TOPIC 4

STATIC ELECTRICITY

ELECTRICITY:

Electricity is the flow of electrical charges or power. The charges could be in the form of electrons or ions. Electricity or electrical energy is a secondary energy source which means that we get it from the conversion of other sources of energy, like by burning coal, natural gas, oil or from nuclear power and other natural sources, which are called primary energy sources.¹ (Note: this is only the brief introduction of electricity. It will be discussed in detail in next section.)

STATIC ELECTRICITY:

- a. The electricity so produced by friction (rubbing) is called frictional electricity or static electricity. The word static means stationary or not moving since the charges do not flow through the conductor but only transfer from one substance to another.
- b. The material acquires positive or negative charge it is called charged or electrified bodies.
- c. The branch of physics that deals with the study of electrified or charged bodies, on which the electric charge is at rest, is called electrostatics physics.
- d. When a strip of polythene rod is rubbed with cloth it becomes negatively charged and when a strip of cellulose acetate rubbed with a cloth it becomes positively charged. See the table for different examples that create static electricity by rubbing.

Material	Rubbed with	Charge acquired	Behavior
Polythene rod	Woolen cloth	Negative	attract each other
Perspex or cellulose acetate	Woolen cloth	Positive	
Ebonite	Fur	Negative	attract each other
Glass	Silk cloth	Positive	
Glass	Flannel cloth	Negative	

- e. It is the substance that is being used for rubbing that is responsible for inducing the positive or negative charge on the material and not the type of material used. For example if the glass rod is rubbed with flannel cloth, it becomes negatively charged, but when it rubbed with silk it becomes positively charged.
- f. Like charges + and + or and repel each other and unlike charges + and attract each other.

ELECTRIC FIELD AROUND A CHARGED BODY:

Electric field around a charged body exists if electric forces are exerted by it on another charged body in that region. The direction of electric field at <u>a point</u> is the direction in which a small positive charge would experience or move (under the influence of the field) if placed <u>at that point</u>.

The electric field intensity or electric field strength (E) of an electric field at a point is defined as the force exerted by the field on a unit charge placed at that point. Unit is newton per coulomb or N/C.

$$E = \frac{F}{Q}$$

¹ http://www.eia.doe.gov/kids/energyfacts/sources/electricity.html

Uniform electric field due to charged parallel metal plates:

If the electric force felt by a charge is same everywhere in a region then the field is called **uniform**. A uniform electric field is produced between two oppositely charged parallel metal plates connected to the terminals of a battery. It can be represented by evenly spaced parallel lines, drawn perpendicular to the metal surface, from positive to negative plate.

Radial electric field due to point charge:

The electric field lines radiating from an isolated positively charged conducting sphere are the field lines emerging at right angles to its surface as shown in the figure.

CURRENT (I):

Current (I) is defined as the rate of flow of electric charge in a conductor. The unit of current is **ampere** (A). It is measured by ammeter.

$$I = \frac{Q}{t}$$

Electric charge (Q) in a conductor is carried by subatomic particles – electrons and protons. Electrons carry negative charge and protons carry positive charge. Unit of electric charge is coulomb (C). It is a charge passing through any point in a circuit when a steady current of 1 ampere maintained for 1 second, that is 1Coulomb = 1Ampere -second.

Measuring current:

The size of the current in the circuit can be measured by using an **ammeter**. It can be digital or analogue. It is always connected in series in the circuit. It is important that the positive terminal of the ammeter is connected to the positive terminal of the battery and negative terminal to the negative; otherwise the pointer of the ammeter will move in the opposite direction.

Conventional current:

The electric current is really a flow of electrons from negative to positive terminal of the battery. However when it was first discovered, scientists wrongly guessed that the something that carry charges flows from positive to negative terminal and therefore they describe it as conventional current.







Insulators	Conductors		
In an insulator all electrons are bound firmly to their atoms.	In a conductor some electrons can move freely from atom to atom or molecule to molecule		
An insulator can be charged by rubbing. In insulator the electric charge is static that is it cannot move from where the rubbing occurs.	Conductor will become charged only if it is held with an insulating handle otherwise charge can transfer to earth through human's body.		
Plastic, wood, glass nylon, rubber and acetate are good insulators.	Most metals are good conductors for example silver, copper, aluminium etc		

Conductors and insulators:

POTENTIAL DIFFERENCE:

An electric potential difference (V) must exist for current to flow in electric circuit. It is the work done per unit charge as the charge is moved between two points in an electric circuit. The potential difference (p.d.) between two points in a circuit is 1 volt if 1 joule of electrical energy (W) is transferred to another form of energy when 1 coulomb of charge passes from one point to another.

$$V = \frac{W}{Q} \qquad \therefore Q = I \times t$$
$$\Rightarrow W = I \times t \times V$$

Electromotive force (e.m.f.):

In energy terms the e.m.f. is defined as the energy (chemical or mechanical in joules) transferred to electrical energy and when one coulomb of charge passes through a circuit.

Or

e.m.f. is the amount of energy required to move the unit charge through a circuit.

e.m.f. = lost volts + terminal potential difference

To measure e.m.f. or potential difference (p.d.) in a circuit the voltmeter should be connected in parallel. Voltmeter should always have high internal resistance.

Measuring potential difference:

A **voltmeter** is used to measure the electric potential difference between two points in an electric circuit. It is connected in parallel across a resistor in the circuit. It has a very high internal resistance. The unit of potential difference or voltage is **volts**.

Ohms Law:

As the potential difference (V) is increased across a given material (ohmic material) in a circuit, the current (I) flow through the material also increases. $V \propto I$



The potential difference (V) between any two points in a conductor is directly proportional to the current (I) flows through it if the temperature, resistance of the conductor and other conditions are constant.

$$V \propto I$$

V = IR Where R is the resistance of a conductor.

RESISTANCE:

The opposition of to the flow of current in a conductor is called resistance of that conductor. The unit of resistance is ohm (**symbol omega** Ω). One ohm is the resistance when current is one ampere and potential difference of one volt is applied. A resistance of a cylinder or wire of certain material:

- increases if its length (L) increases,
- increases if its cross-section area (A) decreases,
- depends upon the type of material $\rightarrow R = \rho \frac{L}{\Lambda}$

Where ρ is the resistivity of the conductor which is constant for every material.

Measuring resistance:

The resistance (R) of a conductor is measured by **ohmmete**r. Alternatively the resistance of a conductor can be found by measuring the current (I) through it when the potential difference (V) applied across it and using the

formula $R = \frac{V}{I}$. Multiple values of (A) and (I) can be found

by changing the resistance of a variable resistor or rheostat. The ratio between V and I should be constant and equal to the value of resistance R.

ELECTRIC POWER (P):

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or

or

Rate of doing work is called power. It is define as

Power (P) =
$$\frac{\text{work done (W)}}{\text{time taken (t)}} = \frac{\text{energy transfer (E)}}{\text{time taken (t)}}$$

P = $\frac{W}{t}$
t W = I x t x V
P = I x V
P = I² x R
P = $\frac{V^2}{R}$



also the larger units of power are

1 kilowatt (kW) = 1000 W

 $1 \text{megawatt} (MW) = 1000\ 000\ W$

The power of electrical appliances can be calculated by multiplying the current (I) passing through it by the potential difference (V) across it.

Electrostatic induction:



The diagram above shows a process called "charging by electrostatic induction" in which a neutral metal sphere is supported on an insulating stand. When a negatively charged rod is placed close to the neutral metal sphere the (negatively) charged electrons in the sphere are repelled to the far side of the sphere, leaving the atoms on the near side positively charged owing to their missing electrons. If we then connect a copper wire to the negative side of the sphere and an electrical ground some of the free electrons will flow into the ground. When we then remove the copper wire and the negatively charged rod what remains is a metal sphere with a uniform distributed positively charge. The attraction of an uncharged object by a charged object near it is due to electrostatic induction. The common example is the attraction between small pieces of aluminium foil and negatively charged polythene held just above them.

Dangers of static electricity:

- 1. **Lightning** is static electricity due to charges in clouds, and it can damage buildings and harm people.
- 2. Static electricity can damage sensitive electrical components, such as the **parts inside computers**. To prevent this, these parts are handled with anti-static bags and wrist straps, which drain the static charge off the person.
- 3. Static electricity can be responsible for the ignition of flammable gases, such as the vapors produced by petrol (gasoline) when you are filling your car at the **petrol-station**.
- 4. Dusts and germs are attracted by charged objects and so it is essential to ensure that **equipment and medical personal** are well earthed allowing electrons to flow to and from the ground e.g. by conducting rubber.

Use of static electricity

- 1. Static electricity is used to paint cars. Special powder paints that have been charged positively spread out to form a very even coating of paint on an earthed metal body of a car.
- 2. It is used in computer printers to distribute toner or ink to go at the right place.
- 3. Static electricity is also used to remove pollution from smoke-chimneys. Electrostatic plates are placed in the chimneys of the factories that attract all the polluted dust.

