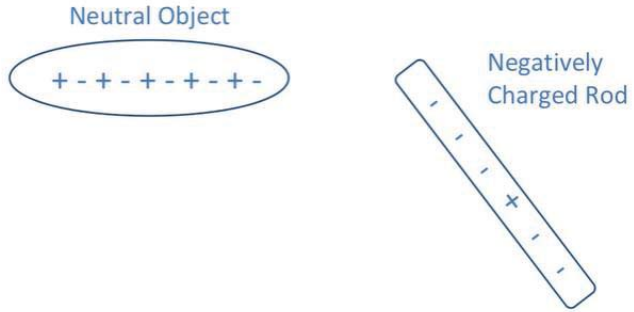
Electrostatic Conduction

- Occurs when an already charged object touches another object neutral of with opposite charges
- Charges (electrons) moves between two objects till overall charges on each object is equal.



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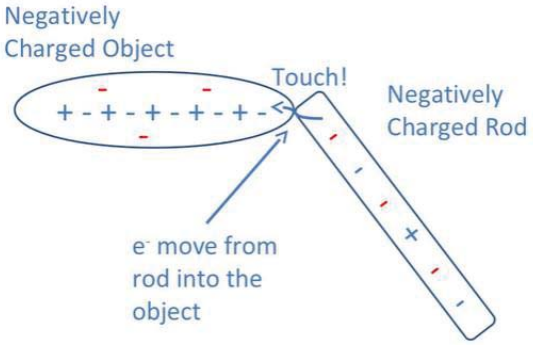

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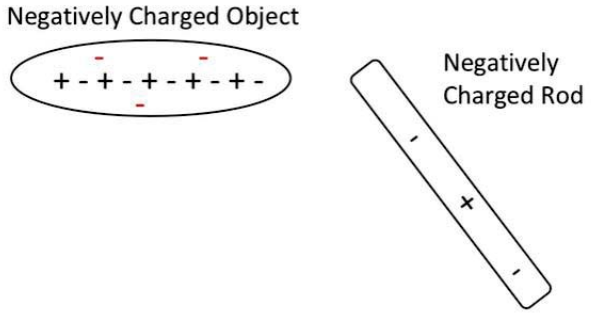
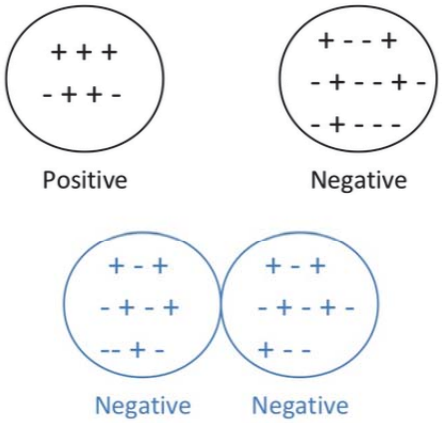


- If charged object touches a neutral object, both objects will have the same resultant charges

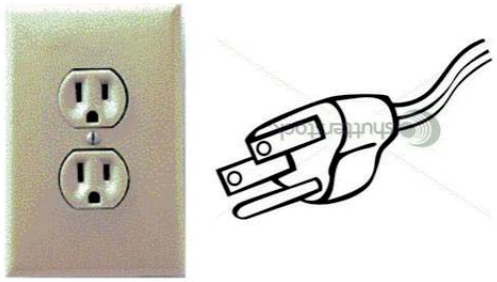


Grounding

- Grounding is a process by which a charged object is neutralized by coming in contact with a large neutral object
- Ground is considered as infinite sink or source of e
- Conduction with earth is the ultimate way to naturalized an object

- Ground will provide enough e^- to make a +ve objects neutral

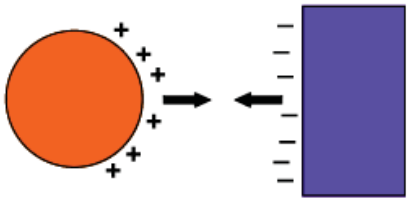
- Ground absorbs enough e^- to make objects neural



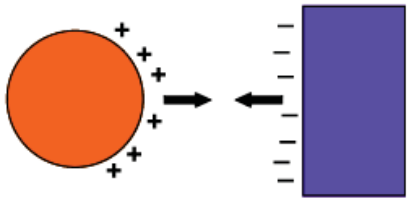
Static Electricity Forces

Opposite charges attract

- The electric field moves from positive (+) electrical charges to negative (−) charges.
- There is an electrical force that causes positive (+) electrical charges and negative (−) charges to attract each other.
- This can happen on a small scale, where a single electron is attracted to a positive charged ion.

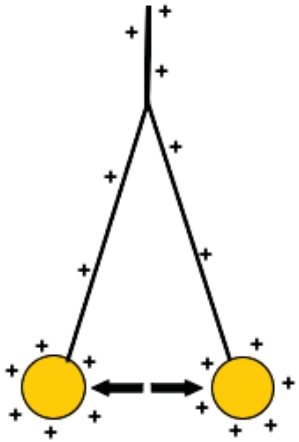


- In the case of static electricity, when one object has an excess of ions or atoms that have a positive charge on its surface and another object having an excess of electrons or of ions that have a negative charge on its surface, the two objects will attract toward each other.



Like charges repel

- Similarly, when two objects have a buildup of like electrical charges on their surfaces, the electrical force causes them to repel each other.



Charges can attract to neutral item

- An interesting phenomenon is that an object with an excess of static electric charges will attract an apparently neutral object. This can be seen by rubbing a balloon on some material to give it a charge and then sticking it to the wall.
- The reason this works is because of what is called electrostatic induction. There are some free opposite charged atoms in the wall material. Thus, the wall is not completely neutral. But the number of available charges is not great. If the wall had been given opposite static electrical charges, the balloon would stick much better.

MCQs

1. Why is there a force of attraction between opposite electrical charges?

A. Opposites repel
B. They are both magnetic
C. It is a property of electrical charges

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2. Would two tennis balls on strings and with like charges repel each other?

A. No, because tennis balls only attract each other
B. Yes, but you would barely notice it because the balls are so heavy
C. Only if hit with a tennis racquet

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3. What is another example of a charged object attracting neutral objects?

A. It only works with balloons
B. The movement of a compass with a magnet
C. Bits of paper can be attracted to a charged comb

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Thanks,..
See you next week (ISA),...