# Electricity (Part I)

# Electrostatics

## In this lecture

★Electricity
★Electric Charge
★Electrification
★Electrostatic Charge
★Electric Field
★Electrostatic Force
★Lines of Equipotential

## Electricity

- X-ray tube converts electric energy into electromagnetic energy
- Other devices convert electric energy into other forms of energy
  - Kinetic energy:
  - Heat energy:
  - Chemical energy:

## Matter

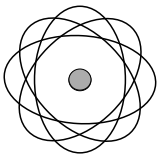
- Matter has mass, form and energy equivalence.
- Matter may also have electric charge

## Electric Charge

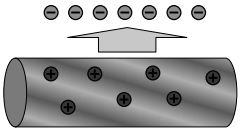
- Comes in discrete quanta
  - Negative or positive
  - Electrons & Protons
  - Equal in magnitude, opposite in sign
- In most cases the net charge of matter is neutral
  - Total negative charge balances total positive charge

## Electric Charge

- Electrons are often free to move form the outer shell of one atom to another
- Protons are fixed in the nucleus and are not free to move



## Electrification

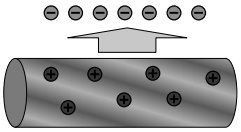


- Material takes on net charge (+ve or –ve)
- Outer-shell electrons of some types of atoms are loosely bound and can easily be removed
- Removal of these electrons leaves the material with a net positive charge
- Created by contact, friction or induction

## Electrification

- Electrification causes static (stationary) charge
- Electrostatics is the study of stationary electric charge

## Electrification



- Electrification occurs due to movement of negative charge
- Positive charge remains in material
- Transfer of electrons from one object to another causes the first object to become positively and the second to become negatively charged

## Electrostatic Charge

- Smallest unit of charge (electron) far too small to be useful
- Units of electric charge: Coulombs (C)
  - Charles Coulomb (1736-1806)
  - 1 Coulomb = 6.24 X $10^{18}$ electron charges
  - Electron charge = 1.6 X $10^{-16}$ C

## Electrostatic Charge

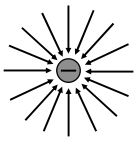
Example:

An electrostatic charge is transferred between two people after one has scuffed their feet across a nylon rug is of the order of one microcoulomb.

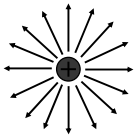
How many electrons are transferred?

- Unlike charges attract
- Like Charges repel

## Electric Field



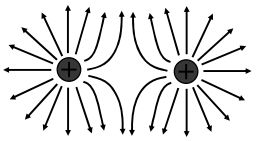
- An electric field is associated with each electric charge



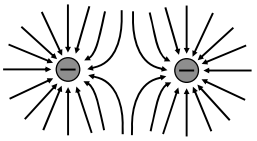
- Field radiates outwards from +ve charges and into –ve charge

## Electric Field

- What happens when we bring charges close together?



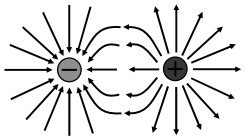
- Similar charges
- Fields in opposite direction



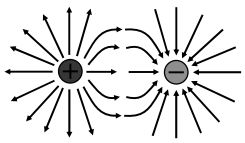
- Charges repel each other

## Electric Field

- What happens when we bring charges close together?



- Like charges
- Fields in same direction



- Charges attract each other

## Electric Field

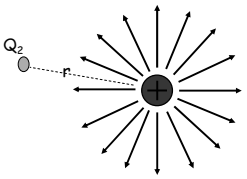
- What happens when we bring charges close together?
- Neutral objects


- No Fields
- No attraction or repulsion

## Electrostatic Force

- Force between charges is due to electric field
- Repulsive or attractive force known as *electrostatic force*
- Uncharged particles have no field are not affected by electric field

## Coulomb's Law




- Governs magnitude of electrostatic force

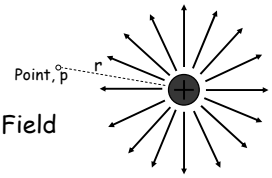
$$F = K\frac{Q_1 Q_2}{r^2}$$

F = electrostatic force (Newtons)
Q = electrostatic charge (Coulombs)
R = distance between charges
K = constant

$$K = \frac{1}{4\pi\varepsilon_o} = 8.988 \times 10^9 m^2 C^{-2}$$

- Force is directly proportional to product of electrostatic charges and inversely proportional to the square of the distance between them

## Electric Field




- Magnitude of Electric Field at point, p

$$E = K\frac{Q_1}{r^2}$$

E = electric field
Q = electrostatic charge (Coulombs)
R = distance between charges
K = constant

- Electric Field is directly proportional to the electrostatic charges and inversely proportional to the square of the distance between them

## Electric Field and Force

- Charge Q placed in an electric field E experiences the following force:

$$F = Q \times E$$

- What are the units of Electric field?

## Electric Potential

- What is potential energy?
- Electric charges possess potential energy when placed in an electric field
- Units of electric potential

## Electric Potential

- Work is done by the electric field if the electric force acting on the charge causes it to move from one point to another.
  - These two points differ in their electric potential.

$$V = \frac{W}{Q}$$

- A charge of one Coulomb in a potential difference of 1 Volt is equivalent to 1 Joules

## Summary

★Electricity
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★Electrification
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★Lines of Equipotential

## Practice Questions

**PAM2011: Lecture 5 Problem Sheet Solutions**

1. If the distance between two charged bodies is doubled, what will be the change in electrostatic force?
2. A lightening bolt caries 50 Coulombs of charge. How many electrons is this?
3. What is the electrostatic charge of one electron?
4. Two electrons are separated by 100 nm. What is the electrostatic force between them? Is the force attractive or repulsive?
5. mAs is a measure of what quantity?