TOPIC 16 Static Electricity

Objectives

Candidates should be able to:

(a) state that there are positive and negative charges and that charge is measured in coulombs
(b) state that unlike charges attract and like charges repel
(c) describe an electric field as a region in which an electric charge experiences a force
(d) draw the electric field of an isolated point charge and recall that the direction of the field lines gives the direction of the force acting on a positive test charge
(e) draw the electric field pattern between two isolated point charges
(f) show understanding that electrostatic charging by rubbing involves a transfer of electrons
(g) describe experiments to show electrostatic charging by induction
(h) describe examples where electrostatic charging may be a potential hazard
(i) describe the use of electrostatic charging in a photocopier, and apply the use of electrostatic charging to new situations

NOTES.....

16.1 Atomic Structure

1. Matter is made up of small units called atoms.
2. An atom consists of a positively-charged nucleus surrounded by negatively charged electrons orbiting around the nucleus. The overall charge of an atom is zero.
3. The positively-charged nucleus consists of positively-charged protons held together by neutral particles called neutrons.
4. When excess electrons are added to an atom, the atom becomes negatively charged.
5. When electrons are removed from an atom, the atom becomes positively charged.

16.2 Electric Charges

1. Electric charges are either positive or negative.
2. Like charges repel each other; unlike charges attract each other.
3. Rubbing (charging by friction) causes electrons to be transferred from one object to another. Charge transfer between two objects only involves electron transfer. There is NO MOVEMENT of positive charges (which are the nuclei of the atoms). Otherwise, the solid will deform.
4. Insulators can be charged by rubbing, unlike conductors (metals), because **electrons** are not free to move about in an insulator and thus charges are localised to the surfaces where rubbing occurs.
5. Examples of insulators and the types of charges they gain from rubbing:

Type of insulator rod	Type of cloth used for rubbing	Charges gained by cloth	Charges gained by rod
Cellulose acetate	wool	$-Q$	$+Q$
Glass	silk	$-Q$	$+Q$
Ebonite	fur	$+Q$	$-Q$
Polythene	wool	$+Q$	$-Q$

6. The excess charge, Q, carried away by one body must be equal to the number of electrons removed from the other body. The charges are in multiples of an electron charge, e (-1.6×10^{-19} C) according to the equation:

$$Q = Ne$$ where N is a whole number.

7. The unit of charge is the coulomb (Symbol: C).
8. Electric charge Q is related to current I and time t by the equation:

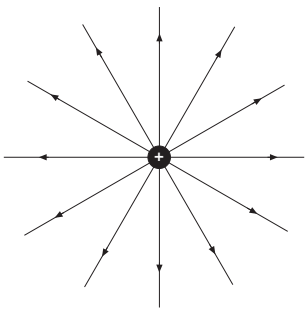
$$Q = It$$

16.3 Concept of Electric Field

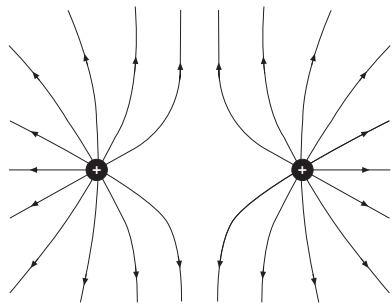
1. An electric field is a region in space in which a unit positive charge experiences a force.
2. Electric field is a vector quantity. The direction of the field is determined by the direction of the force acting on the unit positive charge.
3. An electric field is set up by a charge. When a unit positive charge is brought near a negative charge, the positive charge will experience a force of attraction towards the negative charge and vice versa.

Example 16.1: Examples of field patterns set up by point charges

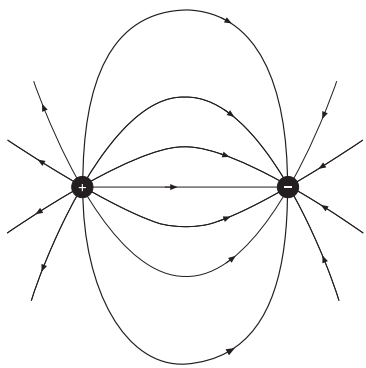
(a) Isolated positive charge



(b) Two equal magnitude, positive charges close to each other



(c) Two charges with equal magnitude but opposite signs



16.4 Hazards of Electrostatic Charging

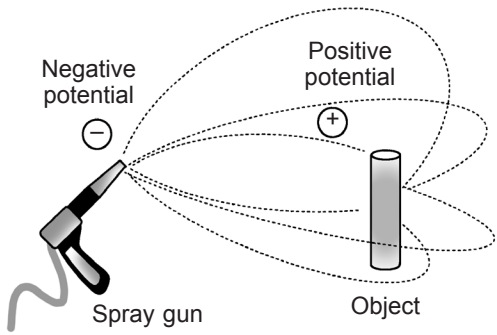
1. Lightning: A large charge build-up in the clouds due to the friction between water and air molecules results in the ionisation of the air. The ionised air provides a path for conduction of electrons to the ground through tall, pointed objects.

   Remedy: Lightning conductors can be placed at the top of tall buildings to allow electrons to flow steadily from the air to the ground.

2. Fire: An excessive build up of charges due to friction with air can lead to an explosion or a fire in aircrafts.
   Remedy: Tyres are made of slightly conductive rubber to discharge the aircraft when it touches down.

16.5 Some Applications of Electrostatics

1. Spray painting:
   Steps:
   (1) A fixed electric potential difference is maintained between the paint spray nozzle and the object to be painted. (i.e. the nozzle is negatively-charged and the object is positively charged)



   (2) As the paint leaves the nozzle, the droplets are charged.

   (3) Since the droplets all have the same charge, they repel each other so that the paint spreads out evenly.

   (4) The paint droplets are all attracted to the positively-charged object and stick strongly to its surface.

2. Photocopier:
   Steps:
   (1) Positive charges are arranged in a pattern to be copied on the surface of an insulator drum.

   (2) Negatively-charged toner powder is sprinkled on the drum.

   (3) Only the portions of the drum with positive charges allow the toner powder to stick to it to form the image.

   (4) The resultant pattern is then transferred onto the paper and fixed permanently by heat.