ELECTRIC CHARGE , STATIC ELECTRICITY , COULOMB'S LAW, ELECTRIC POTENTIAL &ELECTRIC CURRENT

For MET-05

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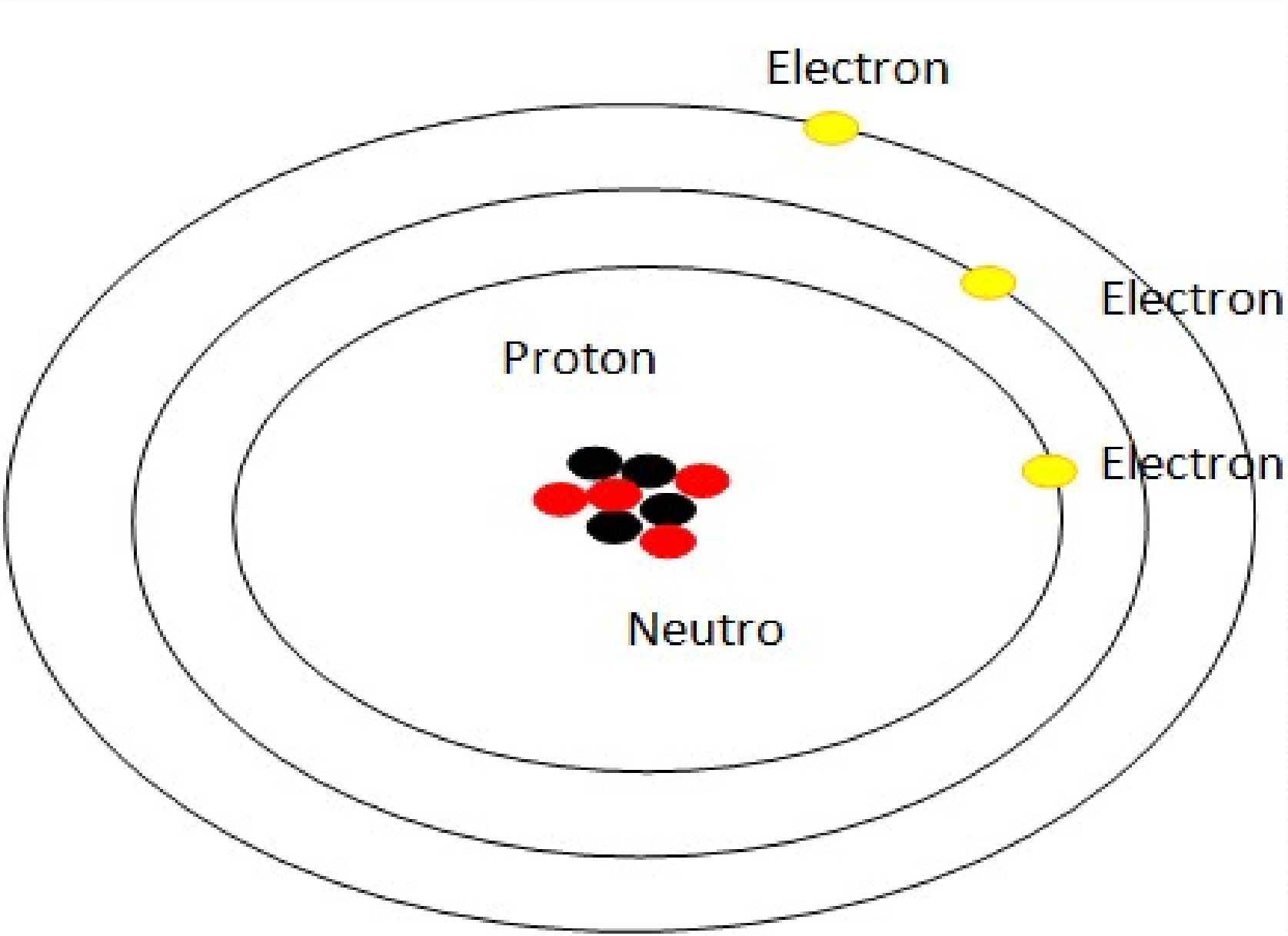
ELECTRIC CHARGE

- All matter is made of atoms, which contain electrons, protons, and neutrons.
- Objects normally contain equal numbers of electrons and protons: such objects are called neutral.
- When an object has an imbalance in the number of electrons and protons, it is electrically charged.
- Neutrons are not involved in electric interactions.


Electron
Electron
Proton
Electron
Neutro

ELECTRIC CHARGE

- An object with more electrons than protons is said to carry a negative charge.
- An object with more protons than electrons is said to carry a positive charge.
- There are two types of charges.positive (+), negative (-)

Particle	Relative Mass	Relative Charge	Charge / C	Mass / kg
Protons	1	+ 1	$+ 1.6 \times 10^{-19}$	1.67×10^{-27}
Neutrons	1	neutral	0	1.67×10^{-27}
Electrons	0.0005	- 1	$- 1.6 \times 10^{-19}$	9.11×10^{-31}

Like energy and momentum, electric charge is a conserved quantity:

Charge cannot be created or destroyed, but it can be transferred between objects.

- Charged objects exert electric forces on each other:

Opposite charges attract;
Like charges repel.

UNITS FOR ELECTRIC CHARGE

The symbol for electric charge is usually a “q”.

The elementary charge unit (e) is equal to the charge of a single proton or electron:

$$q_{proton} = +1e$$

$$q_{electron} = -1e$$

The elementary charge unit is not the standard SI unit.

The SI system uses the Coulomb (C) as the standard unit of charge.

UNITS FOR ELECTRIC CHARGE

A Coulomb is defined as the number of electrons passing through a current of 1 Amp each second:

$$C = A \cdot s.$$

The conversion between C and e was determined by Robert A. Millikan:

$$1\ e = 1.60 \times 10{-}19\ C.$$

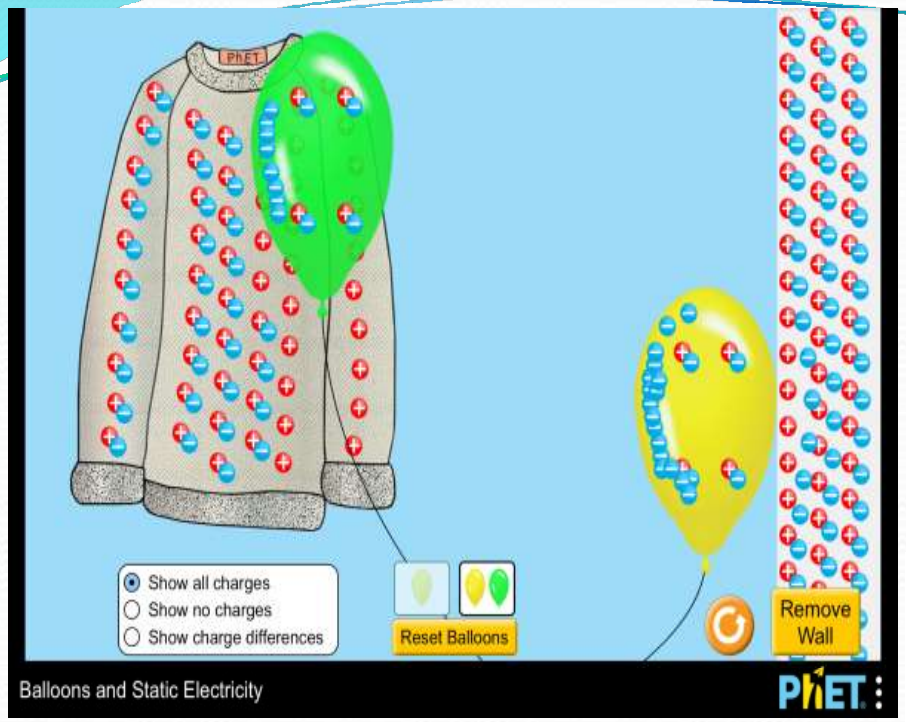
It is much easier to measure charge flowing in a current than to count protons and electrons individually.

STATIC ELECTRICITY

Static Electricity is the study of the behavior of electric charges, including how charges are transferred between objects.

When walking across carpet with socks on your body collects negative charges

Touching another object like a doorknob or your friend causes negative charge (electrons) to “jump” to the positive object


Show all charges
Show no charges
Show charge differences
Reset Balloons
Remove Wall
Balloons and Static Electricity
PhET

TRANSFERRING CHARGES

Three ways to transfer a charge:

1. Friction
2. Conduction (Direct Contact)
3. Induction

TRANSFERRING CHARGES

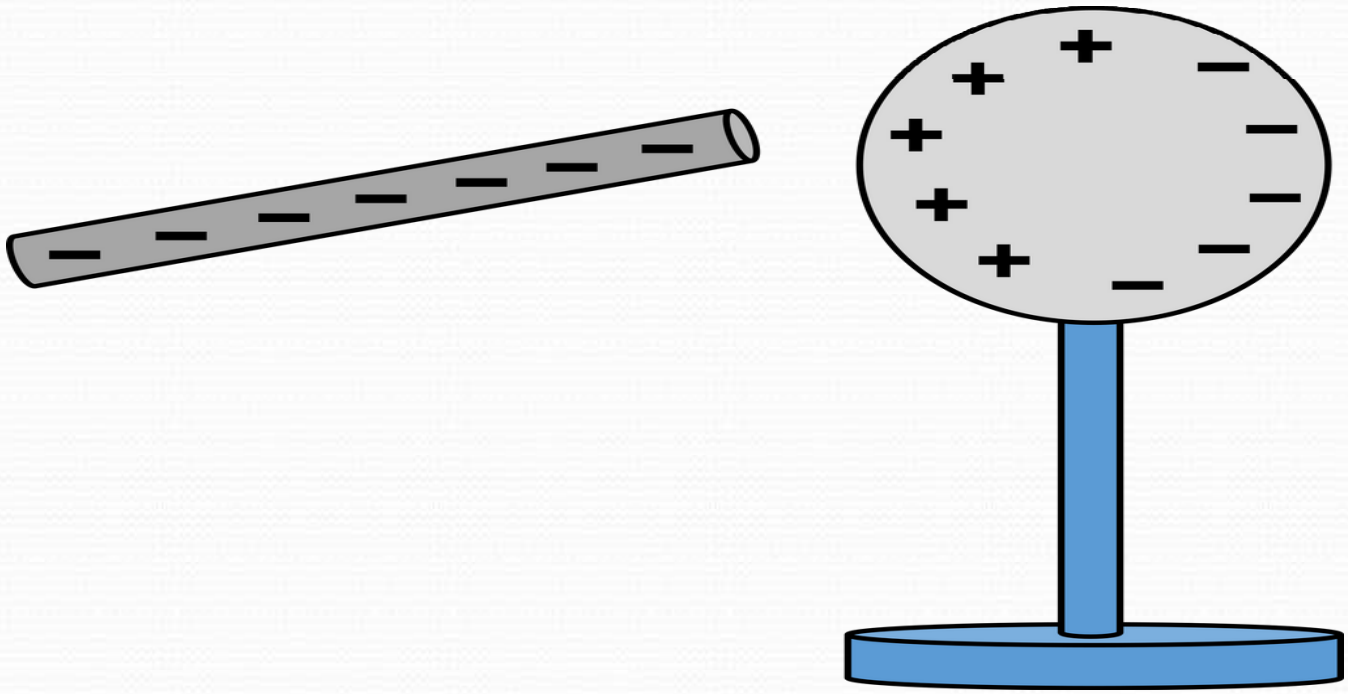
Friction Charge transferred by objects rubbing together

Example –

Rubbing a balloon on your hair

TRANSFERRING CHARGES

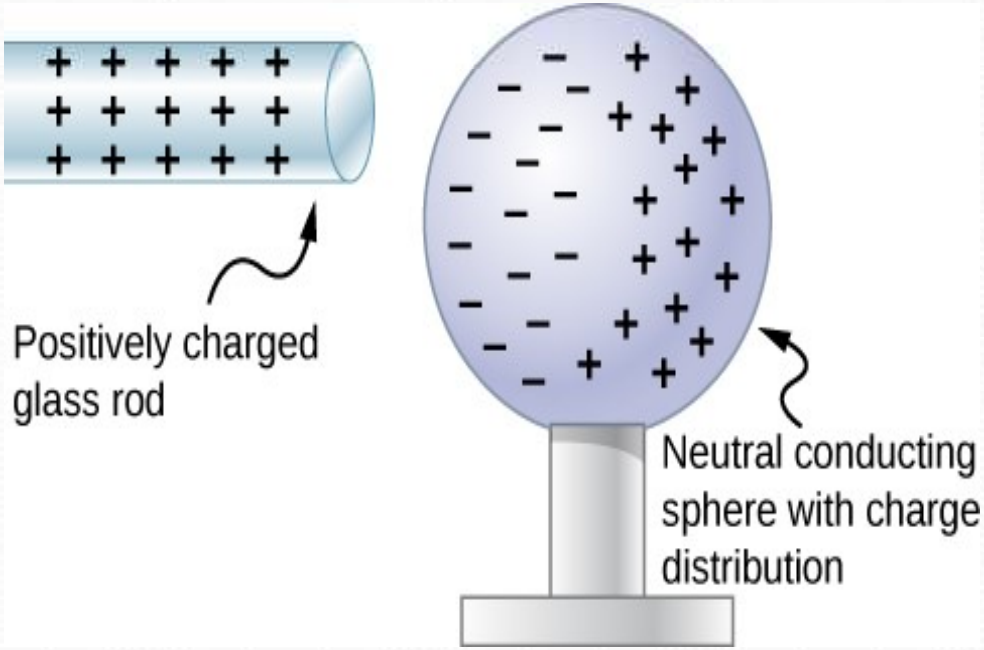
Conduction Charge transferred by direct contact
Example A metal rod touching a charged object



TRANSFERRING CHARGES

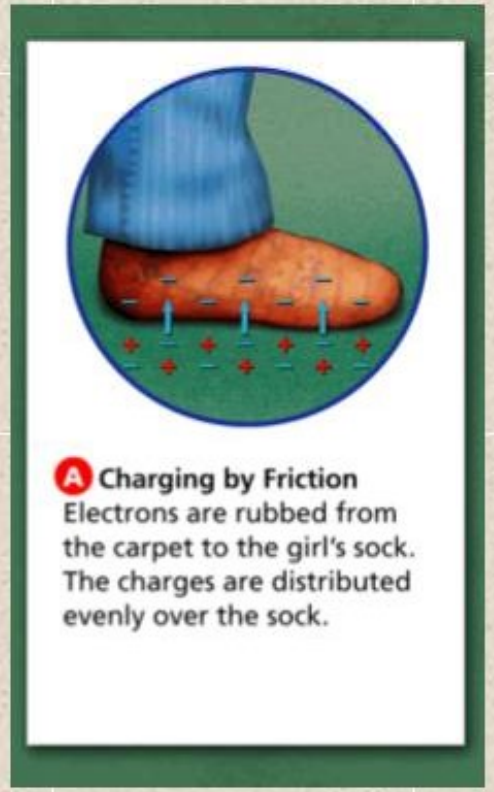
Induction

Charge transferred from a distance

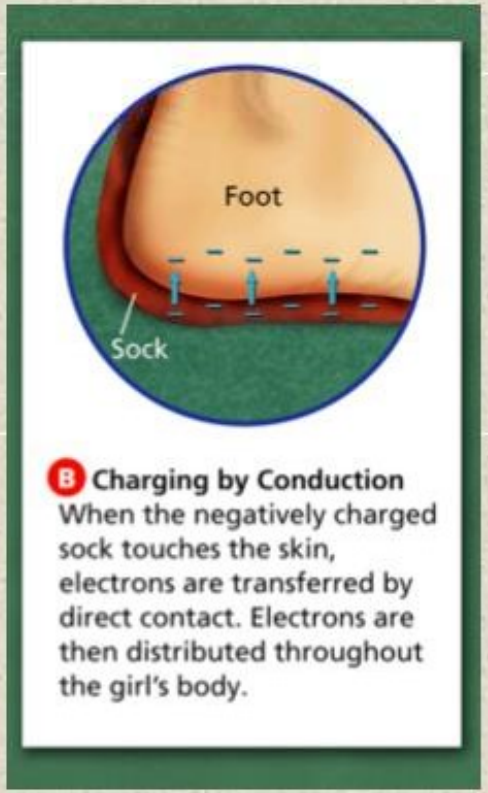


Transferring Charge

- There are three methods by which charges can be transferred to build up static electricity: charging by friction, by conduction, and by induction.



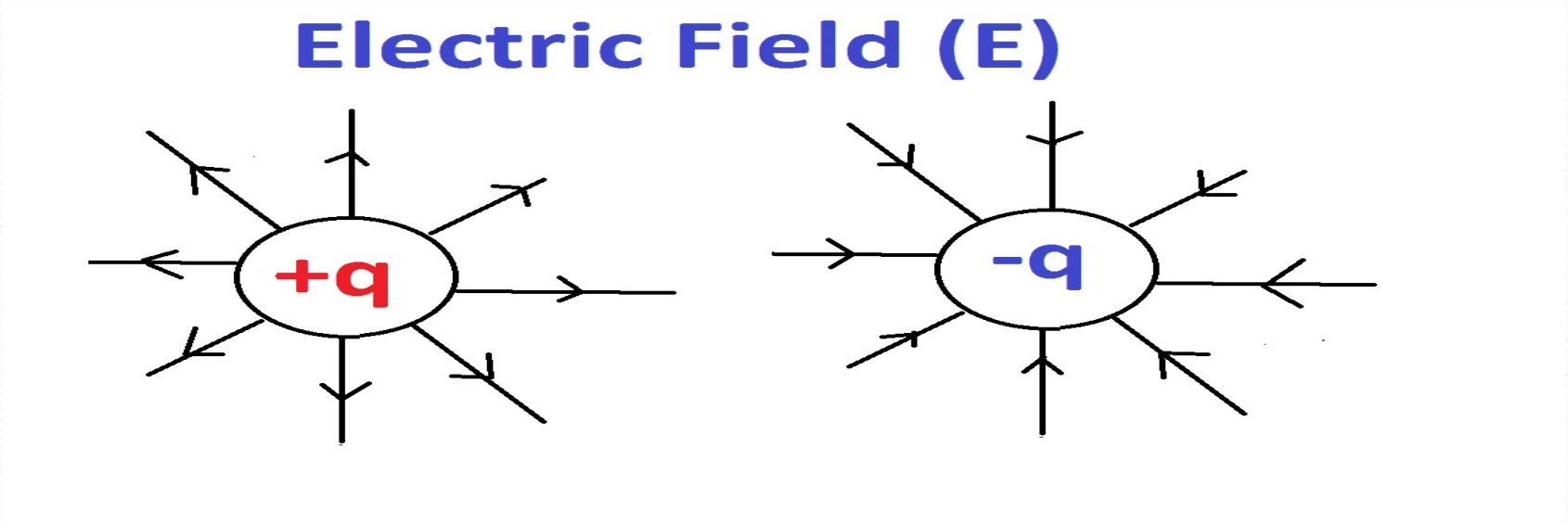
A Charging by Friction
Electrons are rubbed from the carpet to the girl's sock. The charges are distributed evenly over the sock.



B Charging by Conduction
When the negatively charged sock touches the skin, electrons are transferred by direct contact. Electrons are then distributed throughout the girl's body.

ELECTRIC FIELD

A region around a charged particle or object within which a force would be exerted on other charged particles or objects.



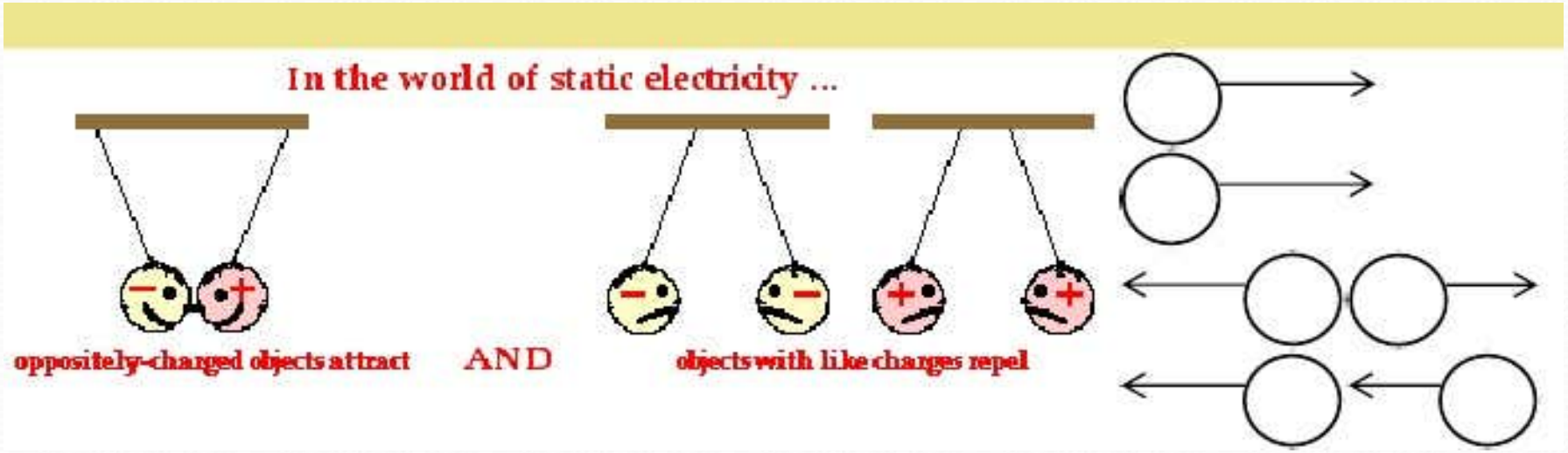
INTERACTION BETWEEN CHARGES

There are two different types of electric forces:

Attraction- a positively charged object will attract a negatively charged object

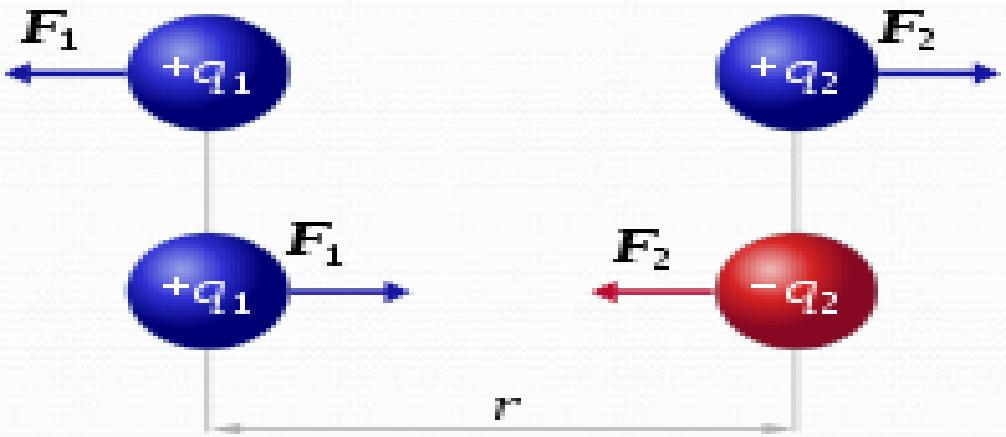
Repulsion- a positively charged object will push a positive charged object

Like charges repel, and opposite charges attract



COULOMB'S LAW

The **Coulomb force** (F), also called **electrostatic force** or **Coulomb interaction**, states that the magnitude of the electrostatic force of interaction between two point electrical charges (q_1, q_2) is directly proportional to the scalar multiplication of the magnitudes of electrical charge and inversely proportional to the square of the distance (r) between them.



$$|\boldsymbol{F}_1| = |\boldsymbol{F}_2| = k_e \frac{|q_1 \times q_2|}{r^2}$$

The mathematical expression of Coulomb's law is:

$$|\mathbf{F}| = k_e \frac{|q_1 q_2|}{r^2}$$

where:

F [N] – Coulomb force

q_1, q_2 *[C]* – electrical charges

r [m] – distance between electrical charges

k_e *[F/m]* – is called the **Coulomb's constant**, or electric force constant or electrostatic constant.

ELECTRIC POTENTIAL & ELECTRIC POTENTIAL DIFFERENCE

The electric potential difference ΔV in volts between two points is the work in Joules needed to move q of charge

VOLT

$$V_A - V_B = W_{BA}/q$$

If q = 1 coulomb

Than $V_A - V_B = W_{BA}$

Volt is the electrical unit of voltage or potential difference (symbol: V).

One Volt is defined as energy consumption of one joule per electric charge of one coulomb.

1V = 1J/C

$$V = \frac{W}{Q} \quad or \quad V = \frac{E}{Q}$$

V = Potential Difference (Voltage)
W = Work done
E = Energy
Q = Charge

ELECTRIC CURRENT

Electric current is defined as the rate of flow of charges of the conductor is called an electric current.

Since the charge is measured in coulombs and time in seconds, so the unit of electric current is coulomb/Sec (**C/s**) or amperes (**A**). The amperes is the **SI** unit of the conductor. The **I** is the symbolic representation of the current.

$$I = q/t$$

If q = 1 coulomb, time = 1 second than I = 1 A

DIRECTION OF FLOW OF CURRENT

When the potential difference is applied across the conductor , matter flows from higher potential to lower potential, i.e. positive terminal to the negative terminal of the cell through the external circuit.

direction of flow of current is from the positive terminal of the cell to the negative terminal of the cell through the external circuit. The magnitude of flow of current at any section of the conductor is the rate of flow of electrons i.e. charge flowing per second.