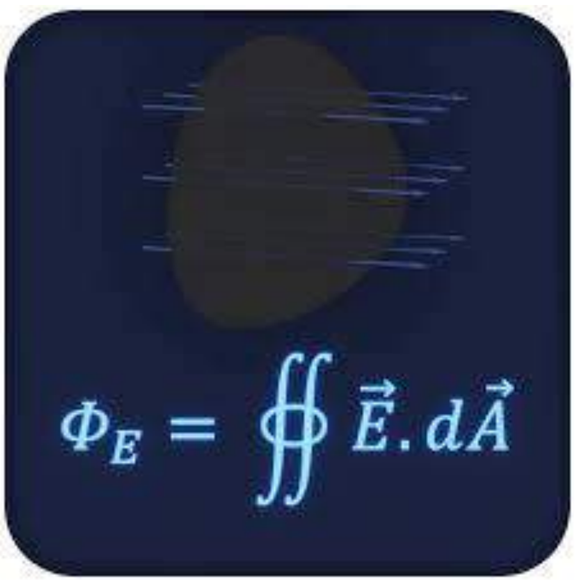
TSWRAFPDCW, Bhongir

PAPER: ELECTROMAGNETIC THEORY

TOPIC: GAUSS 'S LAW AND IT'S APPLICATIONS



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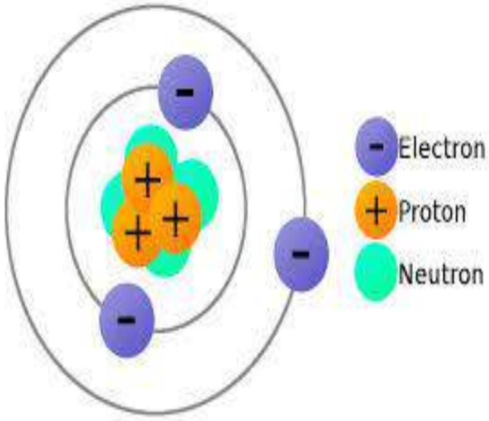
Learning Objectives

- Electric charges
- Coulomb's law
- Electric field
- Limitations of Coulomb’s law
- Concept of Electric flux
- **Gauss’s law**
- Integral and Differential form of Gauss’s law
- Various charge distributions
- **Applications of Gauss’s law**
- Summary
- Worked out examples
- Quiz
- Student Assignment

Electric charge

Every substance is made up of atoms.
Atom consists of protons, neutrons, electrons.

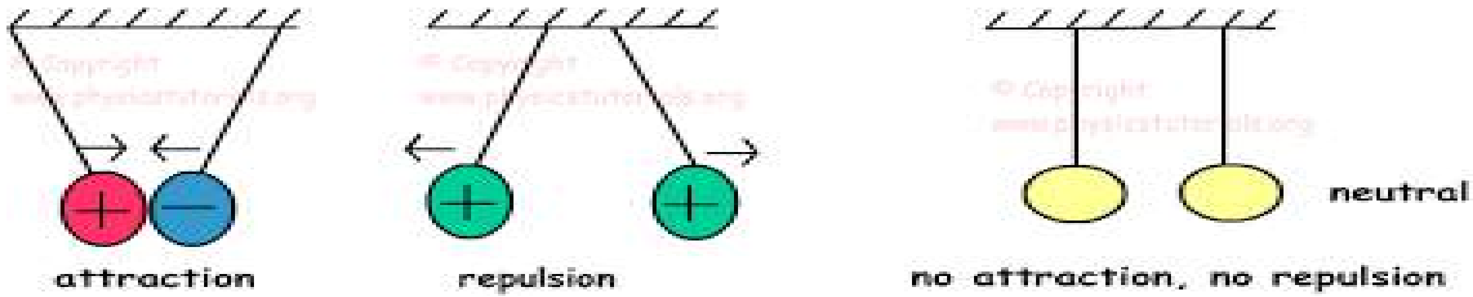
- ❖ Protons = Positive charge
- ❖ Electron = Negative charge
- ❖ Neutron = Zero charge



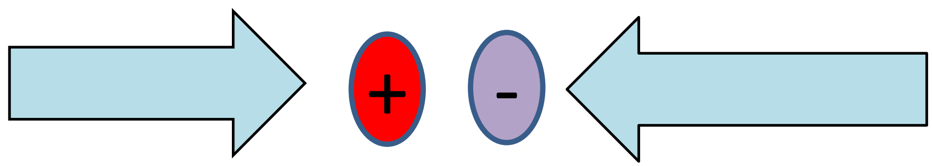
	Mass	Charge
Proton	1.673×10^{-27} kg	$+ 1.6 \times 10^{-19}$ C
Electron	9.1×10^{-31} kg	$- 1.6 \times 10^{-19}$ C
Neutron	1.675×10^{-27} kg	0

- ✓ Charge: Scalar quantity
- ✓ Units: Coulomb (C)
- ✓ Dimensional formula: [AT]

How do charges behave?



Unlike charges attract



Like charges repel

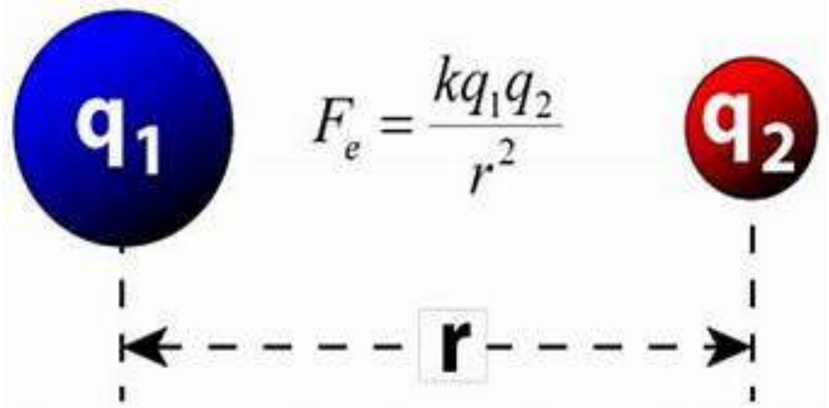
Coulomb's law

The force of attraction or repulsion between two electric point charges is directly proportional to the product of the magnitude of charges and inversely proportional to the square of the distance between the two charges.

$$F = \frac{k(q_1 q_2)}{r^2}$$

$$k = \frac{1}{4\pi\varepsilon_0} = 9X10^9\ Nm^2/C^2$$

$$\varepsilon_0 = 8.85x10^{-12}\ C^2\ /Nm^2$$



Units: Newton (N)

It is a Vector quantity

Electric Field

The region surrounding an electric charge or a group of charges, in which another charge experiences a force is called electric field.

Electric field intensity $E = \frac{F}{q}$

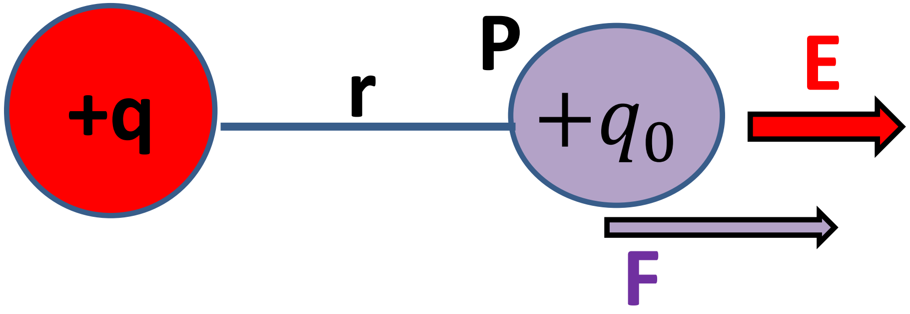
Units: N/C, V/m, Vector quantity

Intensity of electric field due to a point charge

$$E = \frac{F}{q_0}$$

$$F = \frac{k(q q_0)}{r^2}$$

$$\mathbf{E} = \frac{1}{4\pi\varepsilon_0}\left(\frac{q}{r^2}\right)$$



Limitations of Coulomb's Law

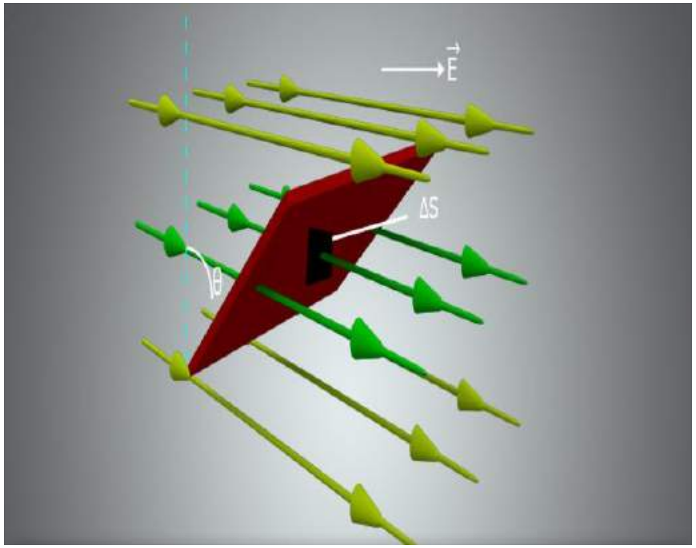
- Coulomb's law is valid for point charges only.
- It is valid only for static charges.
- It is valid only up to nuclear distance of 10^{-15} m.
- It is complex to deal with charges having irregular shapes.
- It is difficult to apply Coulomb's law when the charges are in arbitrary shape.

Electric flux

The electric flux through a surface placed inside electric field represents the total number of electric field lines crossing the surface in a direction normal to the surface.

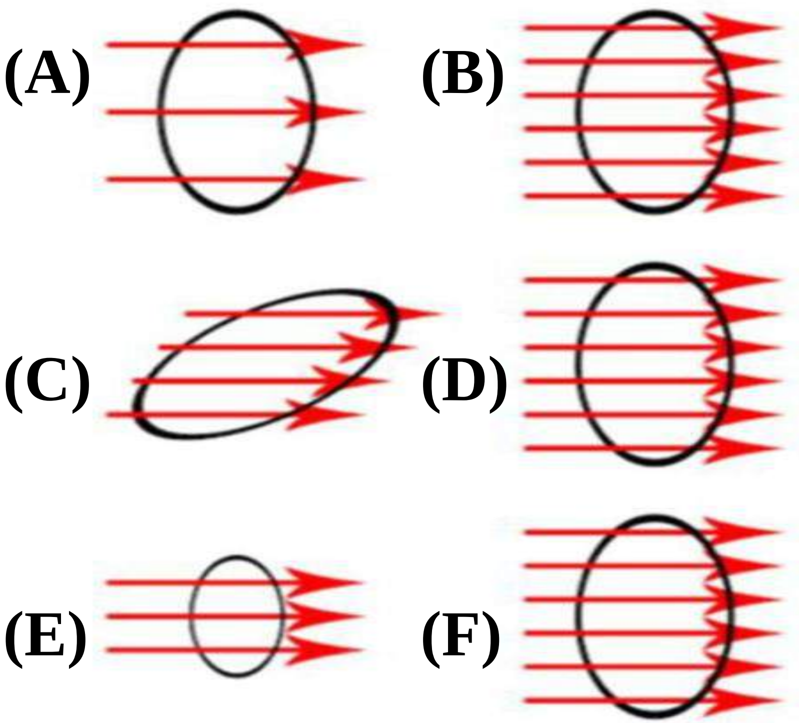
$$\phi_E = \oint \boldsymbol{E} \cdot \Delta \boldsymbol{S}$$

$$\phi_E = \text{E S} \cos\theta$$



Units: N.m^2 /C, Scalar quantity

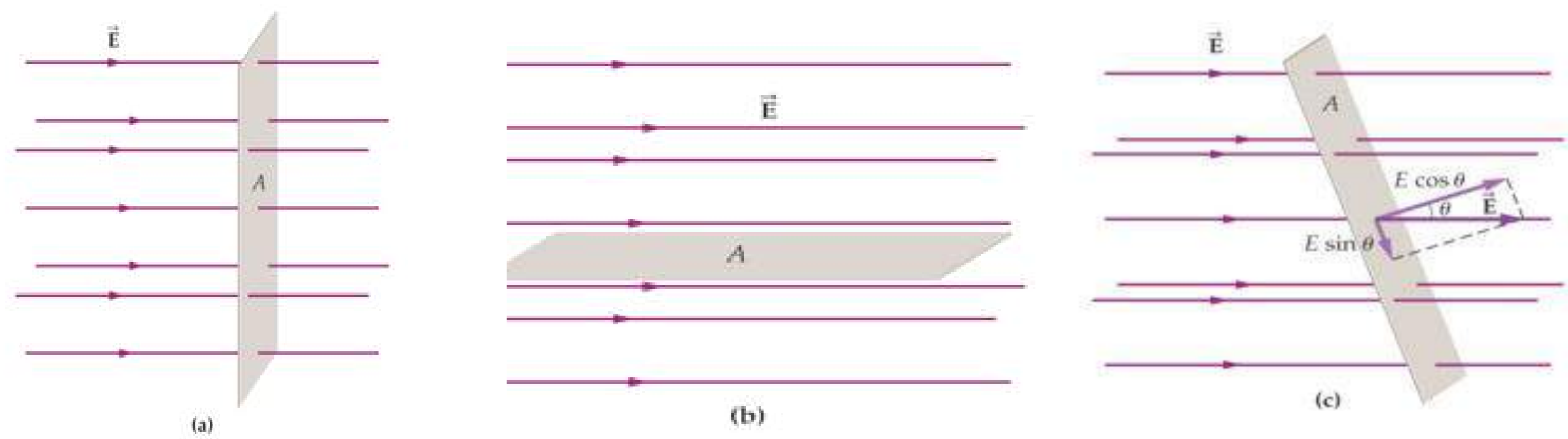
Electric flux depending factors



- Electric flux is proportional to the *density of flow (E).*
- Electric flux varies by how the *boundary faces the direction of flow (θ).*
- Electric flux is proportional to the *area within the boundary (S).*

$$\phi_{\boldsymbol{E}} = \mathbf{E} \,.\, \mathbf{S} = \mathrm{E\ S} \cos\theta$$

Calculate the flux of the electric field E, through the surface A, in each of three cases shown.



(a) $\Phi = EA$

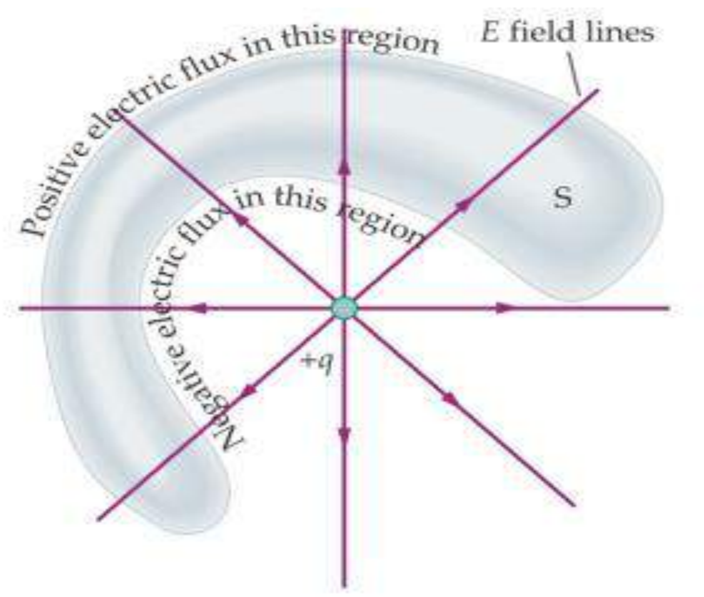
(b) $\Phi = 0$

(c) $\Phi = EA \cos \theta$

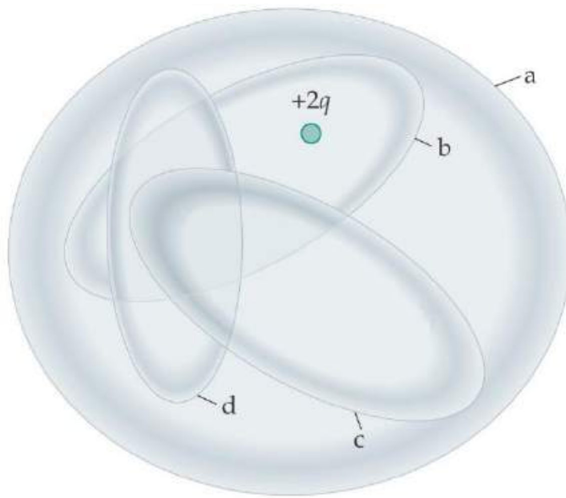
Properties of Electric flux

- *Flux is positive* for field lines that leave enclosed volume
- *Flux is negative* for field lines that enter enclosed volume

- If a charge is outside a closed surface, the net flux is zero.
- Lines leaving the surface is same as lines entering.



For which of these closed surfaces (a, b, c, d) the flux of the electric field, produced by the charge +2q, is zero?



2q charge is out of closed surfaces c, d.
Net electric flux is zero for surfaces c and d.

Gauss's law (History)

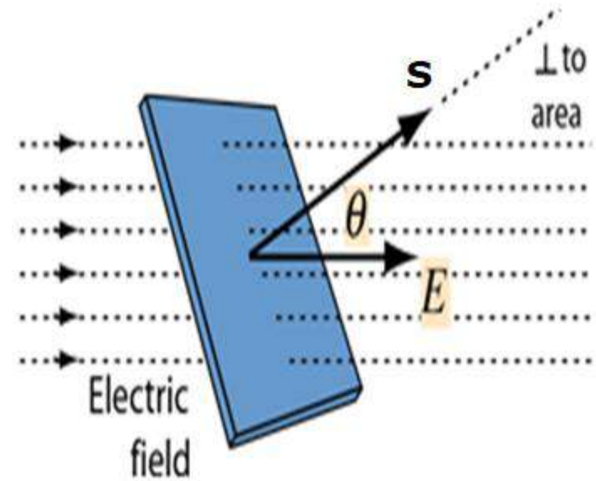
- Gauss's law is basically the relation between the distribution of charges to the resulting electric field.
- Gauss's law is based on the fact that flux through any closed surface is measure of total amount of charge inside that surface.
- *Any charge outside that surface would not contribute anything to the total flux.*

CARL FRIEDRICH GAUSS

German Scientist

Gauss's law

Gauss Law states that total normal electric flux $\emptyset_E$ over a closed surface is $(1/\varepsilon_0)$ times the total charge q enclosed within the surface.



$$\emptyset_E = \frac{q_{enclosed}}{\varepsilon_0}$$

Integral form of Gauss's law

$$\emptyset_E = \oint \mathbf{E} \cdot d\mathbf{S} = \frac{q_{enclosed}}{\varepsilon_0}$$

$q = \iiint \rho \, dV$, ρ = volume charge density,

Gauss divergence theorem

$\oint \mathbf{E} \cdot d\mathbf{S} = \iiint \mathrm{div}\boldsymbol{E} \; dV$

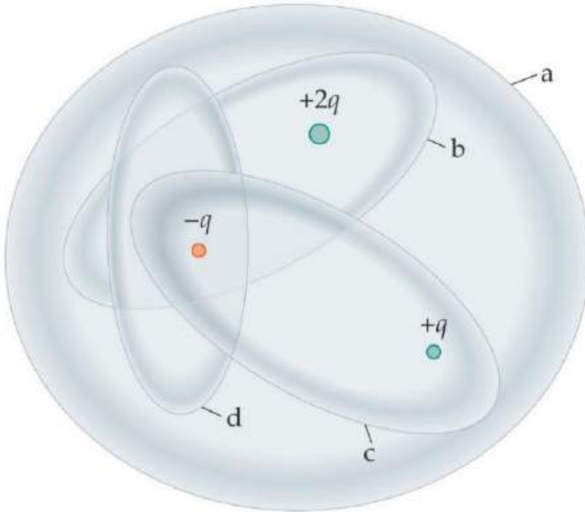
Electric displacement vector **D** = ε_0**E**

Differential form of Gauss's law

$$\nabla . \mathbf{E} = \frac{\rho}{\varepsilon_0}, \qquad \nabla . \mathbf{D} = \rho$$

Maxwell's First equation

Calculate the flux of the electric field Φ for each of the closed surfaces a, b, c, and d



Gauss's law: $\phi_E = \frac{q_{enclosed}}{\varepsilon_0}$

Surface a, $\Phi_a = \frac{+2q}{\varepsilon_0}$

Surface b, $\Phi_b = \frac{+q}{\varepsilon_0}$

Surface c, $\Phi_c = 0$

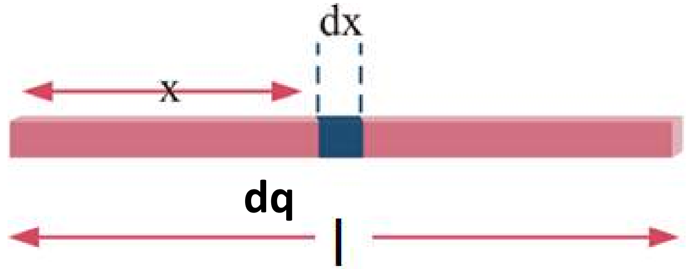
Surface d, $\Phi_d = \frac{-q}{\varepsilon_0}$

Applications of Gauss's law

Various Charge distributions

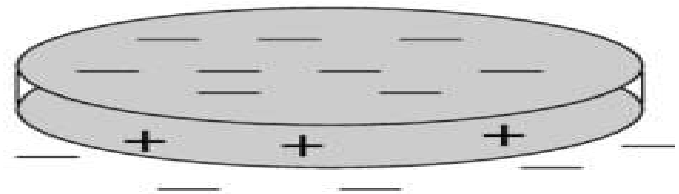
Linear charge density: $\lambda = \frac{q}{l}$

Units: C/m



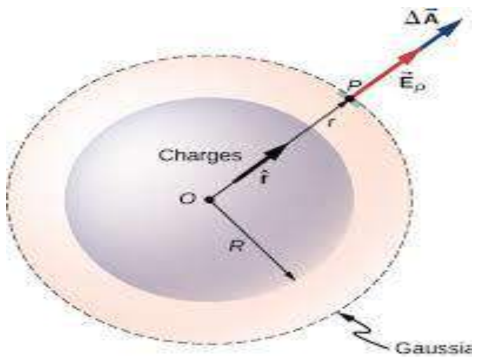
Surface charge density: $\sigma = \frac{q}{s}$

Units: C/m^2



Volume charge density: $\rho = \frac{q}{V}$

Units: C/m^3



Problem solving strategies for Gauss's law

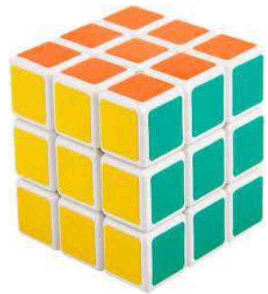
1. **Select a Gaussian surface with symmetry that matches charge distribution**
2. Draw Gaussian surface so that electric field is either constant or zero at all points on the Gaussian surface
3. Use symmetry to determine direction of E on Gaussian surface
4. Evaluate surface integral (Electric flux)
5. Determine the charge inside the Gaussian surface
6. **Solve for Electric field**

How to select suitable closed Gaussian surface ?

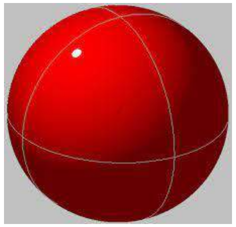
Possible closed surfaces

Cylinder

Cube



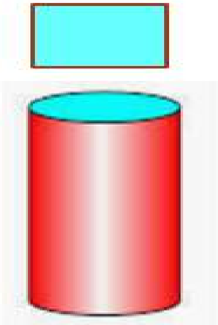
Sphere



Selection of suitable closed Gaussian surface

Plane charge distribution*: Infinite line of charge* **(Cylinder)**

Surface charge distribution*: Infinite sheet of charge* **(Cylinder)**

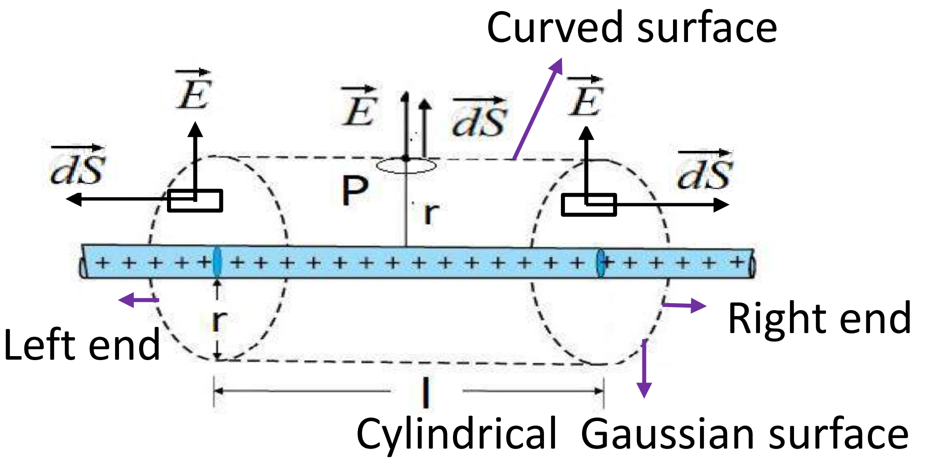


Volume charge distribution: *Charged Sphere* **(Sphere)**

Electric field due to infinite long charge distribution

Linear charge distribution $\lambda = \frac{q}{l}$

Gaussian surface: coaxial cylinder of length l and radius r



Gauss's law

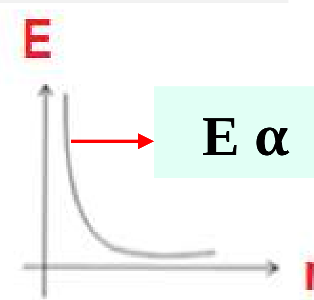
$$\emptyset_E = \oint \mathbf{E} \cdot d\mathbf{S} = \frac{q_{enclosed}}{\varepsilon_0} = \frac{\lambda l}{\varepsilon_0}$$

$$\emptyset_E = \oint \mathbf{E} \cdot d\mathbf{S} = \oint_{left\ end} \mathbf{E} \cdot d\mathbf{S} + \oint_{right\ end} \mathbf{E} \cdot d\mathbf{S} + \oint_{curved\ surface} \mathbf{E} \cdot d\mathbf{S}$$

$\emptyset_E = 0+0+\oint_{curved\ surface} \mathbf{E} \cdot d\mathbf{S} = E.\ 2\pi rl$, $\quad E.\ 2\pi rl = \frac{\lambda l}{\varepsilon_0}$

$$\mathbf{E} = \frac{\lambda}{2\pi\varepsilon_0 r}$$

Graphical representation of electric field due to a infinity long line of charge.



$\mathbf{E}\ \alpha\ \mathbf{r}$

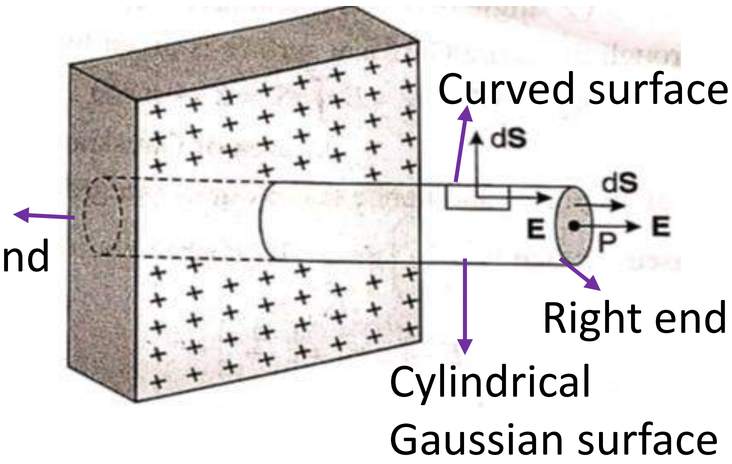
Electric field due to infinite conducting sheet of charge

Surface charge distribution $\sigma = \frac{q}{s}$

Cylindrical Gaussian surface

Gauss's law

$$\emptyset_E = \oint \mathbf{E} \cdot d\mathbf{S} = \frac{q_{enclosed}}{\varepsilon_0} = \frac{\sigma\, S}{\varepsilon_0}$$



$$\emptyset_E = \oint \mathbf{E} \cdot d\mathbf{S} = \oint_{\text{left end}} \mathbf{E} \cdot d\mathbf{S} + \oint_{\text{right end}} \mathbf{E} \cdot d\mathbf{S} + \oint_{\text{curved surface}} \mathbf{E} \cdot d\mathbf{S}$$

$$\emptyset_E = 0 + \oint_{\text{right end}} \mathbf{E}.\, d\mathbf{S} + 0 = E\, S,$$

$$E\, S = \frac{\sigma\, S}{\varepsilon_0}$$

$$\mathbf{E = \frac{\sigma}{\varepsilon_0}}$$

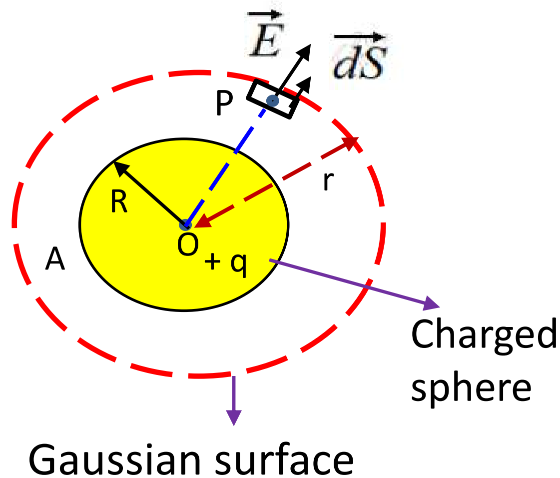
E is independent on r

Electric field due to uniformly charged sphere

(i) At a point outside the charged sphere: (r >R)

Volume charge distribution $\rho = \frac{q}{V}$

Spherical Gaussian surface with radius r

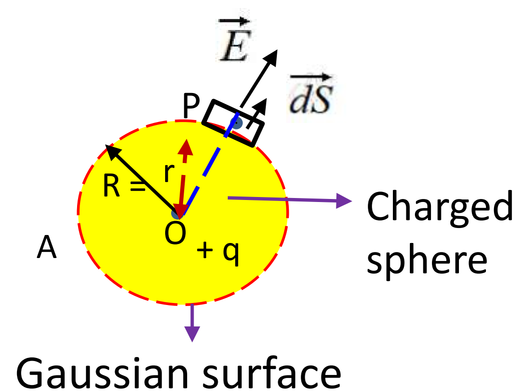


Gauss's law $\varnothing_E = \oint \mathbf{E} \cdot d\mathbf{S} = \frac{q}{\varepsilon_0}$

$\varnothing_E = \oint \mathbf{E} \cdot d\mathbf{S} = E \oint dS = E(4\pi r^2)$, $E(4\pi r^2) = \frac{q}{\varepsilon_0}$

$$\mathbf{E} = \frac{1}{4\pi\varepsilon_0} \times \frac{q}{r^2}$$

(ii) At a point on the Surface: (r = R)



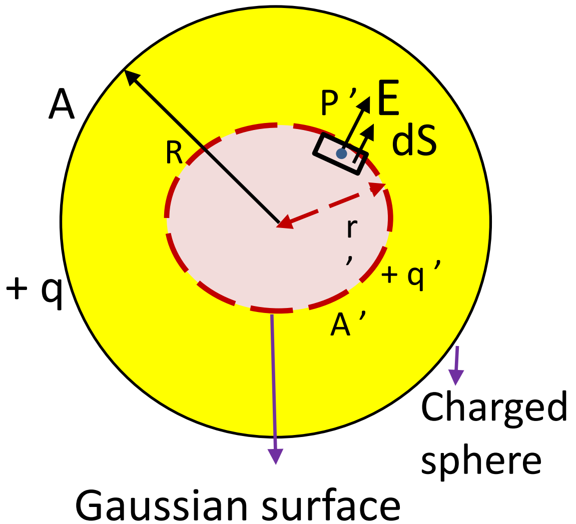
$$\mathbf{E} = \frac{1}{4\pi\varepsilon_0} \times \frac{q}{R^2}$$

Electric field due to uniformly charged sphere

(iii) At a point inside the charged sphere: ($r' < R$)

Volume charge distribution $\rho = \frac{q}{V} = \frac{q}{\frac{4}{3}\pi R^3}$

Spherical Gaussian surface with radius r'



Gauss's law $\emptyset_E = \oint \mathbf{E} \cdot d\mathbf{S} = \frac{q'}{\varepsilon_0}$

Total charge enclosed by Gaussian surface

$$q' = \rho V' = \left(\frac{q}{\frac{4}{3}\pi R^3}\right)\left(\frac{4}{3}\pi r'^3\right) = q\left(\frac{r'}{R}\right)^3$$

$$\emptyset_E = \oint \mathbf{E} \cdot d\mathbf{S} = E\left(4\pi r'^2\right)$$

$$E\left(4\pi r'^2\right) = \frac{q'}{\varepsilon_0}$$

$$E\left(4\pi r'^2\right) = q\left(\frac{r'}{R}\right)^3$$

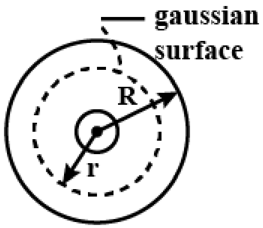
$$\mathbf{E} = \frac{1}{4\pi\varepsilon_0} \times \frac{qr'}{R^3}$$

Graphical representation of Electric field due to uniformly charged sphere

Charged sphere

Inside sphere	On sphere	Outside sphere
$r < R$	$r = R$	$r > R$

Inside sphere ($r < R$)

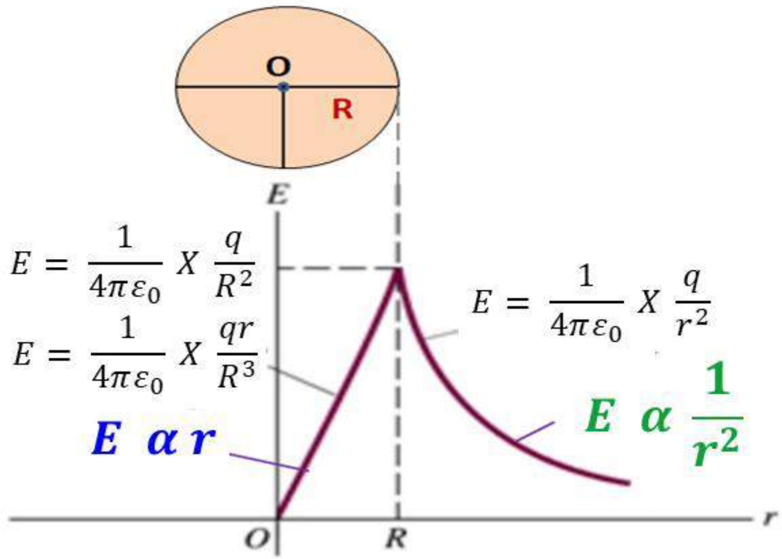


$$E = \frac{1}{4\pi\varepsilon_0} X \frac{qr}{R^3}$$

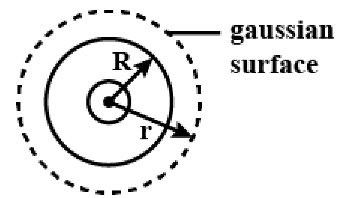
$$\mathbf{E \; \alpha \; r}$$

On sphere ($r = R$)

$$E = \frac{1}{4\pi\varepsilon_0} X \frac{q}{R^2}$$



Outside sphere ($r > R$)



$$E = \frac{1}{4\pi\varepsilon_0} X \frac{q}{r^2}$$

$$\mathbf{E \; \alpha \; \frac{1}{r^2}}$$

Electric field due to uniformly charged cylinder

Charged cylinder

Inside cylinder

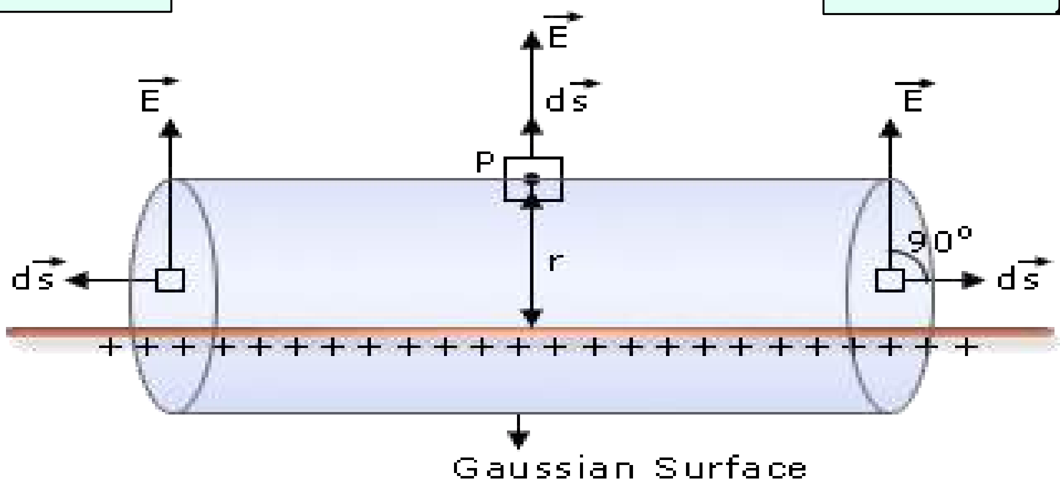
$$E = \frac{\lambda r}{2\pi\varepsilon_0 R^2}$$

$$\mathbf{E \ \alpha \ r}$$

Outside cylinder

$$E = \frac{\lambda}{2\pi\varepsilon_0 r}$$

$$\mathbf{E \ \alpha \ \frac{1}{r}}$$



Summary

- Electric charges: Positive, Negative , $p = e^- = 1.6 \times 10^{-19}$ C
- Unlike charges attracted and like charged repel with each other.
- Coulomb's law: $F = \frac{k(q_1 q_2)}{r^2}$, Electric field strength $E = \frac{F}{q}$
- Electric flux: $\phi_E = \oint \mathbf{E} \cdot d\mathbf{S} = E\,S\cos\theta$
- Gauss's law (Maxwell's first equation):

$$\phi_E = \oint \mathbf{E} \cdot d\mathbf{S} = \frac{\mathbf{q_{enclosed}}}{\boldsymbol{\varepsilon_0}},\ \nabla.\mathbf{E} = \frac{\rho}{\varepsilon_0},\quad \nabla.\mathbf{D} = \rho$$

- Applications of Gauss's law:
- Electric field due to an infinitely long charge distribution: $E = \frac{\lambda}{2\pi\varepsilon_0 r}$
- Electric field due to an infinitely conducting sheet of charge: $E = \frac{\sigma}{\varepsilon_0}$
- Electric field due to uniformly charged sphere :

Inside sphere: $E = \frac{1}{4\pi\varepsilon_0} \times \frac{qr}{R^3}$, On sphere: $E = \frac{1}{4\pi\varepsilon_0} \times \frac{q}{R^2}$, Out side Sphere: $E = \frac{1}{4\pi\varepsilon_0} \times \frac{q}{r^2}$

- Electric field due to a uniformly charged cylinder:

Inside sphere: $E = \frac{\lambda\, r}{2\pi\epsilon o\, R^2}$, Out side Sphere: $E = \frac{\lambda}{2\pi\epsilon o\, r}$

Worked out examples

1) An infinite line charge produces a field of 9×10^4 N/C at a distance of 2 cm. Find the linear charge density.

Solution: $E = 9 \times 10^4$ N/C , r = 2 cm

Formula : $E = \dfrac{\lambda}{2\pi\varepsilon_0 r}$

$$\lambda = \frac{4\pi\varepsilon_0 Er}{2} = \frac{9X10^4 x 0.02}{9x10^9 x\, 2} = \mathbf{0.1\ \mu C/m}$$

2) A charge of 4×10^{-8} C is distributed uniformly on the surface of a sphere of radius 1 cm. It is covered by a concentric, hollow conducting sphere of radius 5 cm. Find the electric field at a point 2 cm away from the centre.

Solution: $q = 4 \times 10^{-8}$ C , R = 1 cm, r = 2cm

r > R (Outside the charged sphere)

Formula : $E = \dfrac{q}{4\pi\varepsilon_0 r^2}$

$$E = \frac{9x10^9 x 4x10^{-8}}{4x10^{-4}} = \mathbf{9x10^5\ N/C}$$

QUIZ

1. Q_1 and Q_2 are 1 Coulomb and r =1 m, ($\frac{1}{4\pi\varepsilon_0} = 9x10^9$) then the force between the charges is [ ]

(a) $18x10^9$ N (b) $9x10^9$ N (c) $0.9x10^9$ N (d) $10x10^9$ N

2. Eight dipoles of charges of magnitude 'q' are placed inside a cube. The total electric flux through the cube will be [ ]

(a) Zero (b) $\frac{8q}{\varepsilon_0}$ (c) $\frac{16q}{\varepsilon_0}$ (d) $\frac{q}{\varepsilon_0}$

3. Electric intensity at a point varies as r^{-1} for [ ]

(a) a point charge (b) spherically symmetric charge distribution

(c) a plane sheet of charge (d) a line charge of infinite length

4. Choose the correct graphical representation for Electric field due to a charge sphere (E vs r) [ ]

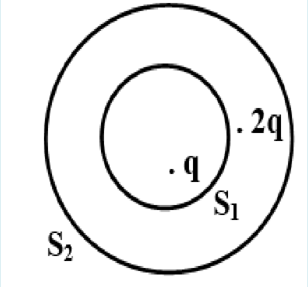
Answers: (1Q : **b**), (2Q: **a**) , (3Q: **d**), (4Q: **d**)

Student Assignment

1. Explain the concept of electric field.
2. What do you mean by electric flux?
3. State and Prove Gauss's theorem in Electrostatics. Derive an expression for the electric field due to uniformly charged sphere.

4. An amount of charge $5x10^{-6}$ C is uniformly distributed over a sphere with radius 5 cm. what if the electric field of the sphere at a point distance of 10 cm from the center?

5. S_1 and S_2 are two parallel concentric spherical surfaces enclosing charges q and 2q respectively as shown in figure. The ratio of electric flux through S_1 and S_2 is [ ]



(a) 3 : 1 (b) 1 : 3 (c) 1 : 1 (d) 1 : 2

THANK YOU

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PAPER: ELECTROMAGNETIC THEORY

TOPIC: MAGNETOSTATICS

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Magnetostatics is the study of magnetic fields in systems where the currents are steady (not changing with time). It is the magnetic analogue of electrostatics

1. There are North Poles and South Poles.

2. Like poles repel, unlike poles attract.

3. Magnetic forces attract only magnetic materials.

4. Magnetic forces act at a distance.

5. While magnetized, temporary magnets act like permanent magnets.

Orested experiment: Current carrying conductor produces a magnet.

Magnetic field intensity (H)

Units : A/m, Oersted

$$B = \mu H$$

μ_0 = permeability of free space

$\mu_0 = 4\pi \text{ x } 10^{-7}$ T.m/A

Magnetic flux density or
Magnetic induction (B)

Units: M.K.S

1 Tesla = wb/m^2 = N/(A.m)

C.G.S

1 Gauss

1 Tesla = 1 wb/ m^2 = 10^4 Gauss

Magnetic flux

The number of magnetic field lines passing **normally** through any surface placed inside electric field is called electric flux.

Units:
weber (wb), Tesla. m^2
Scalar quantity

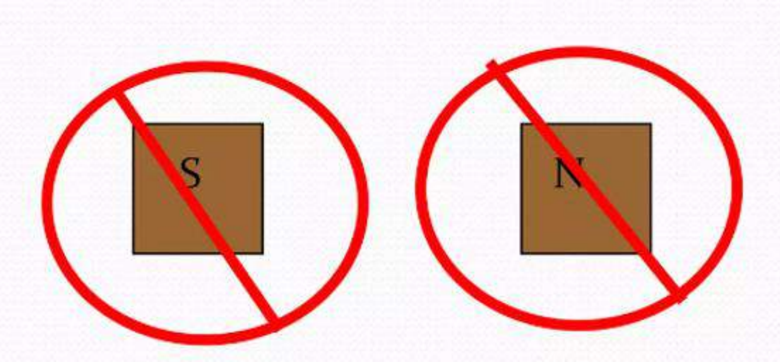
$$\varnothing_B = \oint B \cdot d\boldsymbol{S}$$

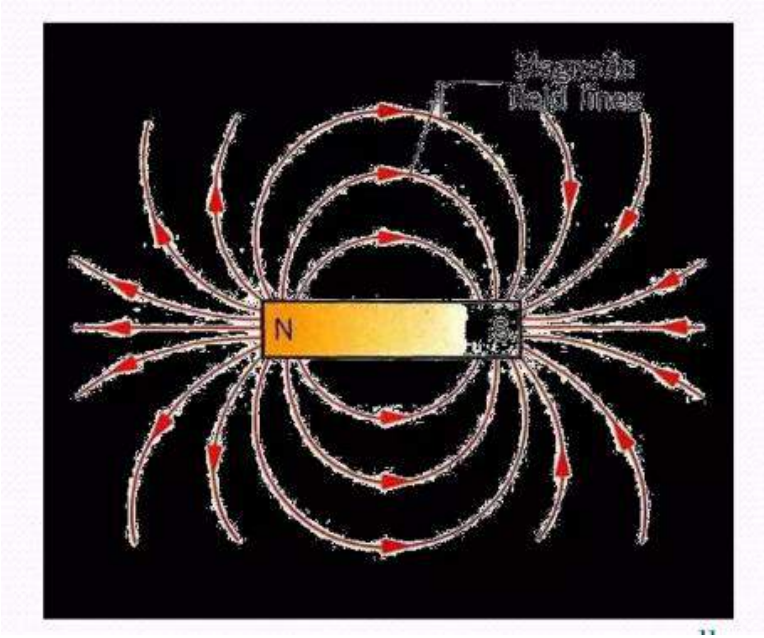
$$\varnothing_E = B\,S\cos\theta$$

$$\boldsymbol{\nabla}.\mathbf{B} = \mathbf{0}$$

Gauss law In Magnetostatics
Maxwell's Second equation.

Magnetic field lines are closed loops.
Started at North Pole and ends at South Pole.
Mono Poles does not exists in magnets





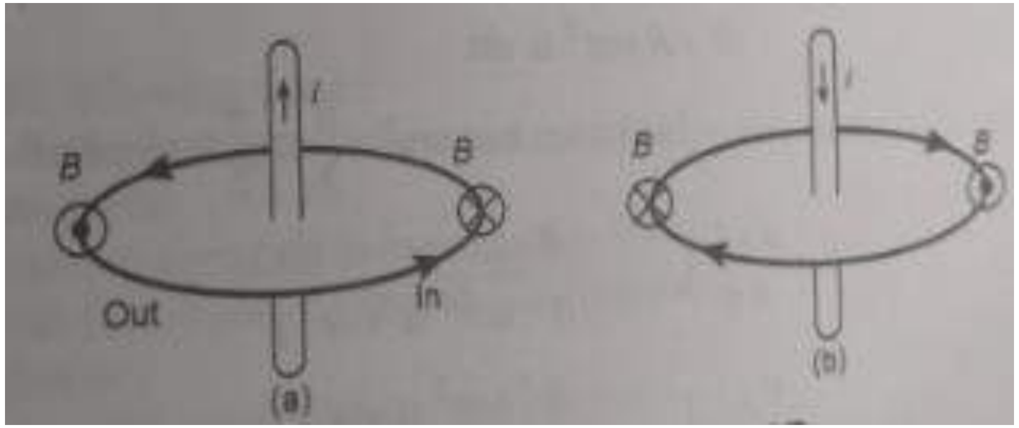
BIOT-SAVART LAW

Orested experiment: Current carrying conductor produces a magnet.
BIOT –SAVART obtained relation for B.

$$d\boldsymbol{B} = \frac{\mu_0}{4\pi} \text{x} \frac{\text{i dl sin}\theta}{r^2}$$

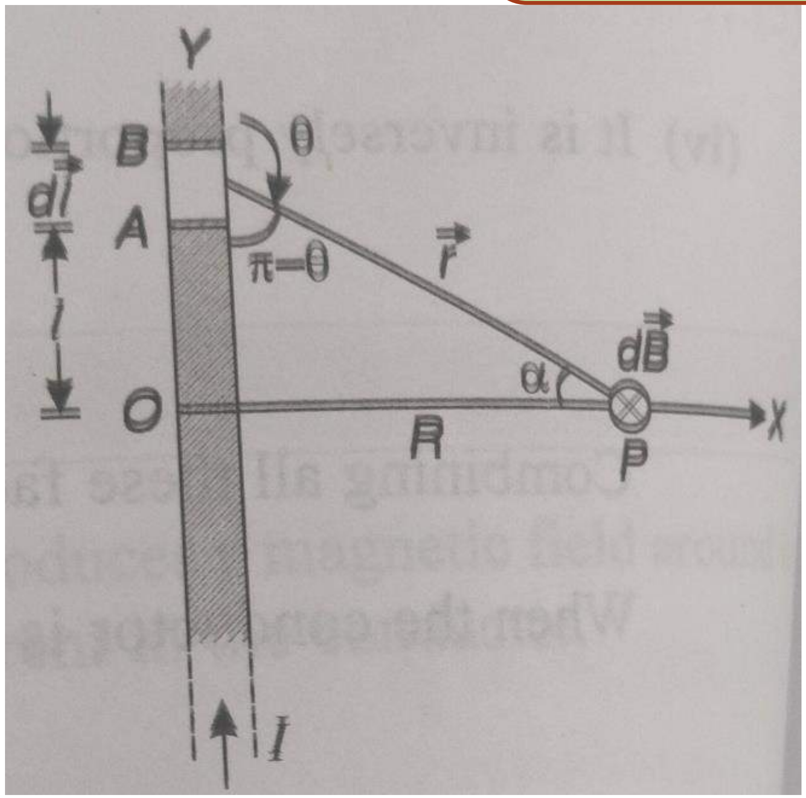
$$d\boldsymbol{B} = \frac{\mu_0}{4\pi} \text{x} \frac{\text{i dl x } \boldsymbol{r}}{r^3}$$ (Vector form)

Direction of B:
Direction of d**B** will be perpendicular to the plane containing dl and r. (Right hand thumb rule).

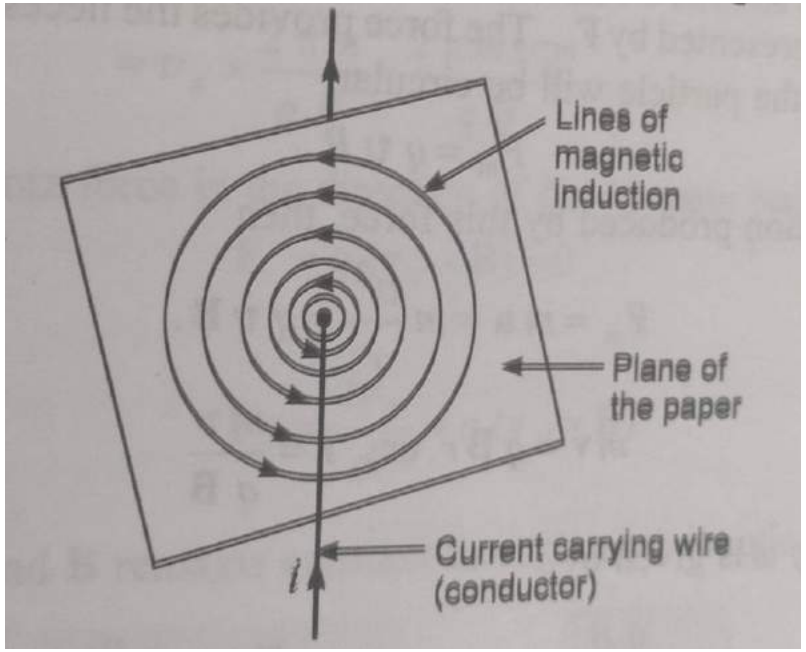


If magnetic field is directed perpendicular and into the plane of the paper, then it is represented by cross.
If magnetic field is directed perpendicular and out of the plane of the paper, then it is represented by dot.

Magnetic field due to Long straight conductor (current carrying wire)



$$B = \frac{\mu_0 \, i}{2\pi R}$$



Concentric circles

Magnetic field on the axis of a circular loop

Consider a circular coil of radius a and carrying a current i. Magnetic field at P point which is on the axis of the coil distance x from the centre.

$$B = \frac{\mu_0 \, N i a^2}{2(a^2 + x^2)^{3/2}}$$

Magnetic field at the centre of coil $\boldsymbol{B = \frac{\mu_0 \, Ni}{2a}}$

Magnetic field induction due to a solenoid

A long, tightly wound helical coil of wire id called as solenoid

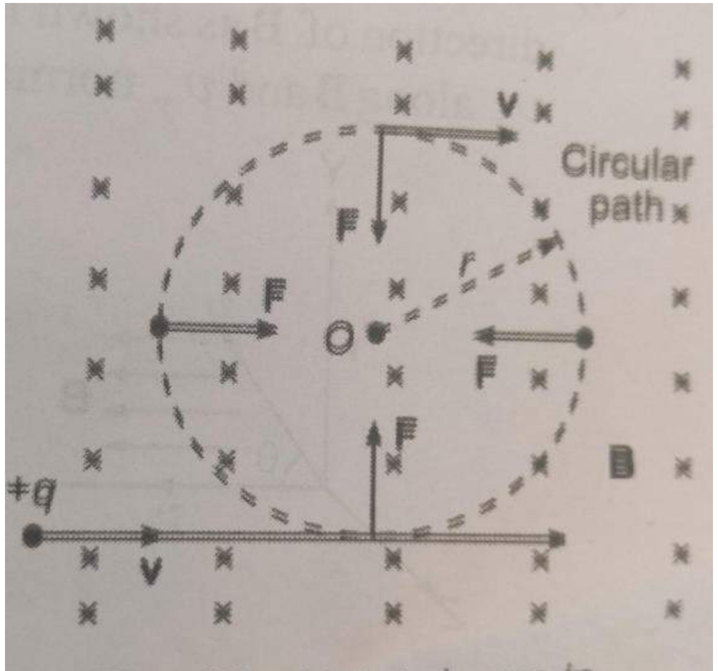
Magnetic field at the centre of solenoid $\boldsymbol{B = \frac{\mu_0 \, Ni}{l} = \mu_0 \, ni}$

Magnetic field at an axial end point $\boldsymbol{B = \frac{\mu_0 \, ni}{2}}$

Force on a point charge in magnetic field

$F = q(v \times B) = qvB \sin\theta$

1) Particle is at rest , F =0
2) Particle is moving along the line of magnetic field, F = 0
3) Particle is moving along the line of magnetic field, F = maximum
4) In magnetic field, the work done by the force acting on the charged particle is zero.
5) When a charged particle enters a magnetic field in a direction **perpendicular to the field, it takes a circular path in the field.**



$$radius\ r = \frac{mv}{qB} \qquad angular\ velocity\ w = \frac{qB}{m} \qquad Cyclotron\ frequency\ f = \frac{qB}{2\pi m}$$

Ampere's law

Line integral of magnetic field B along a closed curve is equal to μ_0 time the net current I through the area bounded by the curve

$$\oint \mathbf{B} \cdot d\mathbf{l} = \mu_0 i \qquad \text{(Inegral form)}$$

$$\nabla \times \mathbf{B} = \mu_0 \mathbf{J} \qquad \text{(Differential form)}$$

$Current\ density\ J = \frac{i}{A}$,

$Units: \frac{A}{m^2}$, $Vector$

$$\oint \mathbf{J} \cdot d\boldsymbol{S} = i$$

Maxwell's Third equation

Magnetic field due to Long straight conductor (current carrying wire) $B = \frac{\mu_0\, i}{2\pi R}$

Magnetic field at the centre of coil $B = \frac{\mu_0\, Ni}{2a}$

Magnetic field at the centre of solenoid $B = \frac{\mu_0\, Ni}{l} = \mu_0\, ni$

Self inductance of Long solenoid

$\emptyset_B = BA, \qquad \emptyset_B = \mathrm{Li}$ $\qquad B = \frac{\mu_0 N i}{l} = \mu_0 n i$

$$L = \frac{\mu_0 N^2 A}{l} = \mu_0 n^2 A l$$

Units: Henry (H)

$n = Number\ of\ turns\ per\ unit\ length = (N/l)$

Length of coil (l), Number of turns in the coil (N)

Cross – sectional area of the coil (A)

Energy density in Magnetic field

$$u = \frac{U}{V} = \frac{1}{2}\frac{B^2}{\mu_0}\ (\mathrm{J/m^3})$$

Force on a current carrying conductor

$$F = i\,(l \times B) = ilB \sin\theta$$

Fleming's left hand rule

Fore finger : Induction finger : Field (B)

Central finger: Current (i)

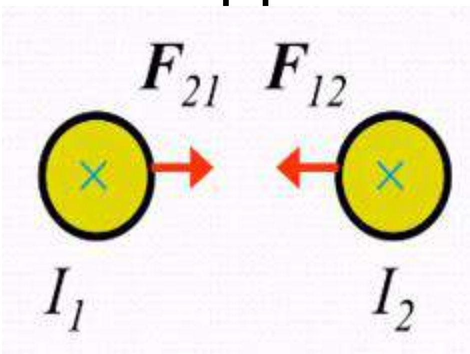
Thumb: Force: Thrust (F)

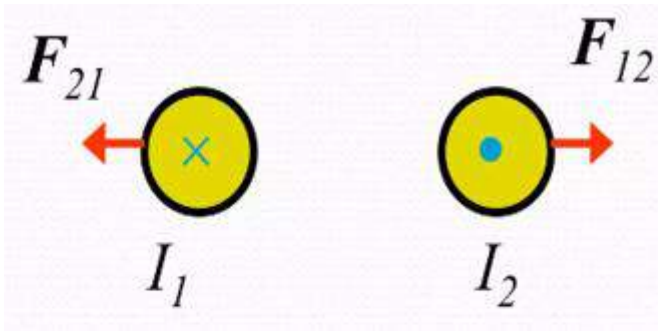
Force between two parallel conductors

Two parallel wires carrying current in the same direction attract.

Two parallel wires carrying current in the opposite directions repel.

$$\boldsymbol{F_{12} = F_{21} = \frac{\mu_0 i_1 i_2}{2\pi d}}$$





Torque on a current loop in Uniform Magnetic field:

$$\tau = i\,N\,AB\,\sin\theta = N\,i\,\boldsymbol{A} \times \boldsymbol{B}$$

$$\tau = \boldsymbol{M} \times \boldsymbol{B}$$

Assignment

1) A long straight wire carries a current of 3.5 A. Find the magnetic induction at a point 0.2 m from the wire. [$3.5 * 10^{-6}$ A/m]

2) An infinitely long conductor carries a current of 10 mA. Find the magnetic field and intensity at a point 10 cm away from it.
[$2 * 10^{-8}$ A/m, 0.01591 A/m]

3) A current of 1 A is flowing in a circular coil of radius 10 cm and 20 turns. Calculate the magnetic field at the centre. [4π x 10^{-7} wb/ m^2]

4) If two parallel conductors separated by 20 cm in free space carry 20 A and 40 A currents respectively, determine magnetic induction at mid-point of line joining the conductors. [8 x 10^{-4} N/m]

5) Calculate the energy stored in the magnetic field of a solenoid of inductance 5 mH, when a maximum current of 3 A flows through it.
[22.5 x 10^{-3} J]

Assignment

6) A circular coil of wire of diameter 10 cm and having 10 turns carries a current of 1 A. If it is placed in a uniform magnetic field of induction 0.5 T, calculate the maximum torque on the coil. [0.3928 N.m]

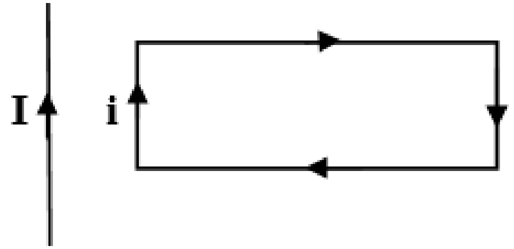
7) At what distance from a long straight wire carrying a current of 12 A will the magnetic induction be equal to 3 x 10^5 T? [8 x 10^{-12} m]

8) Find the energy stored in the magnetic field of a solenoid of inductance 5 mH, when a maximum current of 2 A flows through it. [0.01J]

9) Find the intensity of magnetic field at the center of a circular coil of radius 20 cm and 20 turns having a current 1 A in it. [B]

(A) 200 A/m (B) 100 A/m (C) 10 A/m (D) 20 A/m

10) A rectangular loop carrying a current 'I' is situated near a long straight wire such that the wire is parallel to one of the sides of the loop and is in the plane of the loop. If steady current I established in the wires as show in figure, the loop [C]



(A)rotate about an axis parallel to wire (B) move away from the wire

(C) move towards the wire (D) remains stationary

Previous JAM questions

1) In terms of the basic units of mass (M), length (L) time (T) and charge (Q), the dimensions of magnetic permeability of vacuum (μ_0) are **(JAM -2007)**

(A) MLQ^{-2} (B) $ML^2T^{-1}Q^{-2}$ (C) LTQ^{-1} (D) $LT^{-1}Q^{-1}$

2) Two long, parallel straight conducting wires carry the same current in the same direction. If the distance between them is halved and the current in both is doubled, the force per unit length between them will change by a factor of **(JAM -2007)**

(A) 1/8 (B) 8 (C) 4 (D) 1/4

3) Two long straight parallel wires are carrying current of same magnitude I, but in opposite direction. If the wires are separated by a distance d, then magnetic field at the middle of the separation is **(JAM -2011)**

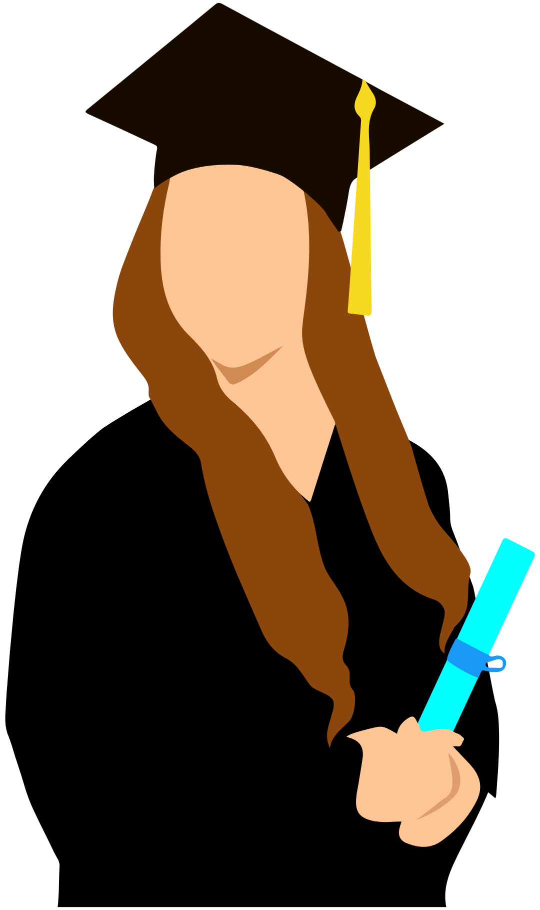
(A) $\frac{\mu_0 I}{2\pi d}$ (B) $\frac{2\pi\mu_0 I}{d}$ (C) $\frac{\mu_0 I}{\pi d}$ (D) $\frac{2\mu_0 I}{\pi d}$

4) In terms of the basic units of mass (M) , length (L) time (T) and charge (C), the dimensions of magnetic induction field (B) is **(JAM -2013)**

(A) $ML^2T^{-1}C^{-1}$ (B) $MT^{-1}C^{-1}$ (C) $L^2T^{-1}C$ (D) $L^{-1}T^{-1}C$

Answers: (1Q : **A**), (2Q: **B**) , (3Q : **D**), (4Q : **B**)

THANK YOU

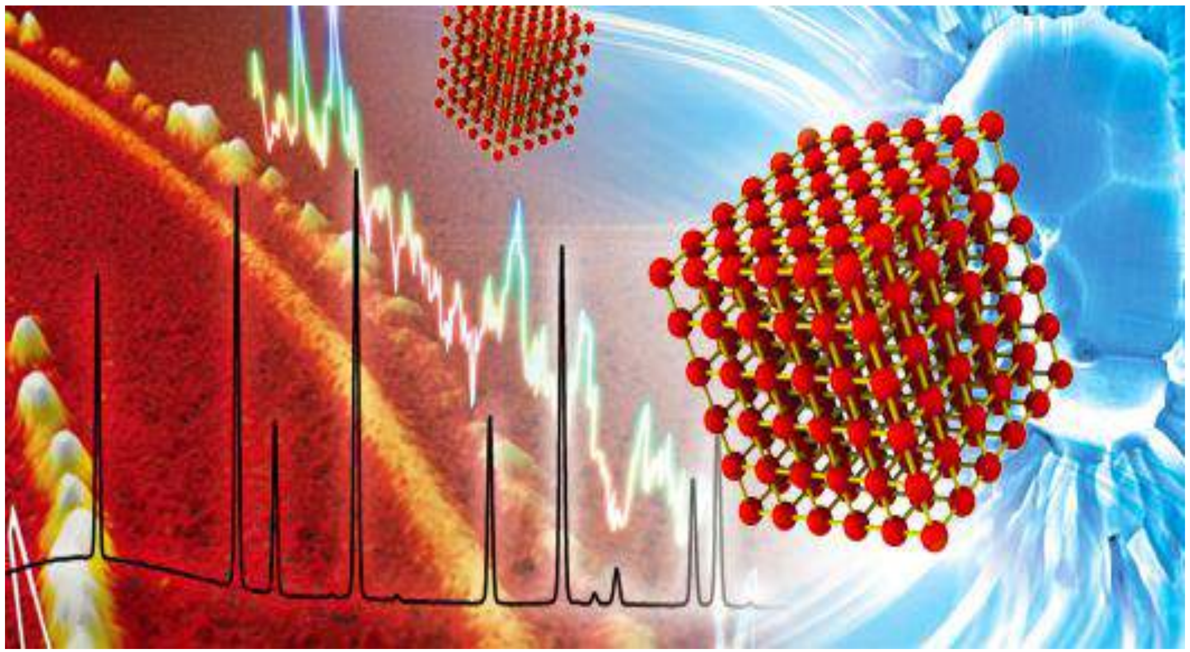


BEST OF LUCK

TSWRAFPDCW, Bhongir

PAPER: SOLID STATE PHYSICS

TOPIC: X-RAY DIFFRACTION (XRD)



K. SPANDANA

HOD, Department of Physics

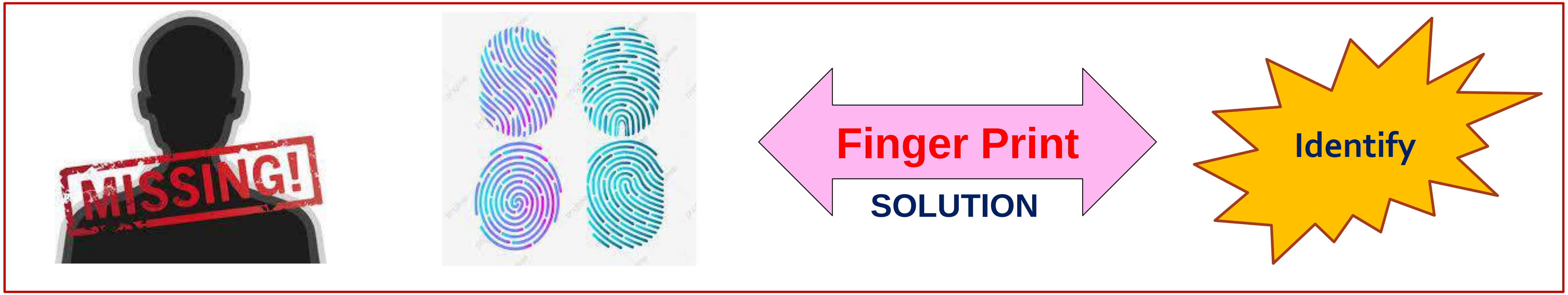
TSWRAFPDCW, Bhongir

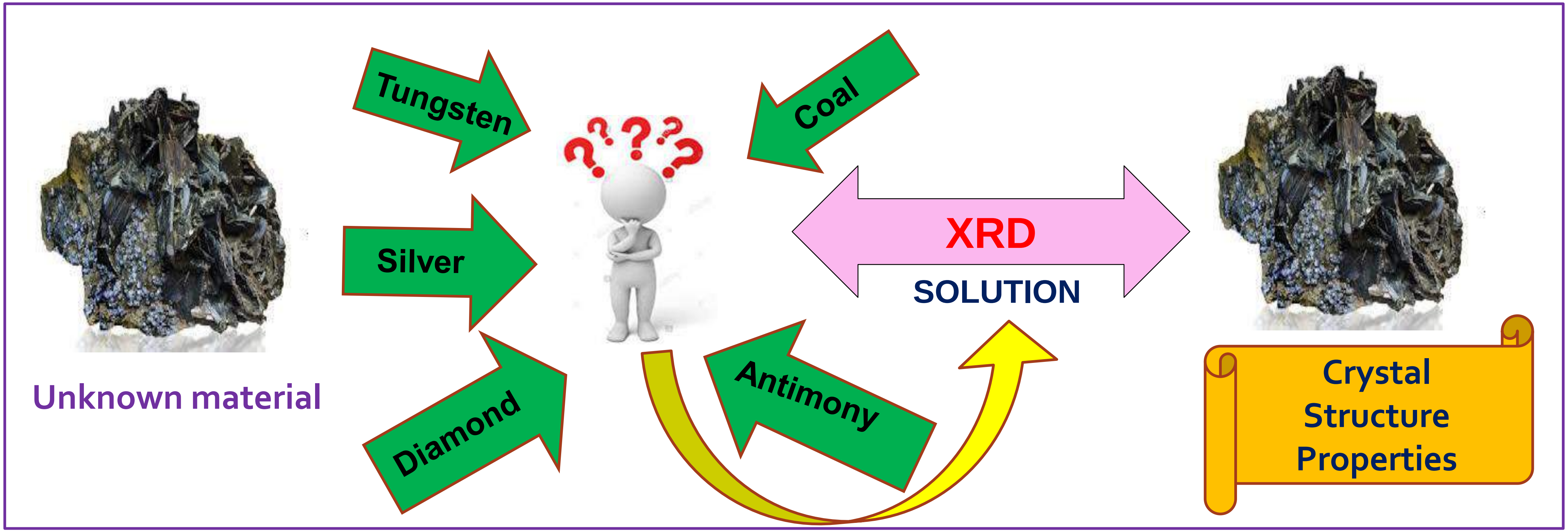
Objectives

X-RAY DIFFRACTION (XRD)

- Introduction
- diffraction
- Electromagnetic spectrum
- Reason for X-rays
- X-Ray Diffraction (XRD)
- Bragg’s law
- x-ray diffraction methods
- Applications of XRD
- Advantages and disadvantages
- Scope of research, references

Introduction

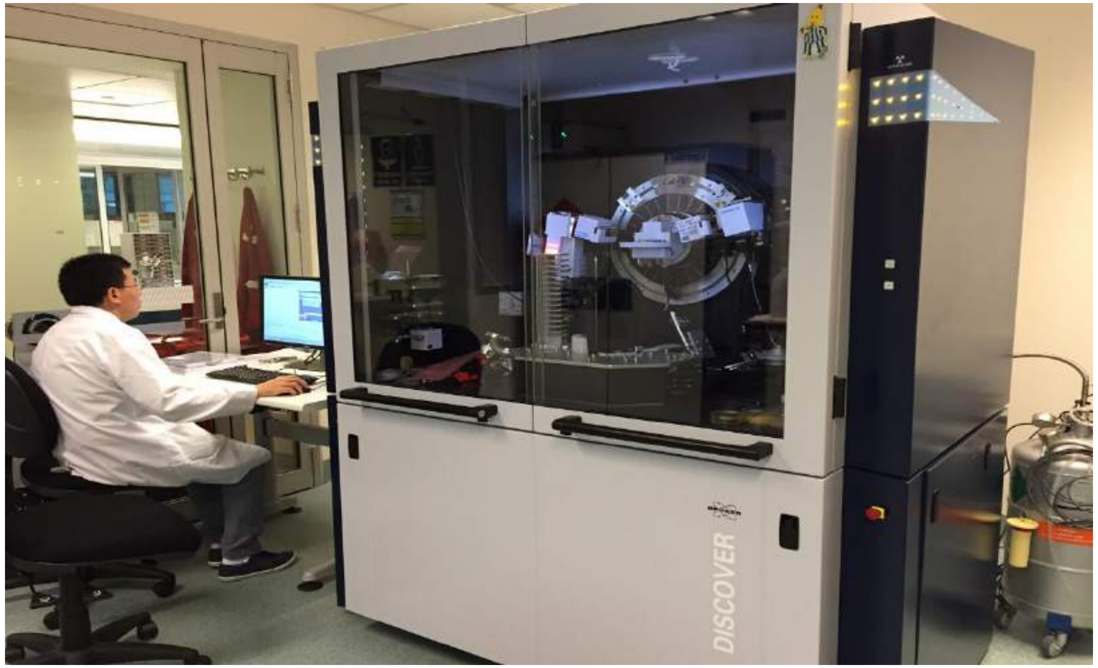




X-Ray Diffraction (XRD)

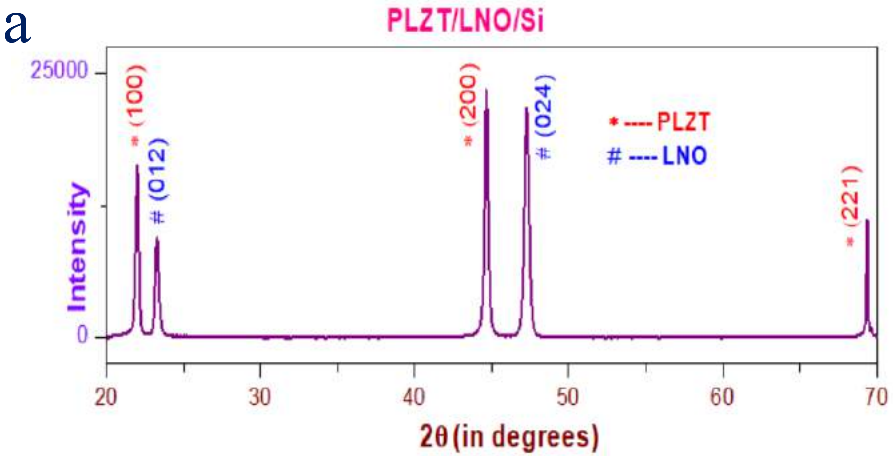
X –Ray Diffraction (XRD):

- Novel and Non-destructive technique
- Finger print of substance
- Provides detailed information about crystallographic structure, chemical composition, physical properties of materials



XRD Measure:

- Average spacings between layers of rows of atoms in a substance
- Determine the orientation of an individual grain or crystal
- Measure the size, shape and internal stress of small crystalline areas
- Identify the crystal structure of an unknown substance.



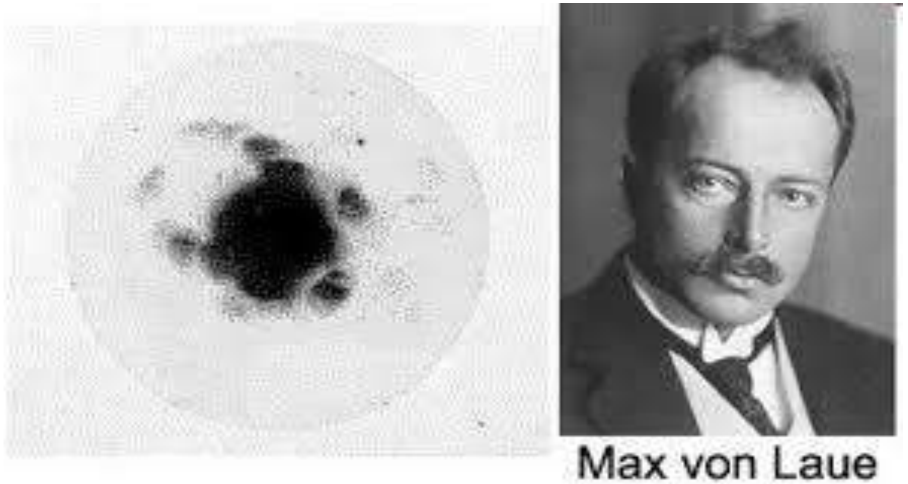
XRD – Thin film (600 nm)

History

Wilhelm Roentgen

Nobel Prize : 1915
German Physicist

X- Rays



Max Von Laue

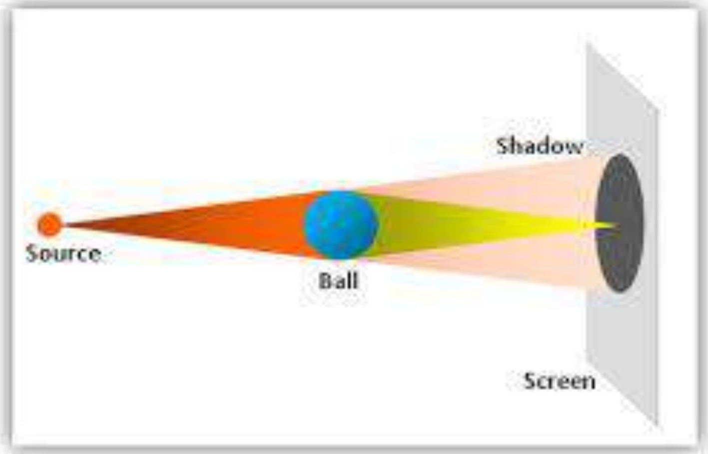
Nobel Prize : 1915
German Physicist

X-Ray Diffraction

Diffraction

Bending nature of light around the corners of aperture.

Diffraction, Interference characterizes wave nature of light.



Condition for Diffraction:

$$\sin\theta \sim \lambda/d$$

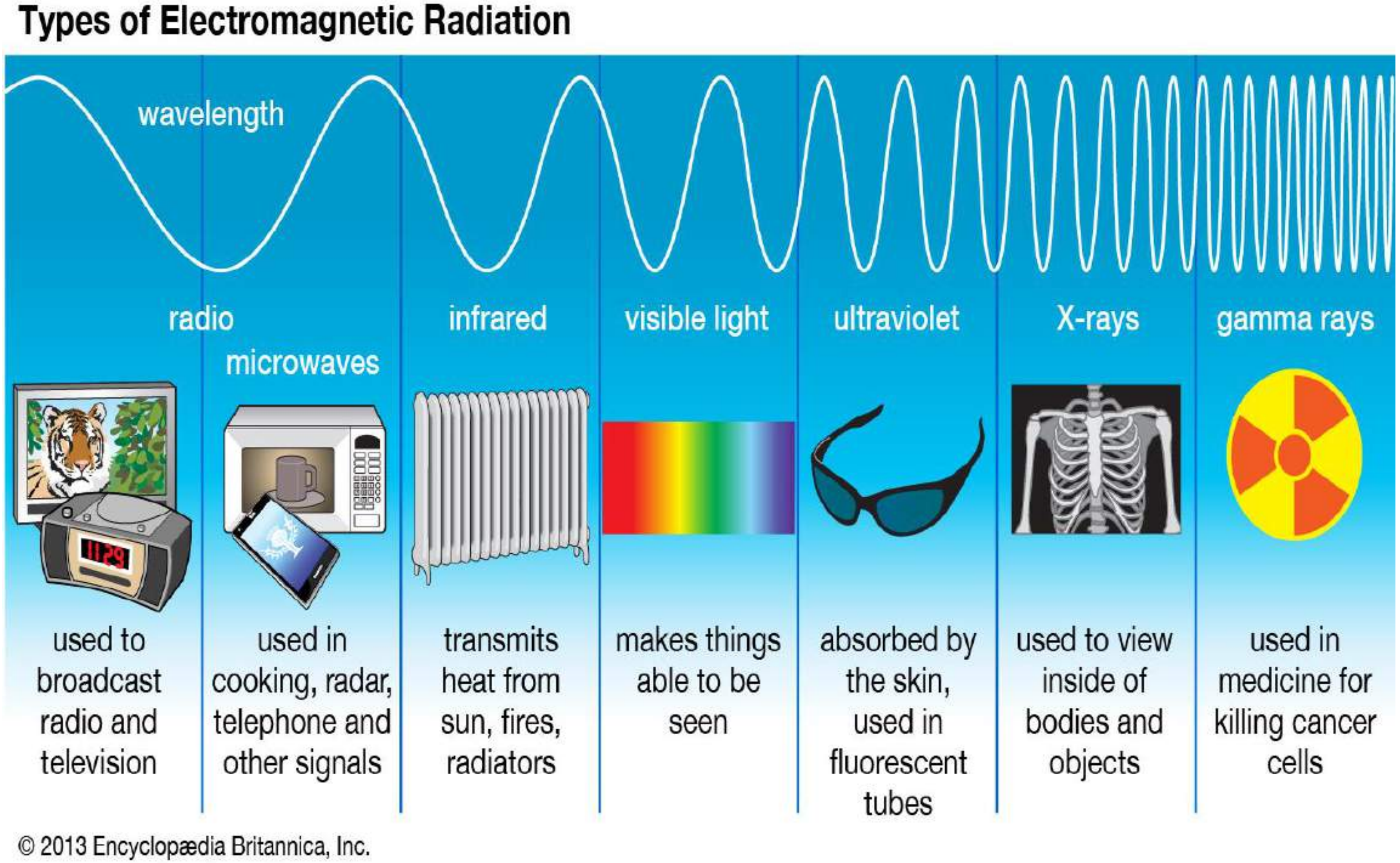
Wavelength of light ~ Size of Aperture

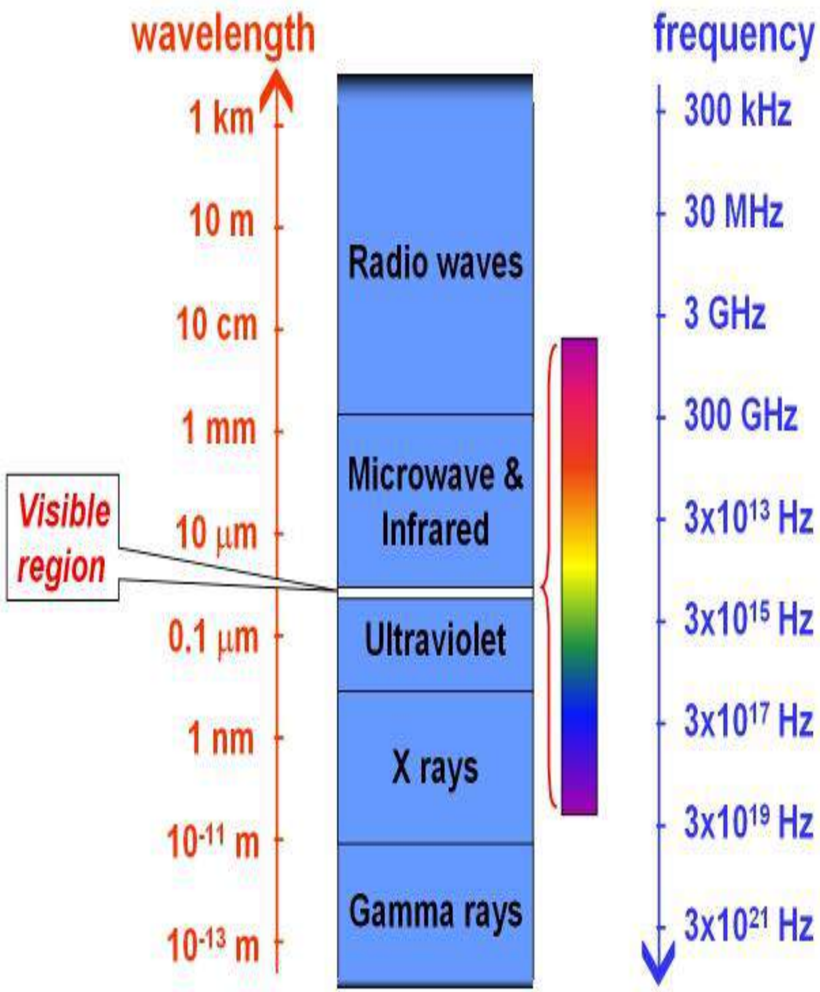
Diffraction in every day example:

Application of Diffraction:

- ✓ **Hologram**
- ✓ **Spectroscopy**
- ✓ ***X-Ray Diffraction (XRD)***

Electromagnetic spectrum





X-Rays

Hard X-Rays
Soft X-Rays

Short Wavelength : 0.1 A^0 to 100 A^0

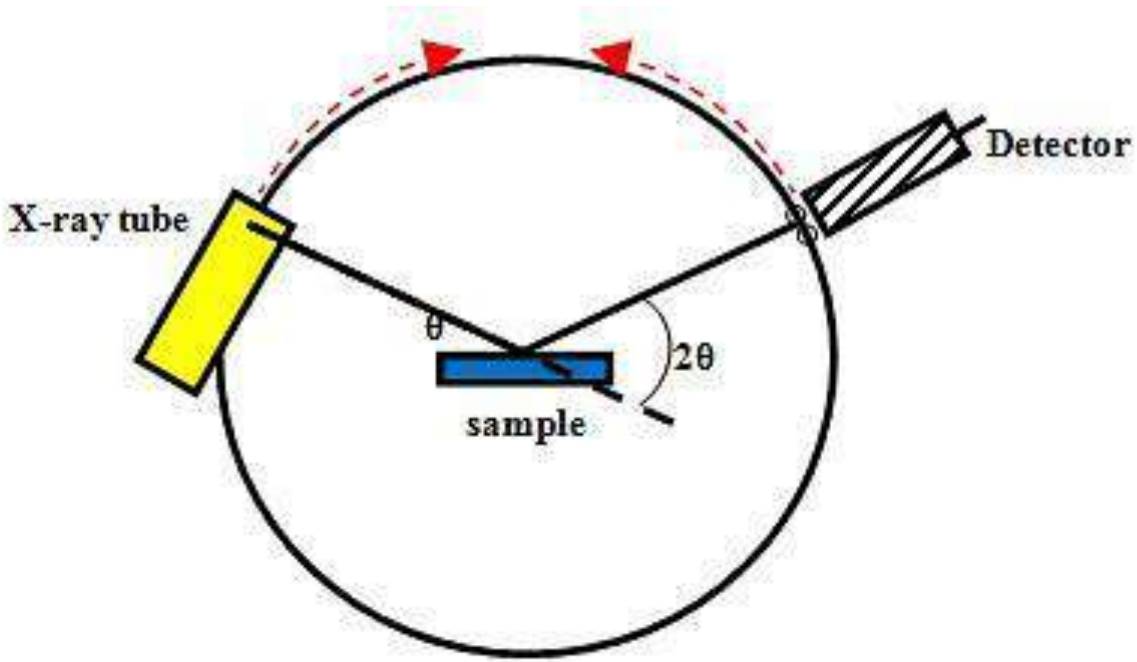
$E = hf = hc/\lambda$

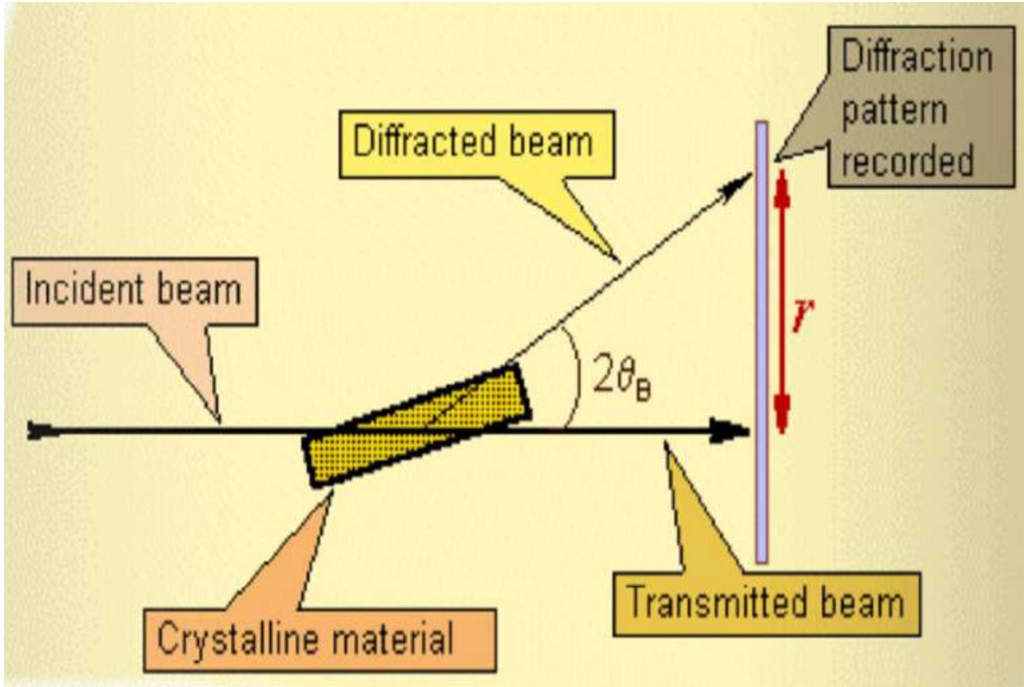
High energy: 100 eV to 100 keV

REASON FOR X-RAYS

Wavelength of X- rays ~ Crystalline size

XRD





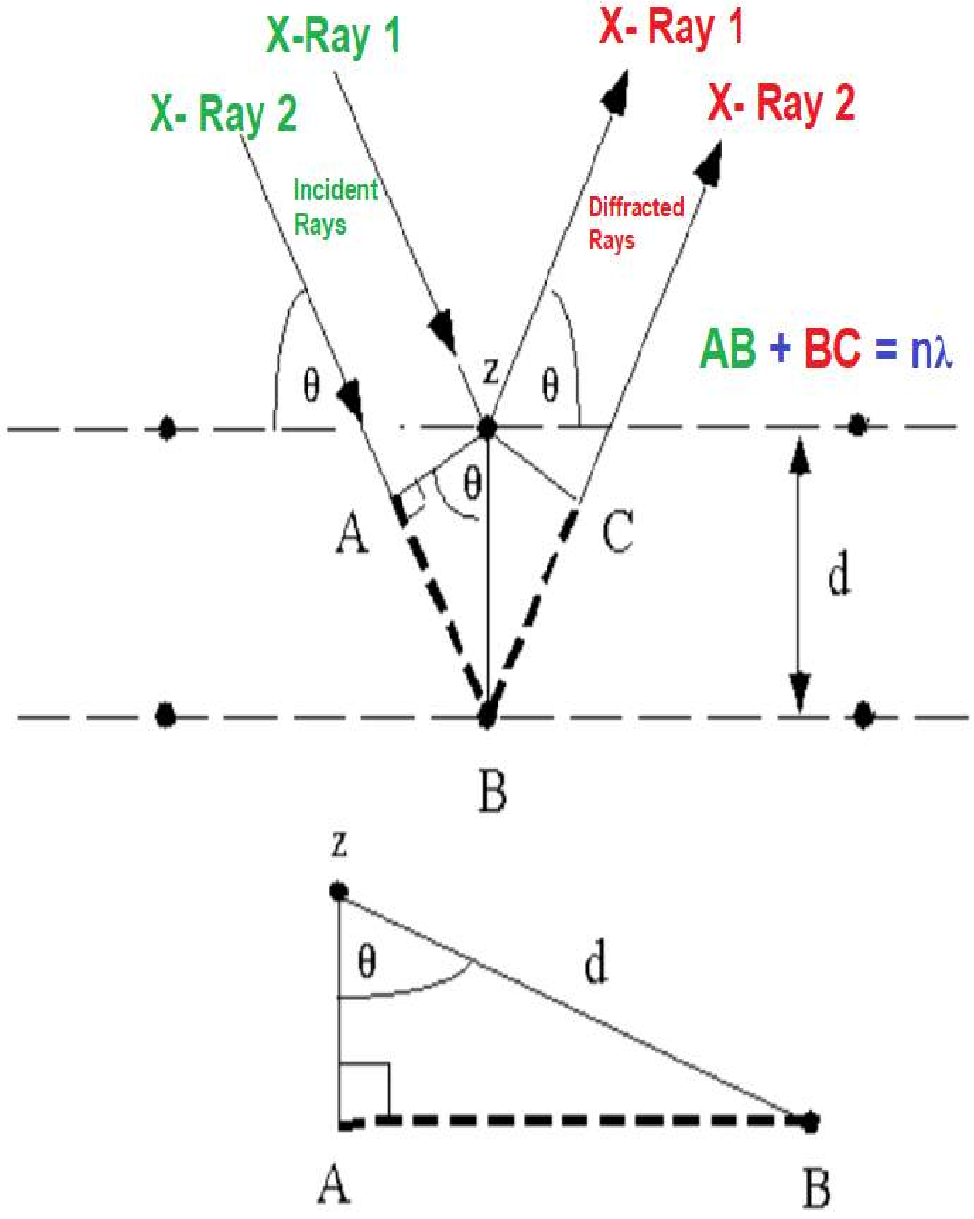
BRAGG'S LAW

d = Interplanar distance in crystal
λ= Wavelength of X-rays
θ = Angle of incidence

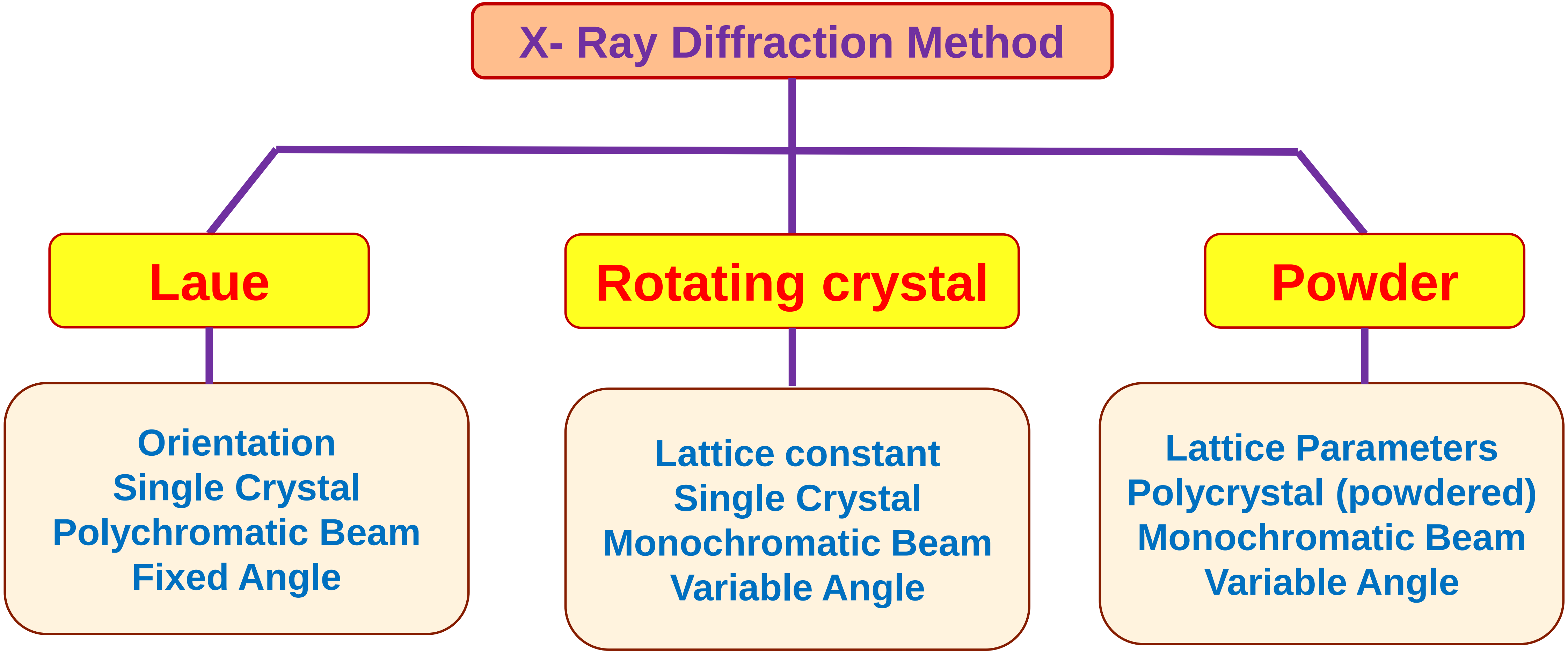
Condition for Constructive interference:

Path difference = nλ
AB +BC = nλ
AB = BC = d sinθ

$$2d \sin\theta = n\lambda$$



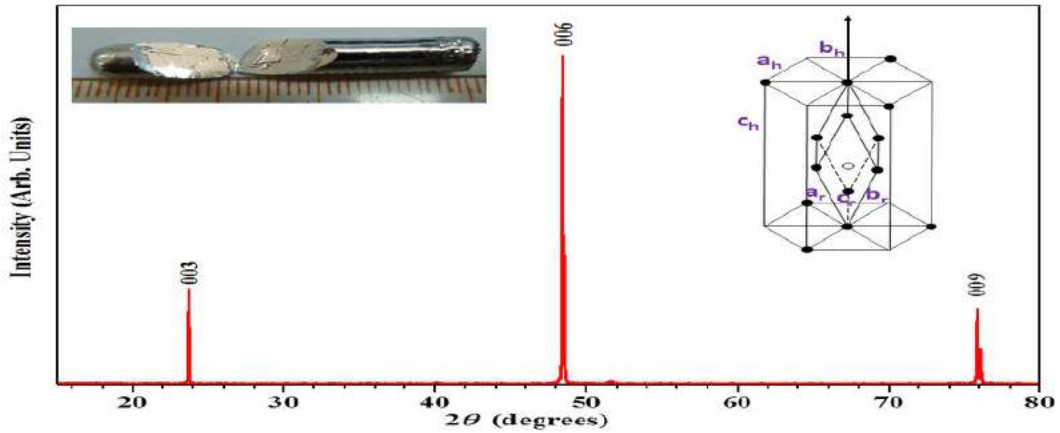
X-Ray Diffraction Methods



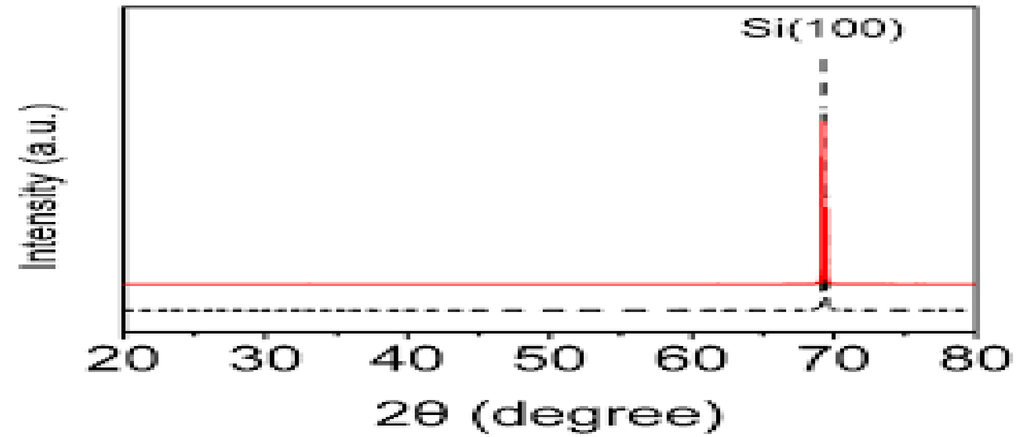
$$2d \sin\theta = n\lambda$$

Joint Committee on Powder Diffraction Standards (JCPDS)- XRD

XRD – Antimony (Sb)

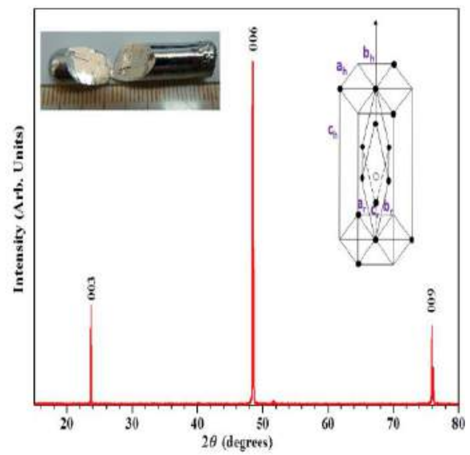


XRD – Silicon (Si)



SOLUTION

XRD



XRD Antimony

Unknown material

ANTIMONY

Applications of XRD

- Structural properties: Lattice parameters (10 - 4A^0), strain, grain size.
- Particle size determination
- determination of unit cell dimensions
- measurement of sample purity
- Study of corrosion products
- Examination of tooth enamel and dentine
- Examination of bone state and tissue state
- Structure of DNA and RNA
- Pharmaceutical industry
- Forensic science
- Geological applications
- Microelectronics industry
- Glass industry

Advantages and Disadvantages

Advantages:

- Least expensive, the most convenient.
- Widely used method to determine crystal structures.
- Best method for Phase analysis.
- X – Rays are not absorbed very much by air, so the sample need not be in an evacuated chamber.

Disadvantages:

- X-Rays do not interact very strongly with lighter elements.
- Intensity is 10^8 times less than that of electron diffraction.

SCOPE OF RESEARCH

Crystal structures using Rietveld refinement

Modal amounts of minerals (quantitative analysis)

Characterize thin films samples by:

- determining lattice mismatch between film and substrate
- determining dislocation density and quality of the film by rocking curve measurements
- measuring superlattices in multi-layered epitaxial structures
- determining the thickness, roughness and density of the film using glancing incidence X-ray reflectivity measurements

References:

https://www.scimed.co.uk/education/what-is-x-ray-diffraction-xrd/

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https://www.slideshare.net/bharathpharmacist/81347482-xraydiffractiontechnique-39635806

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https://serc.carleton.edu/research_education/geochemsheets/techniques/XRD.html

https://www.sciencedirect.com/topics/engineering/x-ray-diffraction

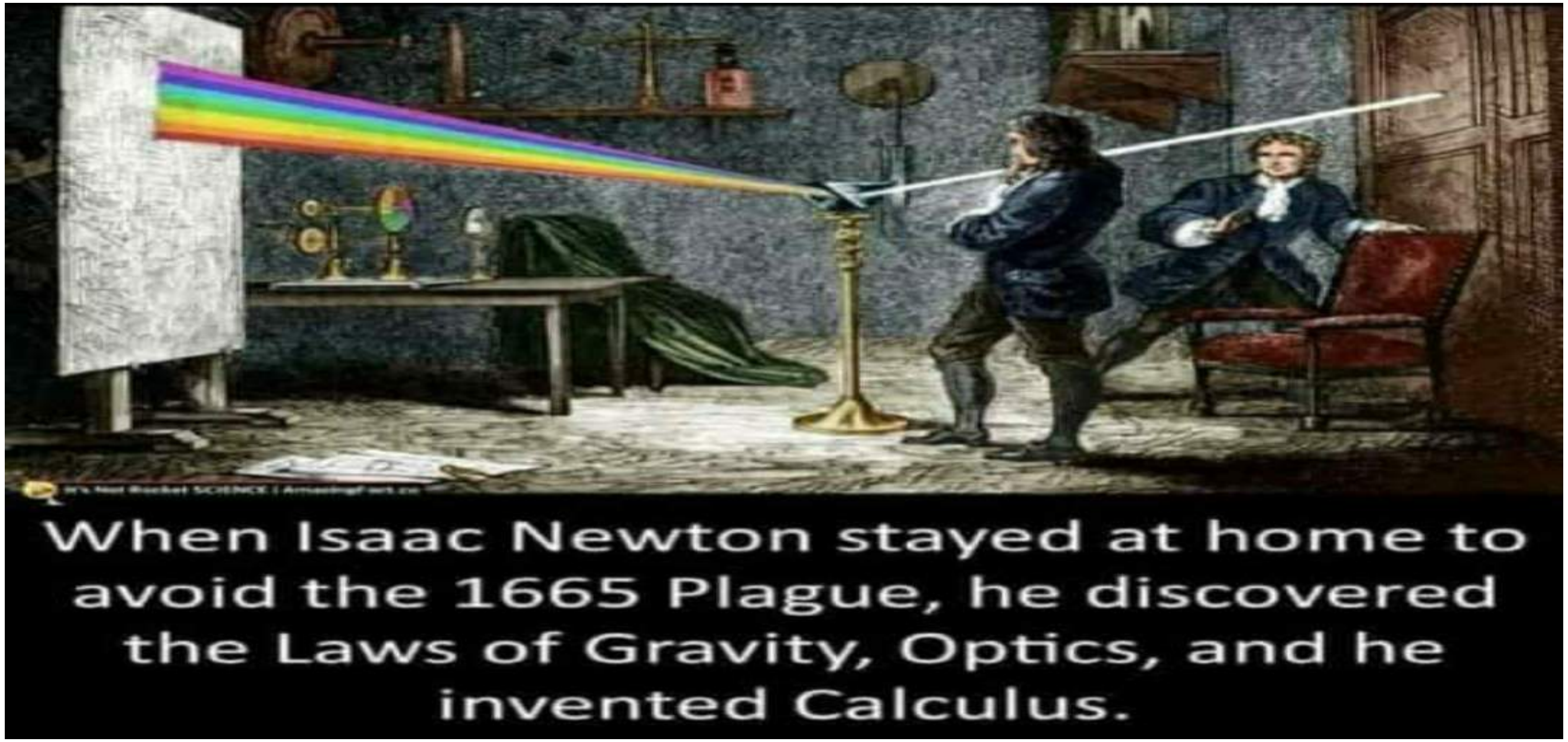
Important points

- X-ray diffraction, or XRD, is a technique for analysing the atomic or molecular structure of materials.
- It is non-destructive, and works most effectively with crystalline materials.
- It act as a finger print of substance.
- Diffraction is bending nature of light as it passes around obstacle or aperture.
- The degree to diffraction occurs depends on the relative size of a wavelength compared to the dimensions of the obstacle or aperture.
- XRD will only occur if the way the x-rays and substance interact meets the conditions of Bragg's law.

❖ The angle of incidence is equal to the angle of scattering.

❖ The path length difference is equal to an integer number of wavelengths.

THANK YOU


When Isaac Newton stayed at home to avoid the 1665 Plague, he discovered the Laws of Gravity, Optics, and he invented Calculus.

TSWREIS

Brief review on

CAREER OPPORTUNITIES WITH PHYSICS

Subject: Physics

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Scope of Science for future employment

Academic (Higher Education) Prospects	Job Prospects	Other Opportunities
• M. Sc. (Physics) in IITs, NITS, IISc (Bangalore), TIFR, JNU, IISER, IIST, Central Universities, State Universities • Integrated M.Sc. (M.Sc.+ Ph.D.) • Integrated M.Tech • Ph.D. (Research) • Researcher (UGC-NET / CSIR/GATE/JEST/State Eligibility Test). • Abroad after qualifying GRE/TOEFL	• Professor/Lecturer/Academician • Research Assistant • Researcher • Lab technician and • Scientist in ISRO, DRDO, ONGC, BARC, TIFR • Scientist in Saha Institute of Nuclear Physics • Scientist in Nuclear Science Centre • Scientist in Physical Research Laboratory • Geo Scientist	• Radiologist • Consulting Physicist • Content Developer • Technical assistant

Brief about CAREER OPPORTUNITIES WITH PHYSICS

- Jobs in government organizations like DRDO, BARC, VSSC, ISRO, BHEL, NTPC, SSPL, etc.
- Lecturer jobs in teaching field.
- Jobs in private field like software engineer.
- Laboratory assistant.

Brief about Higher education

Higher Education and Employment Opportunities in Physics

- All Central Universities and leading State Universities offer Post Graduate and Doctoral programme in Physics. Several leading private universities also offer master's in Physics.
- The teaching of Physics in distance education mode at graduation, post graduation and doctoral level is offered by IGNOU and several other universities recognized by Distance Education Council.
- Post graduate and doctoral programme in Physics is also offered by all IITs, IISc., TIFR and JNU. Admission to these programmes is through Joint Admission Test to M.Sc (JAM) or through Institute level entrance tests/interviews.
- Admissions to Doctoral Programme are on the basis of NET/GATE combined with institute level tests/interviews. Several National Institutes of Technology also offer Masters in Physics/Applied Physics.
- Student can join research institutes like ISRO, DRDO, TIFR etc.. for higher studies as well as job opportunities

Top notch IITs universities which can offer Physics higher education:

- Indian institute of technology (IITs) .. Total – 23
- Indian Institute of Science (IISc) Bangalore
- Joint Entrance Screening Test (JEST)
- National Institute of Technology (NITs) – Total 31
- Top Notch : Trichy, Rourkela, Surathkal, Warangal, Calicut
- Indian Institute of Space Science & Technology (IIST), Trivandrum
- Indian Institutes of Science Education and Research (IISER) (Berhampur, Bhopal, Kolkata, Mohali, Pune, Thiruvananthapuram and Tirupati
- Banaras Hindu University (BHU)
- University of Delhi (DU)
- UoH - University of Hyderabad

Brief about IIT- JAM

IIT jam is a joint admission test conducted by IITs and IISC for admission into MSc, integrated PhD, MSc PhD dual degree, joint MSc PhD courses. Many IISERs and NITs are also taking admission into their MSc courses based on JAM score.

<u>Top notch IITs which can offer Physics higher education:</u>

- ❖ Indian Institute of Technology (IIT) Bombay
- ❖ Indian Institute of Science (IISc) Bangalore
- ❖ Indian Institute of Technology (IIT) Madras
- ❖ Indian Institute of Technology (IIT) Delhi
- ❖ Indian Institute of Technology (IIT) Kanpur
- ❖ Indian Institute of Technology (IIT) Hyderabad
- ❖ Indian Institute of Technology (IIT) Kharagpur

Brief about IIT- JAM

IIT JAM 2021 Exam Pattern Highlights	
Particulars	**Details**
Exam Mode	Online, Computer Based (CBT)
Exam Duration	3 hours
Test language	English
Type of Questions	MCQs, MSQs, NAT
Subjects	Economics, Chemistry (CY), Physics (PH), Mathematics (MA), Geology (GG), Mathematical Statistics (MS), and Biotechnology (BT)
Total Questions	60
Total Marks	100 Marks

IIT JAM 2021 Exam Question Paper Pattern				
Particulars	**Question range**	**Carry marks**	**Max Marks**	**Negative marks**
SECTION-A (MCQS)	(1-10)	One mark	10	1/3
	(11 -30)	Two marks	40	2/3
SECTION-B (MSQs)	(31-40)	Two mark	20	Not applicable
SECTION- C (NAT)	(41-50)	One mark	10	Not applicable
	(51-60)	Two marks	20	Not applicable

MCQ: Multiple Choice Question, MSQ: Multiple Selective Question, NAT: Numerical Answer Type

Brief about IIT- JAM- Physics

IIT- JAM – Physics: Cut off particulars			
Year	**GEN**	**OBC (NCL)**	**SC/ST/PWD**
2021	19.91	17.92	9.96
2020	21.70	19.53	10.85
2019	24.99	22.49	12.49
2018	17.05	15.35	8.53
2017	14.79	13.31	7.39

IIT- JAM- Physics: Topic wise weightage							
Topic	Mecha nics	EMT	Modern Physics	Mathematical Physics	Oscillations, Waves & Optics	Thermal Physics	SSP & Electronics
Avg (%) [2005 – 2018]	16.57	**18.21**	15.64	11.64	11.79	13	13.14

Brief about HCU

Mode of the Exam	Offline
Medium	English (Except the language papers)
Total Papers	1
Sections	2: Part A and Part B
Types of Question	Objective Type (MCQ)
Duration of the Exam	2 Hours
Total Questions	75
Total Marks	100

HCU:

Paper Pattern

Section A : Objective type questions of one mark each. There is negative marking of 0.33 mark for every wrong answer.

The marks obtained by the candidate in this section will be used for resolving the tie cases.

Section B: 50 Objective type questions of one and a half mark each. There is no negative marking in this section.

Brief about HCU

Syllabus: Physics (Mechanics, General properties of matter, Kinematics, heat and thermodynamics. Wave motion, electricity and magnetism , light , modern physics, electronics and measurements)
and mathematics
(algebraic equations, differential and integral calculus including limits , vectors, matrices and determinates, elementary differential equations and elementary functions and their graphs)

Cut off:
HCU Doesn't declare cutoff for Msc physics. In 2019 those students with [60+] marks got Selected in HCU. So those students who got [50+] were also Selected as paper difficulty and no calculator was allowed in 2020. All the above cutoff was for general candidate.

Brief about CPGET

Common Postgraduate Entrance Test

Exam	Osmania University Common Entrance Test
Duration	90 minutes (One Hour and Thirty Minutes)
Mode of the exam	Online
Type of questions	Multiple choice questions (MCQs)
Total marks	100
Number of questions	100
Marking scheme	1 mark for every correct answer; No negative marking

Brief about CPGET

Rank	Marks
11	70
15	67
22	64
31	61
38	60
48	58
49	58
50	58
98	54

Rank	Marks
137	52
190	50
201	50
217	49
266	48
282	48
355	46
365	45

TSWREIS

PAPER: ELECTROMAGNETIC THEORY

TOPIC: ELECTROSTATICS

K. SPANDANA

HOD, Department of Physics

TSWRAFPDCW, Bhongir

Venue: PG Entrance coaching class

Date: 22-05-2021

Time: 2.00 m – 3.30 pm

Brief about IIT- JAM

IIT JAM 2021 Exam Pattern Highlights	
Particulars	**Details**
Exam Mode	Online, Computer Based (CBT)
Exam Duration	3 hours
Test language	English
Type of Questions	MCQs, MSQs, NAT
Subjects	Economics, Chemistry (CY), Physics (PH), Mathematics (MA), Geology (GG), Mathematical Statistics (MS), and Biotechnology (BT)
Total Questions	60
Total Marks	100 Marks

IIT JAM 2021 Exam Question Paper Pattern				
Particulars	**Question range**	**Carry marks**	**Max Marks**	**Negative marks**
SECTION (MCQS)	(1-10)	One mark	10	1/3
	(11 -30)	Two marks	40	2/3
SECTION-B (MSQs)	(31-40)	Two mark	20	Not applicable
SECTION- C (NAT)	(41-50)	One mark	10	Not applicable
	(51-60)	Two marks	20	Not applicable

MCQ: Multiple Choice Question, MSQ: Multiple Selective Question, NAT: Numerical Answer Type

Brief about IIT- JAM- Physics

IIT- JAM – Physics: Cut off particulars			
Year	**GEN**	**OBC (NCL)**	**SC/ST/PWD**
2021	19.91	17.92	9.96
2020	21.70	19.53	10.85
2019	24.99	22.49	12.49
2018	17.05	15.35	8.53
2017	14.79	13.31	7.39

IIT- JAM- Physics: Topic wise weightage							
Topic	Mechanics	EMT	Modern Physics	Mathematical Physics	Oscillations, Waves & Optics	Thermal Physics	SSP & Electronics
Avg (%) [2005 – 2018]	16.57	**18.21**	15.64	11.64	11.79	13	13.14

OBJECTIVES

- Introduction to Electrostatics and examples
- Basic properties of Electric charges
- Coulomb's law
- Electric field and electric field lines
- Electric flux
- Gauss's law (Integral and differential forms)
- Application to linear, plane and spherical charge distributions
- Conservative nature of electric field E, irrotational field
- Electric Potential, Relation between electric potential and electric field
- Potential energy of a system of charges, Energy density in an electric field
- Electric potential for various systems.
- Torque acting on an Electric Dipole placed in uniform electric field
- Applications
- Summary
- Previous year questions, Quiz

INTRODUCTION

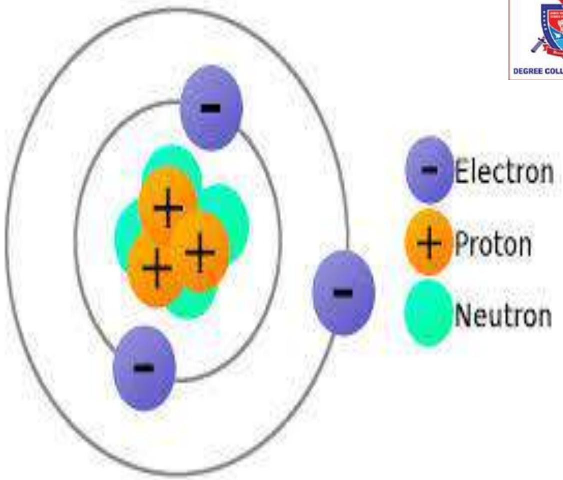
Electrostatics is a branch of physics, which deals with the phenomena and properties of stationary or slow-moving electric charges.

Every day life examples of Electrostatics:

- Attraction of paper to charged comb.
- Rubbing balloons on hair and sticking to the wall
- Thunder and Lighting.
- Photocopier & laser printer operation

ELECTRIC CHARGE

Every substance is made up of atoms.
Atom consists of Electrons ,Protons, Neutrons.



	Mass	Charge
Electron	9.1 X 10^{-31} kg	**- 1.6 X 10^{-19} C**
Proton	1.673 X 10^{-27} kg	**+1.6 X 10^{-19} C**
Neutron	1.675 X 10^{-27} kg	**0**

- **Protons : Positive charge**
- **Electron : Negative charge**
- **Neutron : Zero charge**

Charge: Scalar quantity, Units: Coulomb (C), Dimensional formula : [AT]

Properties of charge:

- Charge quantization: **Q = +/- ne (n is integer)**
- Charge is conserved:

Electric charge can neither be created nor be destroyed

- Additivity of charges:

Total charge of a body is the algebraic sum of all the charges on body.

Worked out Examples-I

Topic: Electric charge

1) What is the charge of Lithium Nucleus?

Solution: Li atomic number = 3, Number of Protons n = 3

Charge of Proton $e = 1.6 \times 10^{-19}$ C

$Q = ne = 3 \times 1.6 \times 10^{-19} = 4.8 \times 10^{-19}$ C

2) When 10^{19} electrons are added to the neutral material, then the electric charge present on it will be [ ]

(a) - 16 C (b) + 16 C (c) - 1.6 C (d) + 1.6 C

Solution:

$n = 10^{19}$, Charge electron $e = 1.6 \times 10^{-19}$ C

$Q = ne = 10^{19} \times 1.6 \times 10^{-19} = 1.6$ C

Electrons are added to material , so it get negative charge

Answer : (c)

Assignment -I

Topic: Electric Charge

1. What is the charge of Gold nucleus?

2. How many number of electrons added to isolated conductor to get charge on its surface is 3.2 $\times 10^{-18}$ C?

3. What is the charge of nucleus with atomic number 4?

4. How many electrons are there in one coulomb of charge? [ ]

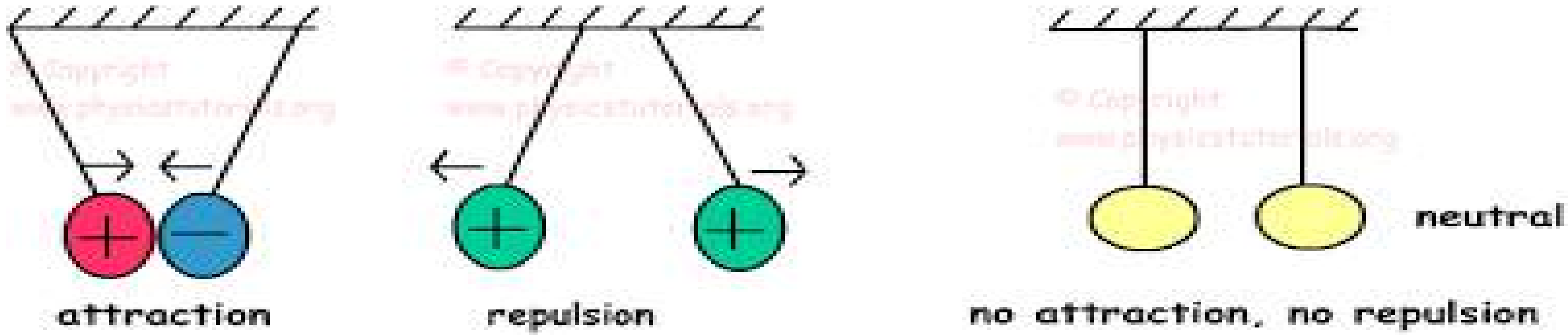
   (a) 6.023×10^{23} (b) 6.023×10^{20} (c) 6.023×10^{18} (d) 6.023×10^{15}

5. When 10^{20} electrons are removed from the neutral material, then the electric charge present on it will be [ ]

   (a) - 16 C (b) + 16 C (c) - 1.6 C (d) + 1.6 C

Answers: (1Q : **126.4 $\times 10^{-19}$ C**), (2Q: **20**) , (3Q: **126.4 $\times 10^{-19}$ C**),(4Q: **c**), (5Q: **b**)

How do charge behaves?



Unlike charges attract with each other

Unlike charges → + - ← Attracts each other

Like charges repel with each other

- ⟷ Like charges repel ⟷ -

\+ ⟷ Like charges repel ⟷ +

COULOMB'S LAW

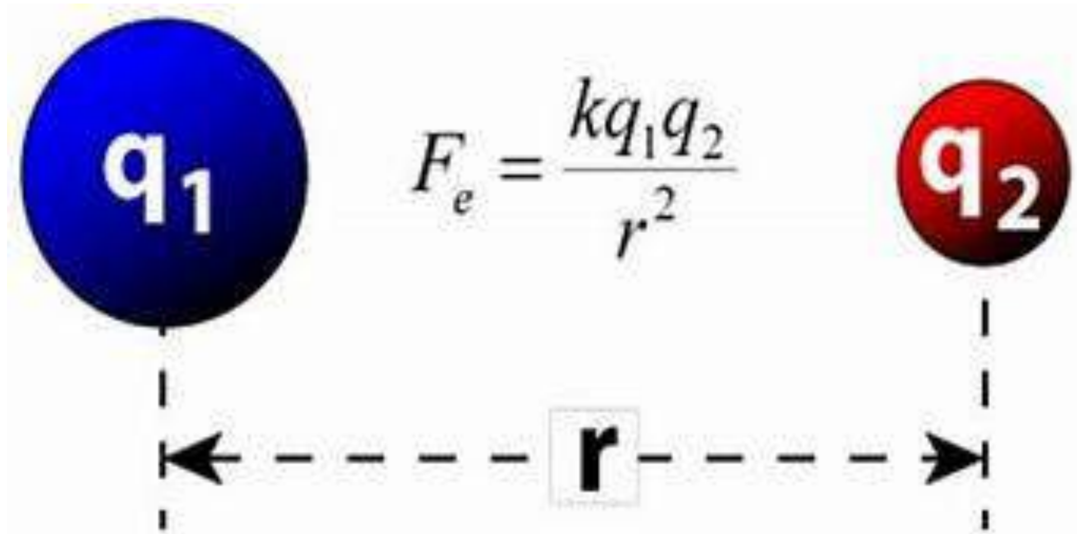
The force of attraction or repulsion between two electric point charges is directly proportional to the product of the magnitude of charges and inversely proportional to the square of the distance between the two charges.

$$F = \frac{k(q_1 q_2)}{r^2}$$

$$k = \frac{1}{4\pi\varepsilon_0} = 9X10^9\ Nm^2/C^2$$

$$\varepsilon_0 = 8.85x10^{-12}\ C^2/Nm^2\ (F/m)$$

Electric force units: Newton (N)
It is a Vector quantity

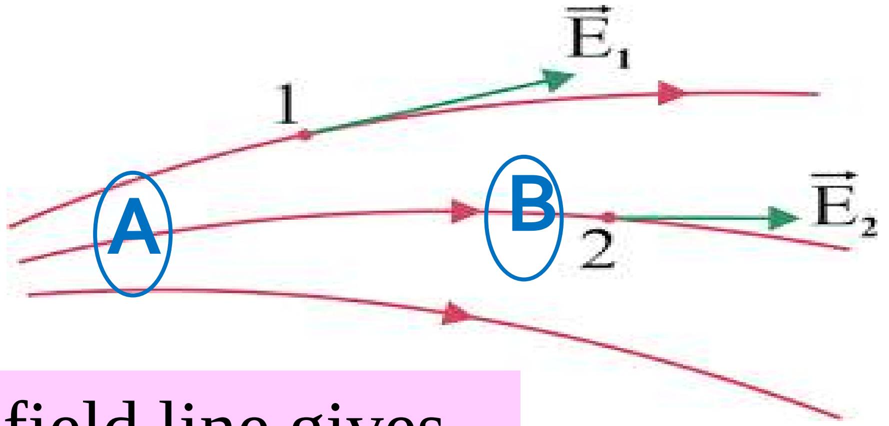


ELECTRIC FIELD

The region around the electric charges where another charge when placed will experience a force of attraction or repulsion is called an **Electric field.**

Electric field intensity $\mathbf{E} = \frac{F}{q}$

Units: N/C, V/m, Vector quantity

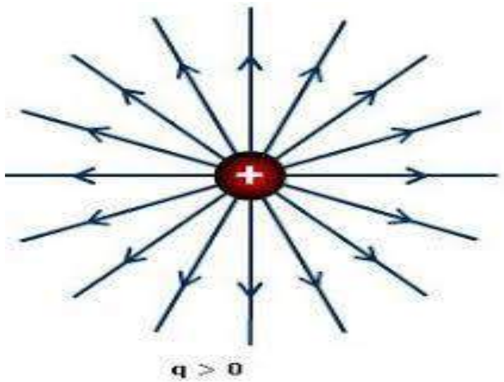


Electric field lines:

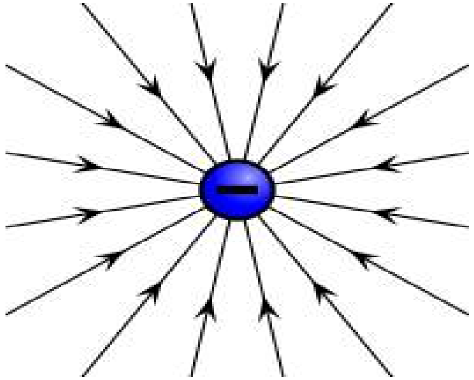
- ❖The tangent drawn at any point on the electric field line gives the direction of electric field at that point.
- ❖ Electric field intensity at any point defined as number electric field lines passing through unit area round that point normally.

$E_A > E_B$

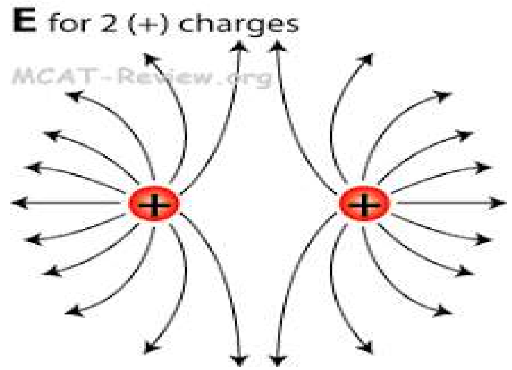
Properties of electric field lines



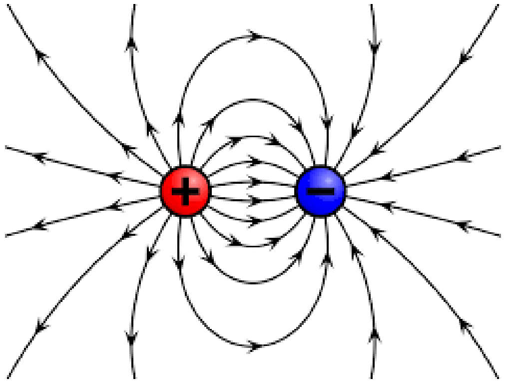
I- Single positive charge
(Radially outward)



II- Single negative charge
(Radially inward)



III- Two equal positive charges



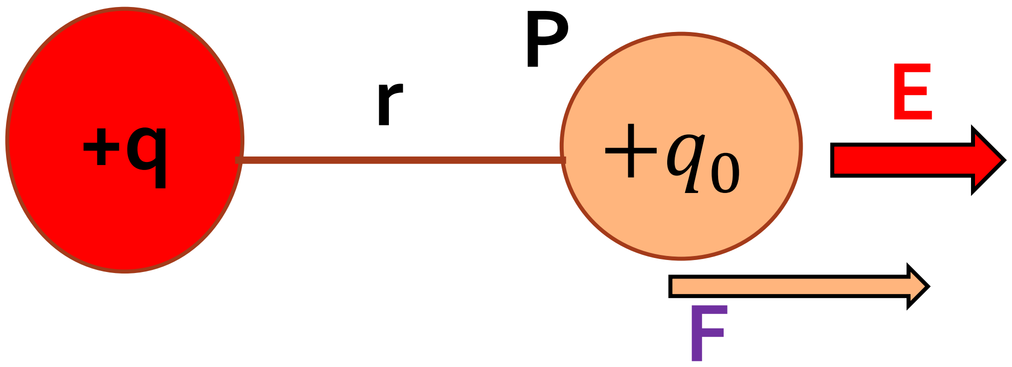
IV - Equal positive and negative charge

- ❖ Electric lines of force are perpendicular to the surface of a positive or negative charged body.
- ❖ Electric field lines are closer where electric field is very strong and spread out when electric field is weaker.
- ❖ The electric lines of force start from positive charge and end on negative charge.
- ❖ The lines of force have a tendency to contract in length. This explains the attraction between opposite charges.
- ❖ The field lines never intersect each other. Two tangents can be drawn, i.e., two directions of force are impossible at one point.

Intensity of electric field due to a point charge

$$E = \frac{F}{q_0}$$

$$F = \frac{k(qq_0)}{r^2}$$



$$\mathbf{E = \frac{1}{4\pi\varepsilon o}\left(\frac{q}{r^2}\right)}$$

Electric field due to multiple charges:

$E = E_1 + E_2 + E_3 + E_4$………. $+ E_n$ (Vector sum)

Worked out Examples-II

Topic: Coulomb force and Electric field intensity

1) The position vectors of two equal charges of 1 μC each are (i + j + k)m and (2i + 3j -k) m. What is the magnitude of electrostatic force between them?

Solution: $q_1 = q_2 = 1\ \mu C$,

$\mathbf{r} = r_2 - r_1 = (2i+3j-k) - (i+j+k) = (i+2j-2k)$, $r = 3$ m

$$F = \frac{K(q_1 q_2)}{r^2} = \frac{(9*10^9)(1*10^{-6})^2}{3^2} = \mathbf{10^{-3}\ N}$$

2) Find the force experienced by a chloride ion having 4 electrons removed, when placed in an electric field of intensity 2 N/C.

Solution: $q = ne = 4e$, $E = 2$ N/C

$F = Eq = 2x4x1.6X10^{-19}$ **= 12.8 X10^-19 N**

3) If the electric field is **uniform,** then [ ]

(a) Its magnitude is same but direction is not same (b) Its magnitude is not same but direction is same

(c) Its magnitude and direction remains same (d) Its magnitude and direction are not same

Answers: **(c)**

Worked out Examples-II

Topic: Coulomb force and Electric field intensity

4) A proton and an electron are place in a uniform electric field [ ]

(a) Their acceleration will be equal
(b) The magnitudes of their acceleration will be equal
(c) The electric force acing on them will be equal
(d) The magnitude of forces will be equal

Solution: $q_e = q_p$, $E_e = E_p$, $F = Eq$, $\mathbf{F_e = F_p}$

Electron and proton has opposite charges $\overline{F_e} \neq \overline{F}_p$

$a = F/m$, $m_e \neq m_p$, $a_e \neq a_p$

Answers: **(d)**

5) Two identical metal spheres posses +60 C and -20 C of charges. They are brought in contact and the separated by 10 cm. Find the force between then?

Solution: $Q_1 = +60$ C , $Q_2 = -20$ C , r = 10 cm = 0.1 m

When two spheres are brought in contact then the net charge on each

$$q_1 = q_2 = \left(\frac{Q_1 + Q_2}{2}\right) = \left(\frac{60 - 20}{2}\right) = +20 \text{ C}$$

$$F = \frac{K(q_1 q_2)}{r^2} = \frac{(9X10^9)(20X20)}{0.1^2} = \mathbf{36 \times 10^{13}\ N}$$

Assignment-II

Topic: Coulomb force and Electric field intensity

1) Two equal charges of 2 μC each are located at points (1 , 3, 3) and (3, 4, 1) . The distance is in meters. The magnitude of electrostatic force (in newton) between them is [ ]

(a) $4x10^{-3}$ (b) $2x10^{-3}$ (c) $4.5x10^{-4}$ (d) $9x10^{-4}$

2) A charge 'q' is placed at the center of line joining two equal charges + Q. The system of the three charges will be equilibrium if the charge q is equal to [ ]

(a) –Q/2 (b) +Q/2 (c) –Q/4 (d) +Q/4

3) The force experienced by an atom having 5 electrons removed, when placed in an electric field of intensity 3 N/C is [ ]

(a) $24x10^{-19}$ N (b) $32x10^{-19}$ N (c) $6.4x10^{-19}$ N (d) $1.6x10^{-19}$ N

4) Two identical metallic sphere A and B carry charge +q and -2q respectively. The force between them is F when they are separated by a distance 'd' in air. The spheres are allowed to touch each other and are moved back to their initial positions. The force between them is now equal to [ ]

(a) F (b) F/2 (c) F/4 (d) F/8

5) At what separation should two equal charges 1 C each be placed so that the force between them equals the weight of 25 kg person? (Take g = 10 m/s^2) [ ]

(a) $8.6x10^3$ m (b) 6 $x10^3$ m (c) 4.5 $x10^3$ m (d) $3.6x10^3$ m

Answers: (1Q : **a**), (2Q: **c**) , (3Q: **d**), (4Q: **b**)

Limitations of Coulomb's Law

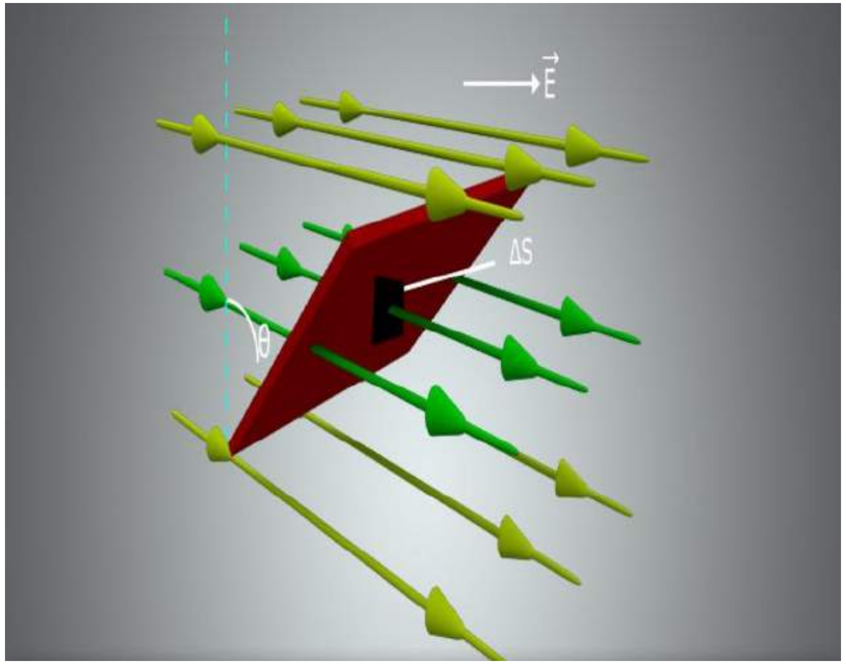
- Coulomb's law is valid for point charges only.
- It is valid only for static charges.
- It is valid only up to nuclear distance of 10^{-15} m.
- It is complex to deal with charges having irregular shapes.
- It is difficult to apply Coulomb's law when the charges are in an arbitrary shape.

GAUSS'S LAW

Electric flux

The number of electric field lines passing **normally** through any surface placed inside electric field is called electric flux.

The electric flux through an area is defined as the electric field multiplied by the area of the surface projected in a plane perpendicular to the field.

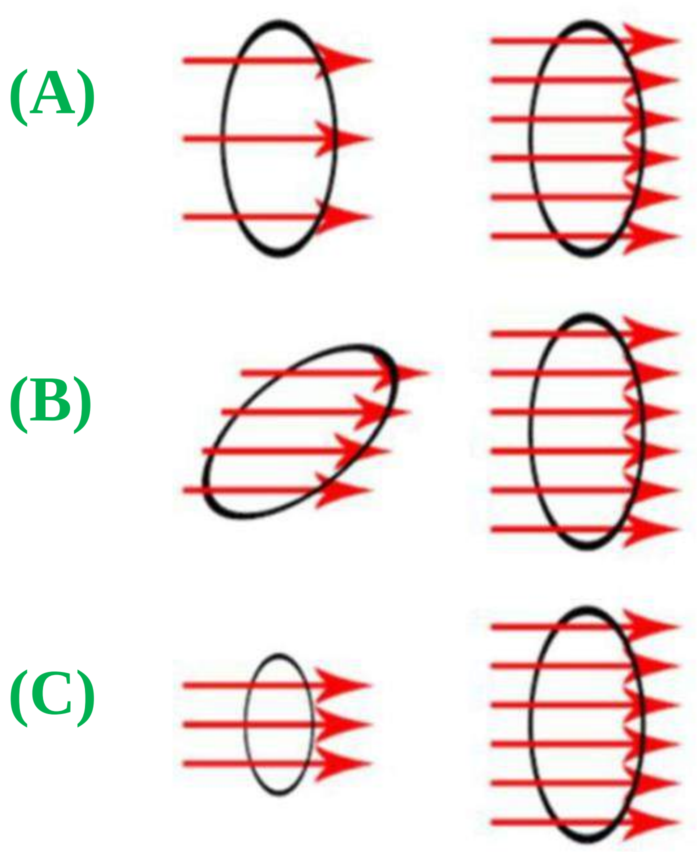


$$\varnothing_E = \oint \boldsymbol{E} \cdot d\boldsymbol{S}$$

$$\varnothing_E = E\ S \cos\theta$$

Units: $N.m^2/C$, Scalar quantity

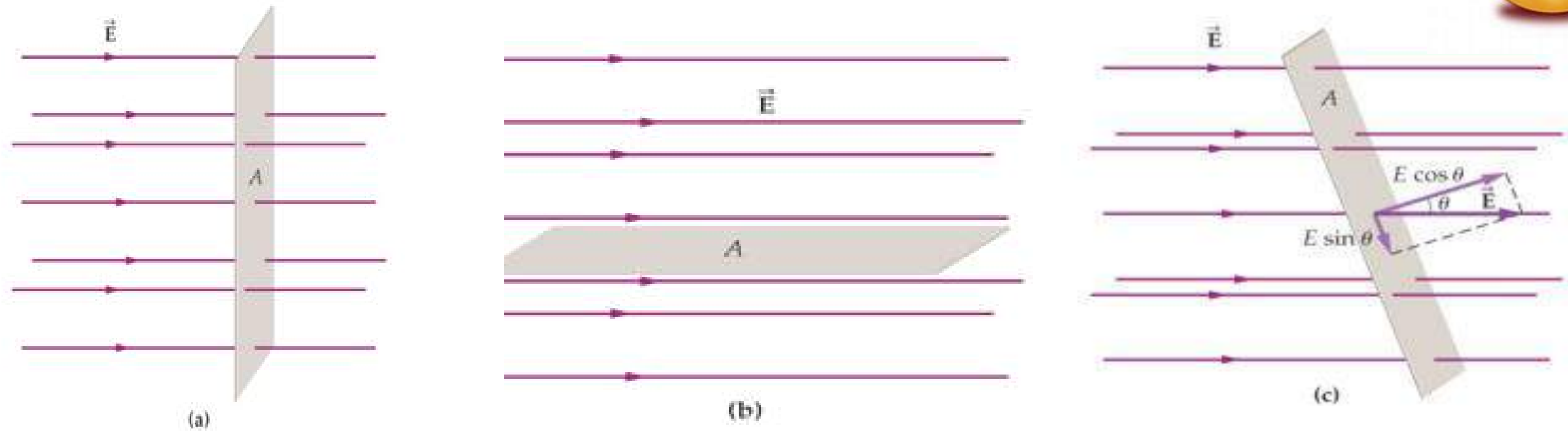
Electric flux depending factors



- Electric flux is proportional to the **density of flow (E).**
- Electric flux varies by how the **boundary faces the direction of flow (θ).**
- Electric flux is proportional to the ***area within the boundary (S).***

$$\phi_E = E\,.\,S = E\,S\cos\theta$$

Calculate the flux of the electric field E, through the surface A, in each of the three cases shown

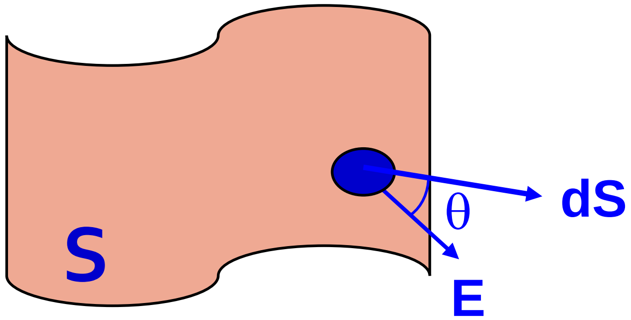


(a) $\Phi = EA$

(b) $\Phi = 0$

(c) $\Phi = EA\cos\boldsymbol{\theta}$

What if the surface is curved, or the field varies with position ??

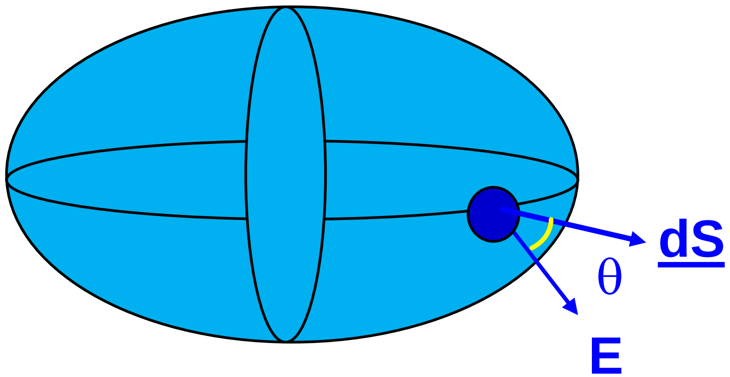


$$d\Phi = E\, dS \cos\theta = \mathbf{E} \cdot d\mathbf{S}$$

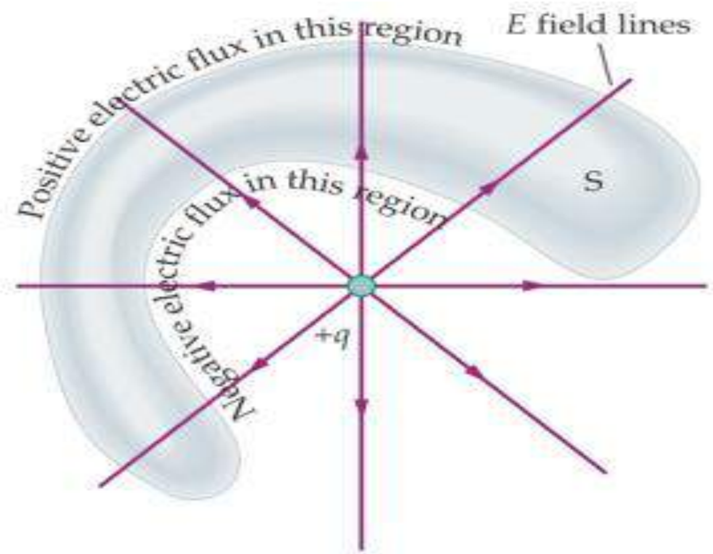
$$\Phi = \int d\Phi = \int \mathbf{E} \cdot d\mathbf{S}$$

In the case of a closed surface

$$\phi_E = \oint d\phi = \oint \boldsymbol{E} \cdot d\boldsymbol{S}$$

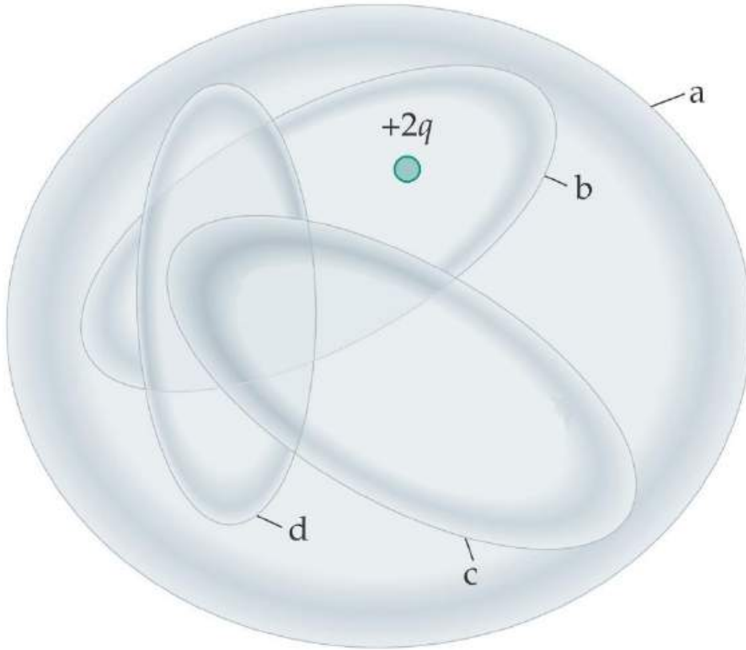


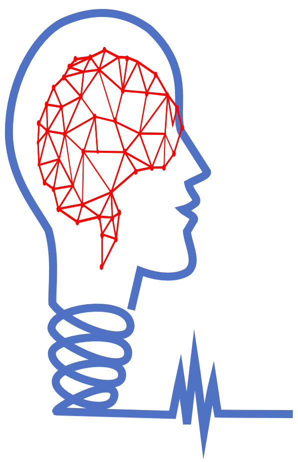
- ❖ Flux is positive for field lines that leave enclosed volume
- ❖ Flux is negative for field lines that enter enclosed volume



If a charge is outside a closed surface, the net flux is zero. As many lines leave the surface, as lines enter it.

For which of these closed surfaces (a, b, c, d) the flux of the electric field, produced by the charge +2q, is zero?



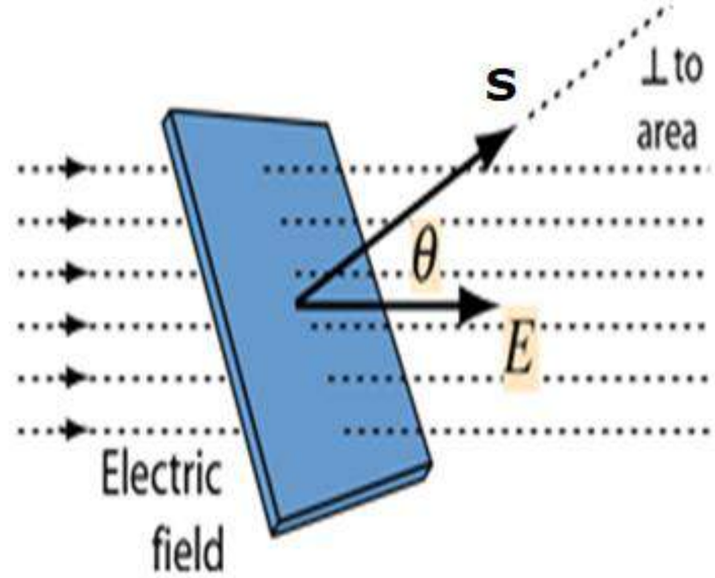


2q charge is out of closed surfaces c, d.
Net electric flux is zero for surfaces c and d.

Gauss's law

Gauss Law states that total normal electric flux $\emptyset_E$ over a closed surface is $(1/\varepsilon_0)$ times the total charge q enclosed within the surface.

$$\emptyset_E = \frac{q_{enclosed}}{\varepsilon_0}$$



$$\oint \mathbf{E} \cdot d\mathbf{S} = \oint \mathbf{E}.\, d\mathbf{S}\cos\theta$$

Integral form of Gauss's law

$$\emptyset_E = \oint \mathbf{E} \cdot d\mathbf{S} = \frac{q_{enclosed}}{\varepsilon_0}$$

$\boldsymbol{\rho}$ = volume charge density, $\mathbf{q} = \iiint \boldsymbol{\rho}\, d\mathbf{V}$

Gauss divergence theorem

$$\oint \mathbf{E} \cdot d\mathbf{S} = \iiint \mathbf{divE}\ \mathbf{dV}$$

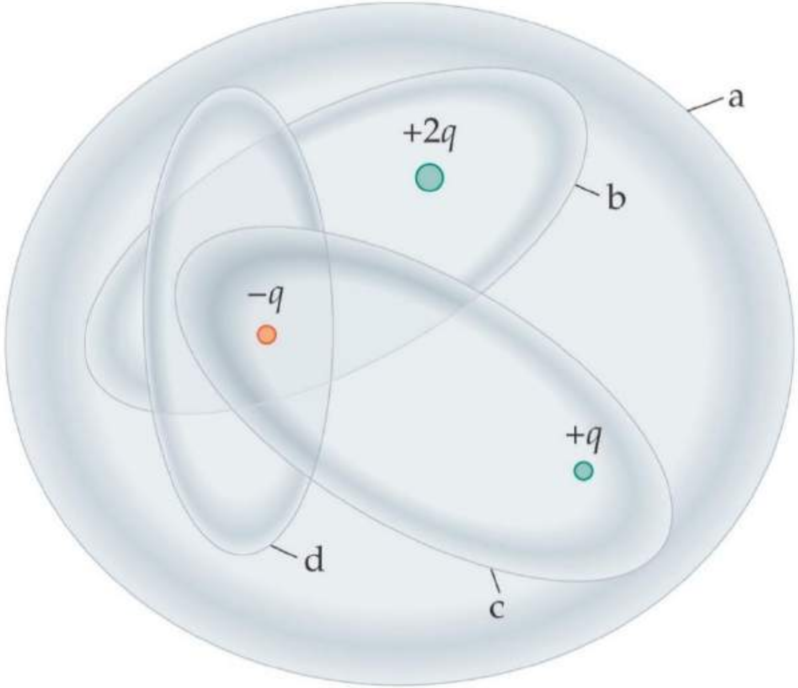
Electric displacement vector $D = \varepsilon_0 \mathbf{E}$

Differential form of Gauss's law

$$\nabla.\mathbf{E} = \frac{\rho}{\varepsilon_0}, \qquad \nabla.\mathbf{D} = \rho$$

Maxwell's First equation

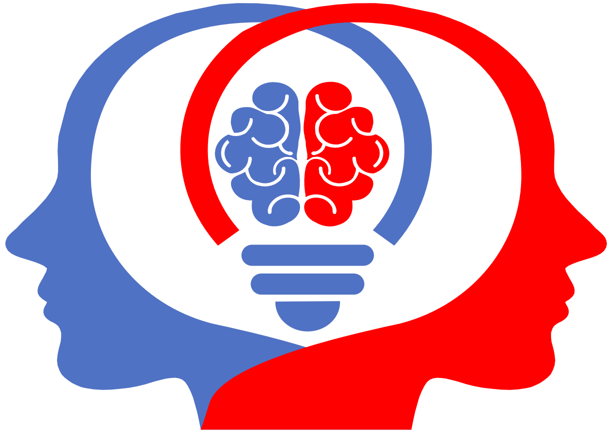
Calculate the flux of the electric field Φ for each of the closed surfaces a, b, c, and d



Gauss's law: $\emptyset_E = \frac{Q_{enclosed}}{\varepsilon_0}$

Surface a, $\Phi_a = \frac{+2q}{\varepsilon_0}$

Surface b, $\Phi_b = \frac{+q}{\varepsilon_0}$



Surface c, $\Phi_c = 0$

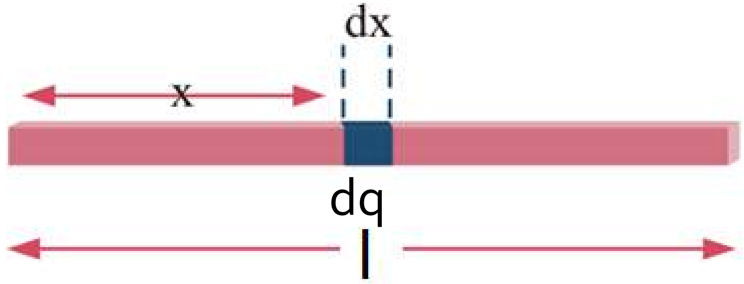
Surface d, $\Phi_d = \frac{-q}{\varepsilon_0}$

Applications of Gauss's law

Various Charge distributions

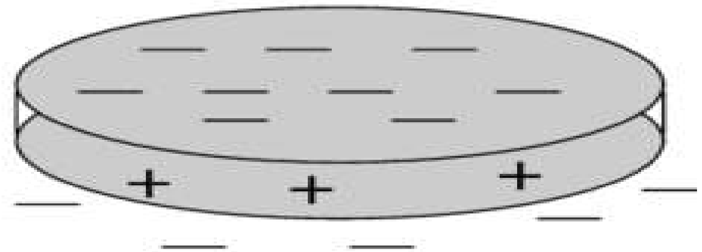
Linear charge density: $\lambda = \frac{q}{l}$

Units: C/m



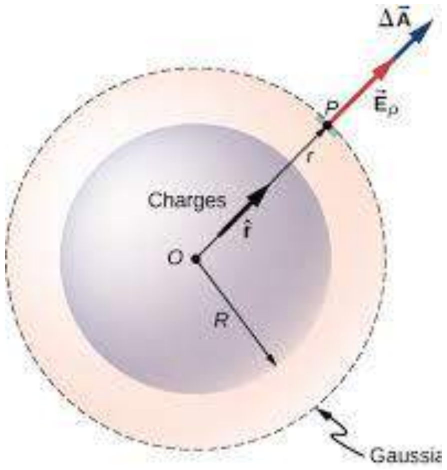
Surface charge density: $\sigma = \frac{q}{s}$

Units: C/m^2



Volume charge density: $\rho = \frac{q}{V}$

Units: C/m^3

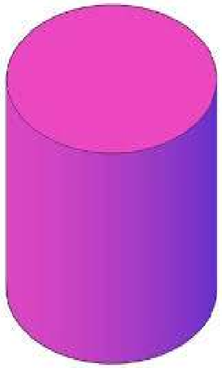


Problem solving strategies for Gauss's law

1. **Select a Gaussian surface with symmetry that matches charge distribution**
2. Draw Gaussian surface so that electric field is either constant or zero at all points on the Gaussian surface
3. Use symmetry to determine direction of E on Gaussian surface
4. Evaluate surface integral (Electric flux)
5. Determine the charge inside the Gaussian surface
6. **Solve for Electric field**

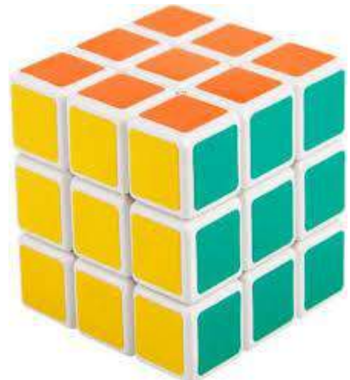
How to select suitable <u>closed</u> Gaussian surface ?

Cylinder

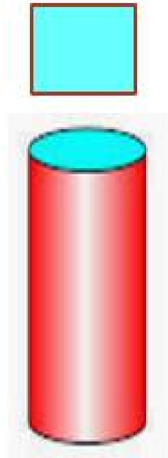


Plane charge distribution:
Infinite line of charge

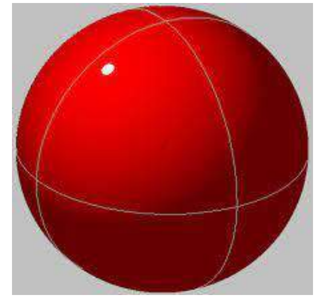
Cube



Surface charge distribution:
Infinitely sheet of charge



Sphere

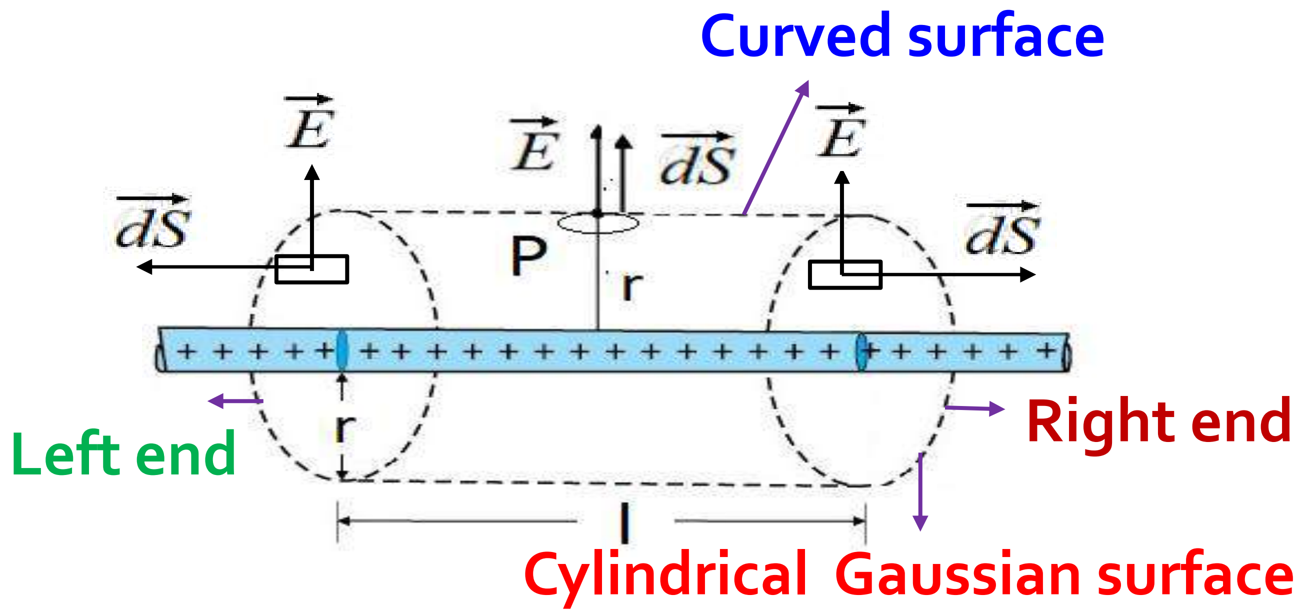


Volume charge distribution:
Charged Sphere

Electric field due to an infinitely long charge distribution

Linear charge distribution $\lambda = \frac{q}{l}$

Gaussian surface: coaxial cylinder of length l and radius r



Gauss's law

$$\phi_E = \oint E \cdot dS = \frac{q_{enclosed}}{\varepsilon_0} = \frac{\lambda l}{\varepsilon_0}$$

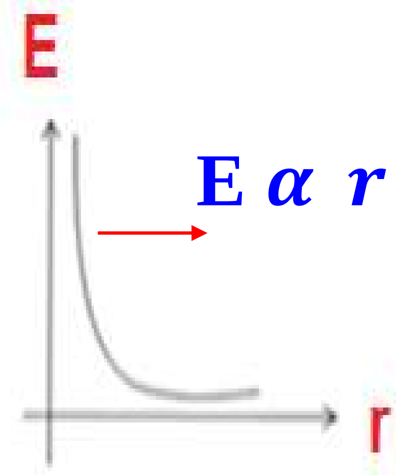
$$\phi_E = \oint \boldsymbol{E} \cdot \boldsymbol{dS} = \oint_{left\ end} \boldsymbol{E} \cdot \boldsymbol{dS} + \oint_{right\ end} \boldsymbol{E} \cdot \boldsymbol{dS} + \oint_{curved\ surface} \boldsymbol{E} \cdot \boldsymbol{dS}$$

$$\phi_E = 0 + 0 + + \oint_{curved\ surface} E.dS = E.\,2\pi r l\ ,$$

$$E.\,2\pi r l = \frac{\lambda l}{\varepsilon_0}$$

$$\mathbf{E} = \frac{\lambda}{2\pi\varepsilon_0 r}$$

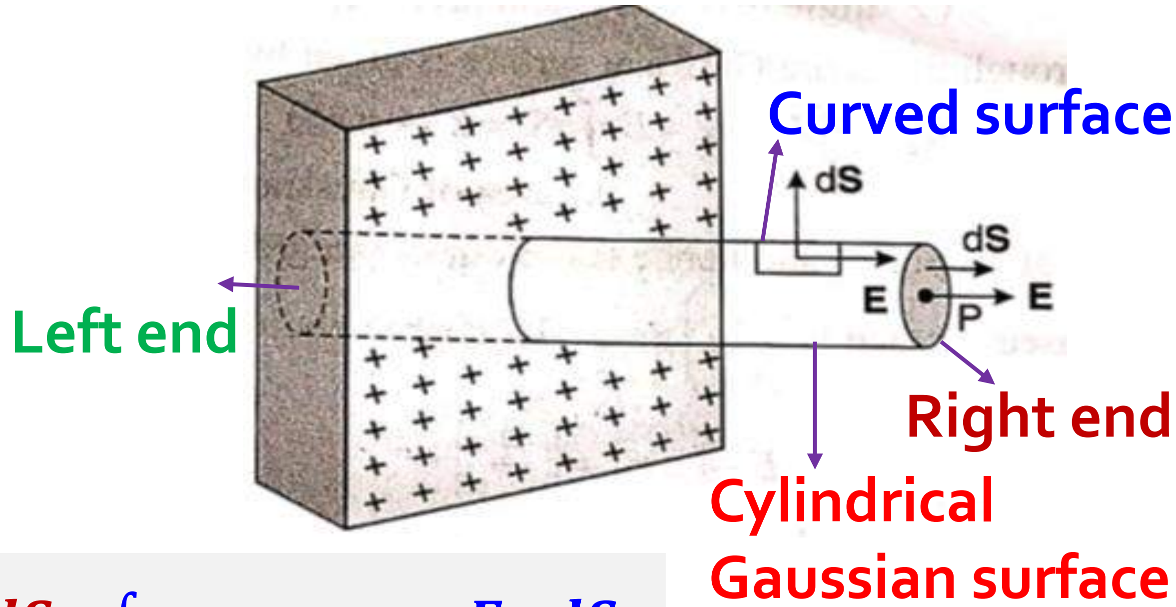
Graphical representation of electric field due to a infinity long line of charge.



Electric field due to an infinitely conducting sheet of charge

Surface charge distribution $\sigma = \frac{q}{s}$

Cylindrical Gaussian surface



Gauss's law

$$\emptyset_E = \oint E \cdot dS = \frac{q_{enclosed}}{\varepsilon_0} = \frac{\sigma S}{\varepsilon_0}$$

$$\emptyset_E = \oint \boldsymbol{E} \cdot \boldsymbol{dS} = \oint_{left\ end} \boldsymbol{E} \cdot \boldsymbol{dS} + \oint_{right\ end} \boldsymbol{E} \cdot \boldsymbol{dS} + \oint_{curved\ surface} \boldsymbol{E} \cdot \boldsymbol{dS}$$

$$\emptyset_E = 0 + \oint_{right\ end} \boldsymbol{E}.\boldsymbol{dS} + 0 = E\,S$$

$$E\,S = \frac{\sigma S}{\varepsilon_0}$$

- Infinitely **conducting** sheet of charge

$$\mathbf{E} = \frac{\sigma}{\varepsilon_0}$$

E is independent on r

- Infinitely **non conducting** sheet of charge

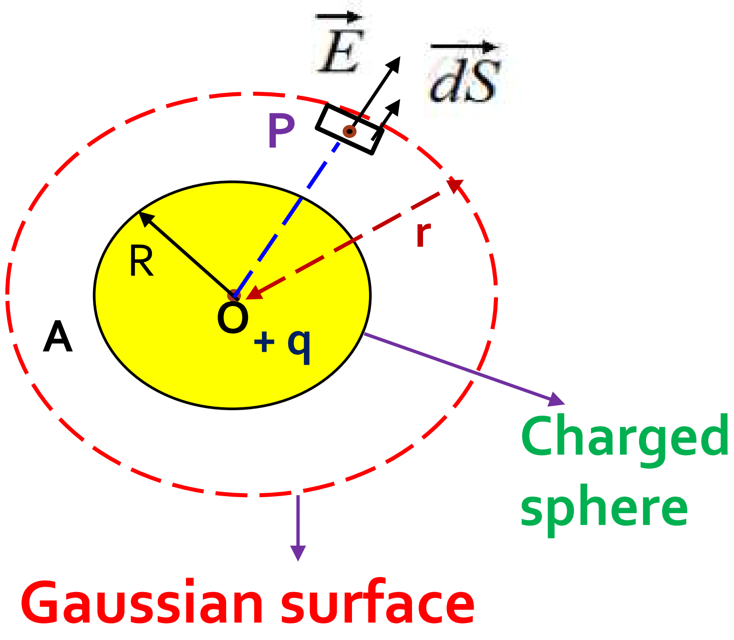
$$\mathbf{E} = \frac{\sigma}{2\varepsilon_0}$$

Electric field due to a uniformly charged sphere

(i) At a point outside the charged sphere: (r >R)

Volume charge distribution $\rho = \frac{q}{V}$

Spherical Gaussian surface with radius r



Gauss's law $\emptyset_E = \oint E \cdot dS = \frac{q}{\varepsilon_0}$

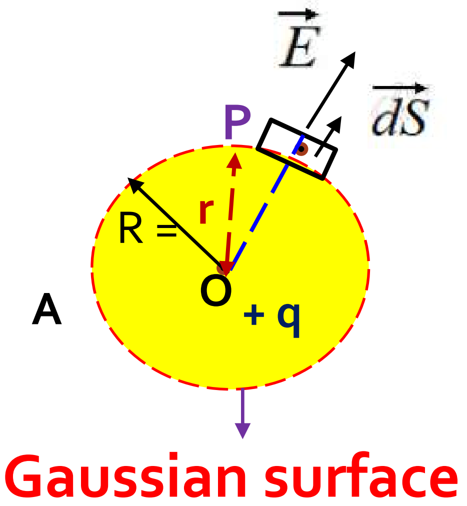
$$\emptyset_E = \oint E \cdot dS$$

$$E \oint dS = E(4\pi r^2)$$

$$E(4\pi r^2) = \frac{q}{\varepsilon_0}$$

$$\mathbf{E} = \frac{1}{4\pi\varepsilon_0} \times \frac{q}{r^2}$$

(ii) At a point on the Surface: (r = R)



$$\mathbf{E} = \frac{1}{4\pi\varepsilon_0} \times \frac{q}{R^2}$$

Electric field due to a uniformly charged sphere

(iii) At a point inside the charged sphere: ($r' < R$)

Volume charge distribution $\rho = \frac{q}{V} = \frac{q}{\frac{4}{3}\pi R^3}$

Spherical Gaussian surface with radius r'

Gauss's law $\phi_E = \oint E \cdot dS = \frac{q'}{\varepsilon_0}$

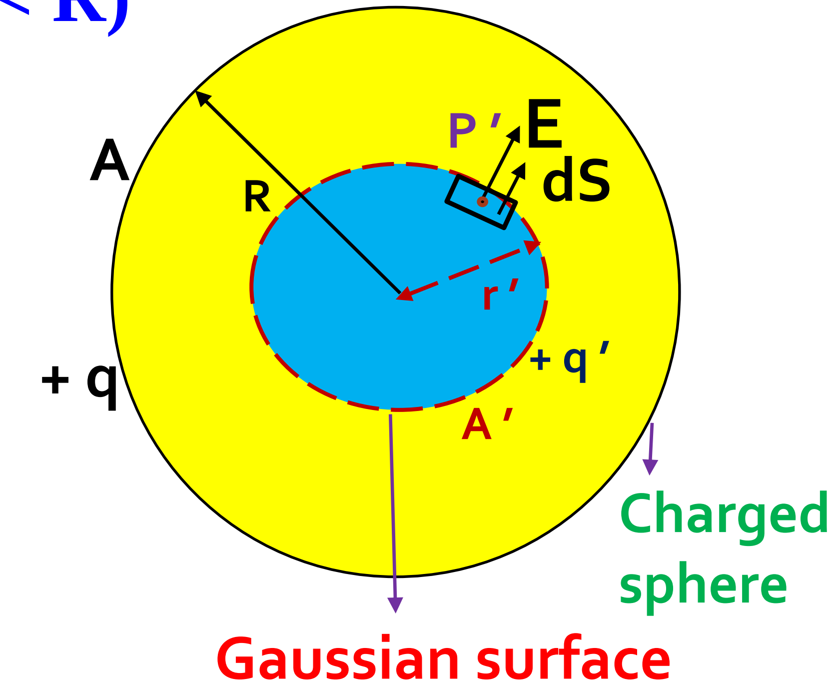
Total charge enclosed by Gaussian surface

$$q' = \rho V' = \left(\frac{q}{\frac{4}{3}\pi R^3}\right)\left(4\pi r'^3\right) = q\left(\frac{r'}{R}\right)^3$$

$$\phi_E = \oint E \cdot dS = E\left(4\pi r'^2\right)$$

$$E\left(4\pi r'^2\right) = \frac{q'}{\varepsilon_0}$$

$$E\left(4\pi r'^2\right) = q\left(\frac{r'}{R}\right)^3$$



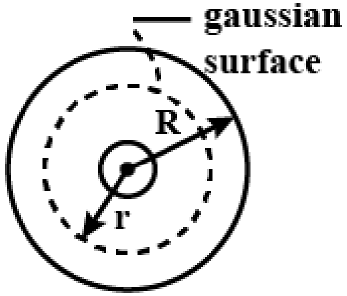
$$\mathbf{E} = \frac{1}{4\pi\varepsilon_0} \times \frac{qr'}{R^3}$$

Electric field due to a uniformly charged sphere

Charged sphere

Inside sphere

r < R



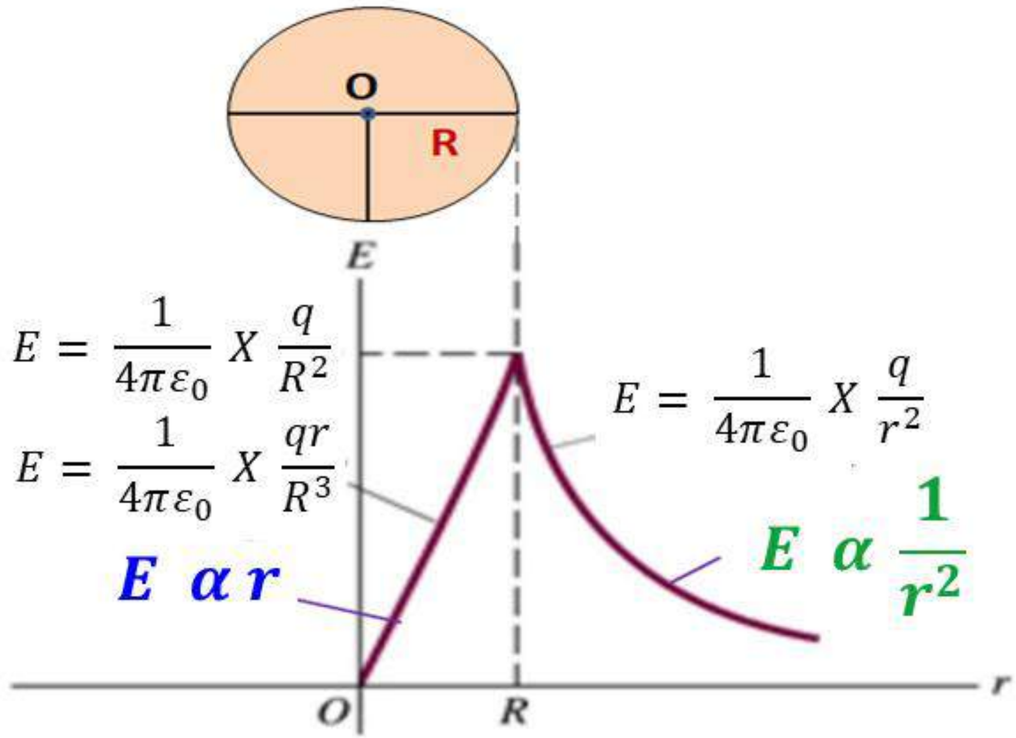
$$E = \frac{1}{4\pi\varepsilon_0} X \frac{qr}{R^3}$$

$$E \ \alpha \ r$$

On sphere

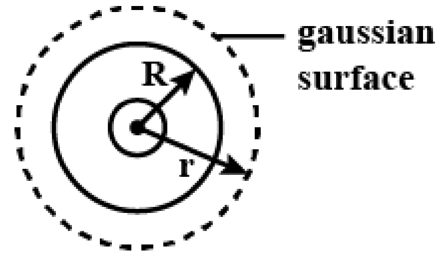
r = R

$$E = \frac{1}{4\pi\varepsilon_0} X \frac{q}{R^2}$$



Outside sphere

r > R



$$E = \frac{1}{4\pi\varepsilon_0} X \frac{q}{r^2}$$

$$E \ \alpha \ \frac{1}{r^2}$$

Electric field due to a uniformly charged cylinder

Charged cylinder

Inside cylinder

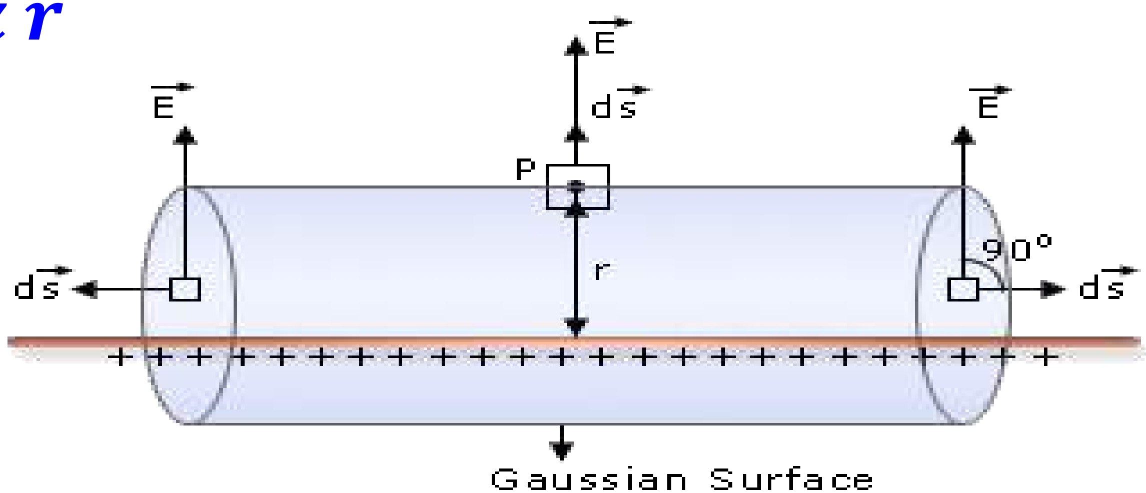
$$E = \frac{\lambda r}{2\pi\epsilon o\, R^2}$$

$$E \;\alpha\; r$$

Outside cylinder

$$E = \frac{\lambda}{2\pi\epsilon o\, r}$$

$$E \;\alpha\; \frac{1}{r}$$



Worked out Examples-III

Topic: Electric flux and Application of Gauss's law

1) An infinite line charge produces a field of 9×10^4 N/C at a distance of 2 cm. Find the linear charge density.

Solution: $E = 9 \times 10^4$ N/C , r = 2 cm

Formula : $E = \dfrac{\lambda}{2\pi\varepsilon_0 r}$

$$\lambda = \frac{4\pi\varepsilon_0 E r}{2} = \frac{9X10^4 x0.02}{9x10^9 x\, 2} = \mathbf{0.1\ \mu C/m}$$

2) A charge of 4×10^{-8} C is distributed uniformly on the surface of a sphere of radius 1 cm. It is covered by a concentric, hollow conducting sphere of radius 5 cm. Find the electric field at a point 2 cm away from the centre.

Solution: $q = 4 \times 10^{-8}$ C , R = 1 cm, r = 2cm

r > R (Outside the charged sphere)

Formula : $E = \dfrac{q}{4\pi\varepsilon_0 r^2}$

$$E = \frac{9x10^9 x4x10^{-8}}{4x10^{-4}} = \mathbf{9x10^5\ N/C}$$

Assignment-III

Topic: Electric flux and Application of Gauss's law

1) Electric intensity at a point varies as r $^{-1}$ for [ ]

(a) a point charge (b) spherically symmetric charge distribution

(c) a plane sheet of charge (d) a line charge of infinite length

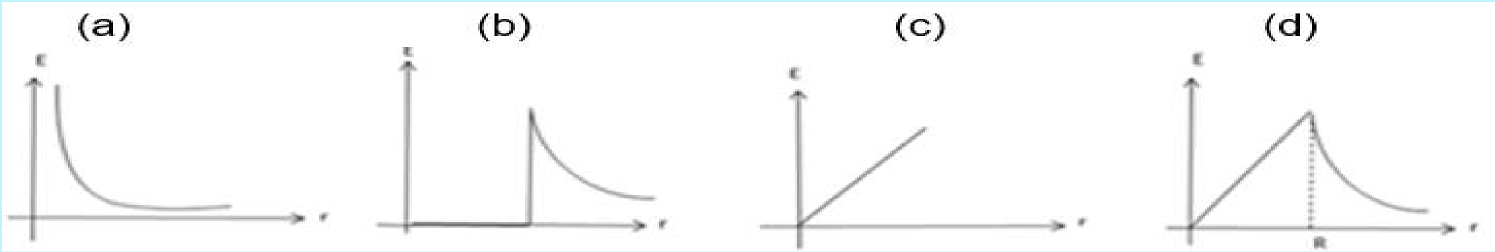
2) Eight dipoles of charges of magnitude 'q' are placed inside a cube. The total electric flux through the cube will be [ ]

(a) $\frac{8q}{\varepsilon_0}$ (b) $\frac{16q}{\varepsilon_0}$ (c) $\frac{q}{\varepsilon_0}$ (d) Zero

3) A uniform electric field is given by $\vec{E} = 3X10^3\hat{\imath}\ N/C$. What is the flux of this field through a square of 10 cm on a side whose plane is parallel to YZ plane? [ ]

(a) $30\sqrt{2}\ Nm^2/C$ (b) $30\ Nm^2/C$ (c) $\frac{30}{\sqrt{2}} Nm^2/C$ (d) Zero

4) Choose the correct graphical representation for Electric field due to a charge sphere **(E vs r)** [ ]



Answers: (1Q : **d**), (2Q: **d**) , (3Q: **b**), (4Q: **d**)

Conservative nature of electric field E, irrotational field

- Work done to move a charge from one point to another point in electric field is independent of path
- Work done depends only on the initial and final positions of the charge.
- Line integral of the electric field along a closed path is zero.
- Conservative electric field is irrotational as the curl of electric field is zero.

$$\oint \mathbf{E} \cdot \mathbf{dl} = \nabla \times \mathbf{E} = 0$$

Electrostatic fields are conservative fields

- Prove that **E** = 2x **i** +2y **j** +3 z **k** is an electrostatic field.
- A field vector has following components: $E_x = 3xy, E_y = x^2 - y^2$ and $E_z = 2x$.

  It is possible that **E** be an electrostatic field?

ELECTRIC POTENTIAL

Electric potential, the amount of work needed to move a unit charge from a reference point to a specific point against an electric field.

Potential difference between the points A and B in the electric field is $V_A - V_B = \frac{W}{q}$

Electric potential at a point $V = \frac{W}{q}$

Units: J/C or Volt (V), e.m.f. It is a scalar quantity

$V = Ed$

Electric Potential due to multiple charges:

$V = V_1 + V_2 + \ldots\ldots\ldots + V_n$ (Algebraic sum)

$V = -\int E \cdot dl$

$E = -\text{grad } V = -\nabla V$

Electric potential due to point charge $V = \frac{q}{4\pi\varepsilon_0 r}$

Relation between electric field and potential:

Negative gradient of electric potential is equal to Electric field.

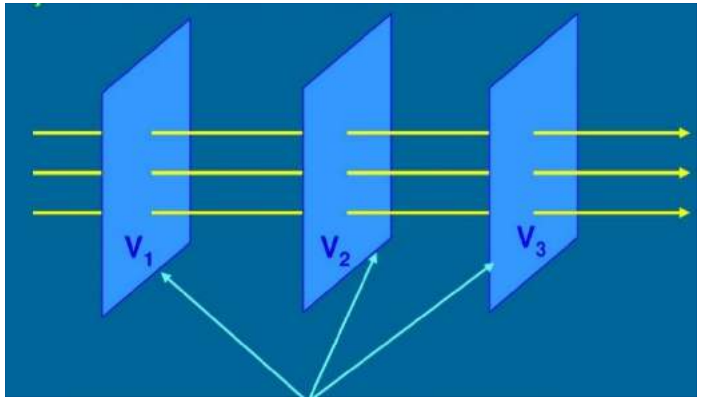
Equipotential surfaces

- The locus of all points which have the same electric potential is called equipotential surface.
- $V_A - V_B = \frac{W}{q} = 0$
- Work done is zero.
- The lines of force at every point of the equipotential surface are perpendicular to the surface.
- Example : Surface of a conductor

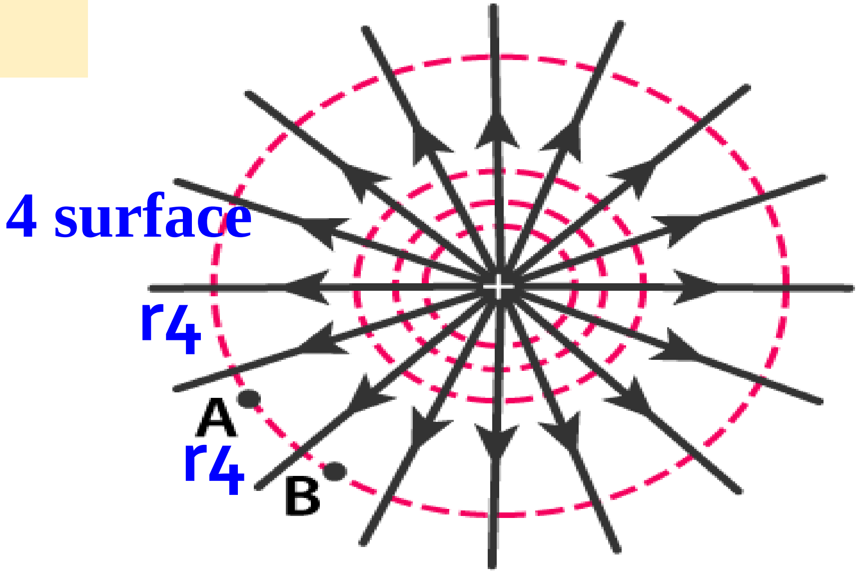
$$V = \frac{q}{4\pi\varepsilon_0 r} \quad , \quad E = \frac{q}{4\pi\varepsilon_0 r^2}$$

$$V_A = V_B$$
$$\bar{E}_A \neq \bar{E}_B$$

Electric field is vector , Electric potential is scalar



Plane equipotential surface



Spherical equipotential surface

Worked out Examples-IV

Topic: Irrotational Electric field and Electric Potential

1) A work of 45×10^{-7}J is being done to move a charge between two points of potential difference 360 V. The charge is [ ]

(a) 12.5 nC (b) 8 nC (c) 25 nC (d) 16 nC

Solution: $W = 45 \times 10^{-7}$ J , $\Delta V = 360$ V

Formula : $\Delta V = \frac{W}{q}$

$$q = \frac{W}{\Delta V} = \frac{45 X 10^{-7} x 0.02}{360} = \mathbf{12.5\ nC}$$

2) The potential due to a charge 10 μC at certain distance(x) is 3×10^4 V. The value of 'x' is [ ]

(a) $3\sqrt{3}$ m (b) $\sqrt{3}$ m (c) 3 m (d) 6 m

Solution: q = 10 μC= 6×10^{-6} C , V= 3×10^4 V

Formula : $V = \frac{q}{4\pi\varepsilon_0 r}$

$$r = \frac{q}{4\pi\varepsilon_0 V} = \frac{9 x 10^9 x 10 x 10^{-6}}{3 x 104} = \mathbf{3\ m}$$

Assignment-IV

Topic: Irrotational Electric field and Electric Potential

1) Choose correct unit for electric field. [ ]

(a) N/C , V/m (b) N/m, V/C (c) Nm, VC (d) J/C, J/m

2) Which of the following is **not** true for static electric field. [ ]

(a) Irrotational field (b) Conservative field

(c) Negative gradient of electric potential is electric field (d) Scalar quantity

3) The electric potential at a point which is at a distance of 1m from a charge of 10 μC is [ ]

(a) 10^5 V (b) 9×10^{-4} V (c) 9×10^4 V (d) 10^6 V

4) Select the correct choice after reading the two statements given below. [ ]

Statement-I: The electric field is always tangential to the surface of a conductor

Statement-II: The potential at every point on the surface of a conductor is the same.

(a) Statement-I is correct, Statement-II is wrong

(b) Statement-I is wrong, Statement-II is correct

(c) Both statements are correct (d) Both statements are wrong

Answers: (1Q : **a**), (2Q: **d**) , (3Q: **c**), (4Q: **c**)

Assignment-IV

Topic: Irrotational Electric field and Electric Potential

5) The electric potential V (in volt) varies with distance x (in meter) according to the relation $V = 5 + 4x^2$. The force experienced by a negative charge of $2x10^{-6}$ C located at x = 0.5 m is

(a) $2x10^{-6}$ N (b) $4x10^{-6}$ N (c) $6x10^{-6}$ N (d) $8x10^{-6}$ N [ ]

6) A charge of 6 μC in an electric field is acted on by a force 3 N. The potential gradient at that point is [ ]

(a) 10^5 V/m (b) $2x10^{-6}$ V/m (c) $5x10^5$ V/m (d) $18x10^{-6}$ V/m

7) The potential at the origin is zero due to electric field $\vec{E} = 20\,\hat{i} + 30\,\hat{j}$ N/C .
The potential at point P (2m, 2m) is [ ]

(a) - 100 V (b) 25 V (c) 50 V (d) $-50\sqrt{2}$ V

8) The electric field due to a point charge is 360 N/C. The electric potential at that point is 18 J/C. The magnitude of the charge in nano- coulomb is [ ]

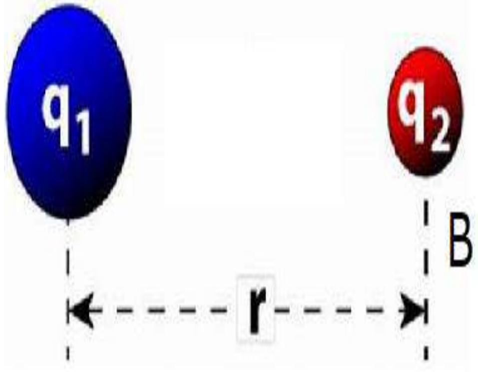
(a) 0.1 (b) 0.4 (c) 10 (d) 40

Answers: (5Q : **d**), (6Q: **c**) , (7Q: **a**), (8Q: **a**)

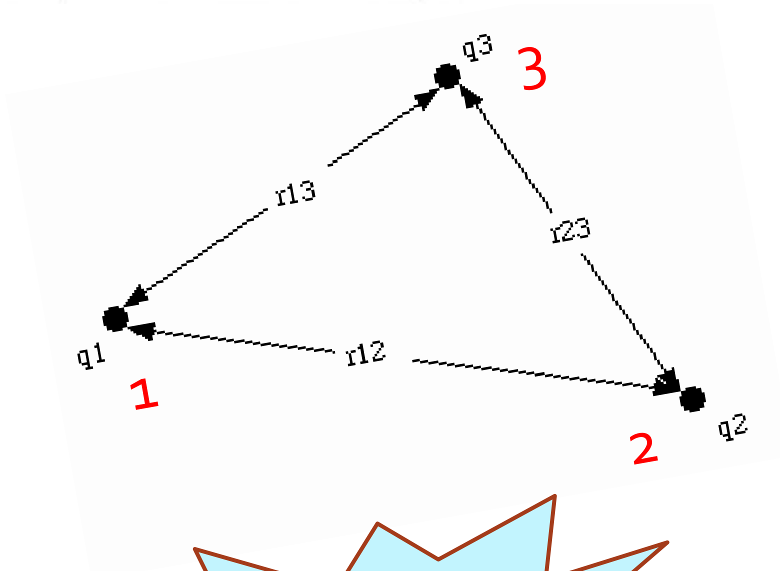
Potential energy of system of charges

Electric potential energy is the energy that is needed to move a charge against an electric field.

$$U(r) = \frac{q_1 q_2}{4\pi\varepsilon_0 r}$$



$$U(r) = \frac{1}{4\pi\varepsilon_0}\left[\frac{q_1 q_2}{r_{12}} + \frac{q_2 q_3}{r_{23}} + \frac{q_1 q_3}{r_{13}}\right]$$



Energy density in electrostatic field:

$$\text{Energy density} = \frac{\text{energy stored}}{\text{unit volume}}$$

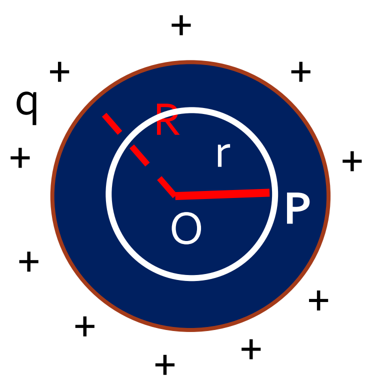
Electrostatic energy : $U = \frac{1}{2} qV$

$$\mathbf{u} = \frac{1}{2}\varepsilon_0 E^2$$

Potential due to a spherical charge distribution

Spherical charge distribution

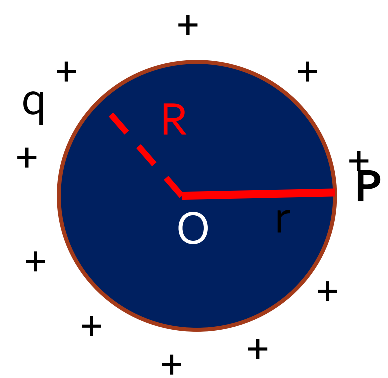
Inside the sphere



$$V = \frac{1}{4\pi\varepsilon_0} X \frac{q}{R}$$

$$E = \frac{1}{4\pi\varepsilon_0} X \frac{qr}{R^3}$$

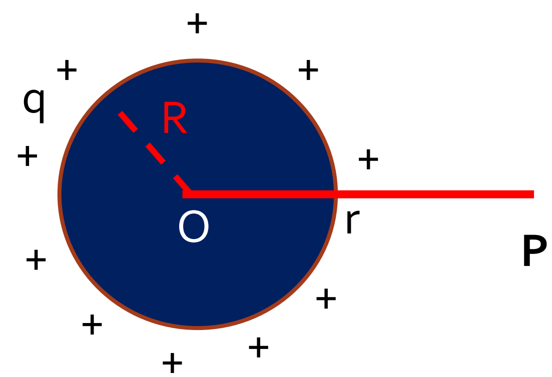
On the sphere



$$V = \frac{1}{4\pi\varepsilon_0} X \frac{q}{R}$$

$$E = \frac{1}{4\pi\varepsilon_0} X \frac{q}{R^2}$$

Outside sphere



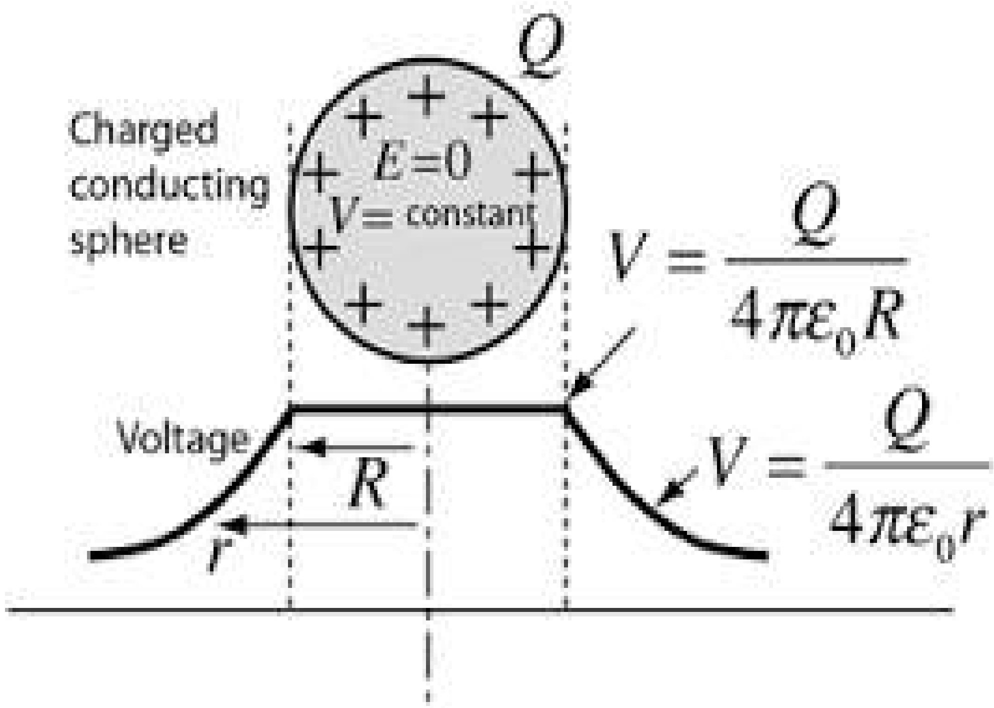
$$V = \frac{1}{4\pi\varepsilon_0} X \frac{q}{r}$$

$$E = \frac{1}{4\pi\varepsilon_0} X \frac{q}{r^2}$$

Potential due to a charged spherical conductor

Spherical conductor

Outside the surface	$V = \frac{1}{4\pi\varepsilon_0} X \frac{q}{r}$ $E = \frac{1}{4\pi\varepsilon_0} X \frac{q}{r^2}$
lies on the surface	$V = \frac{1}{4\pi\varepsilon_0} X \frac{q}{R}$ $E = \frac{1}{4\pi\varepsilon_0} X \frac{q}{R^2}$
Inside the surface	$V = \frac{1}{4\pi\varepsilon_0} X \frac{q}{R}$ $E = 0$



Properties of Conductors

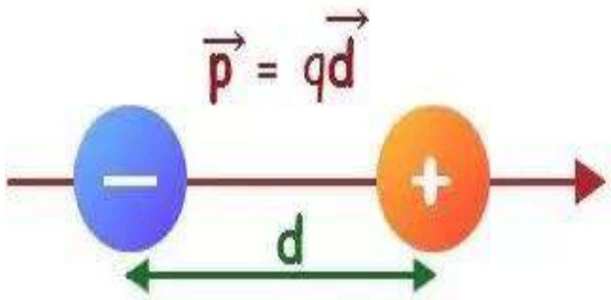
- ❖ The electric field is zero everywhere inside the conductor
- ❖ Any net charge resides on the conductor's surface
- ❖ Electric field just outside charged conductor is perpendicular to conductor's surface.

Torque acting on an Electric Dipole placed in uniform electric field

Electric dipole: Any two point charges which are equal in magnitude but have opposite signs and are separated by a small distance are said to be "electric dipole".

Electric dipole moment **p** = q d Units: coulomb-meter

Vector quantity (Direction is from negative to positive)



- Dipole placed in Uniform electric field
- Total force acting on the dipole is zero
- Total torque on the dipole is not zero
- Torque tends to rotate the dipole

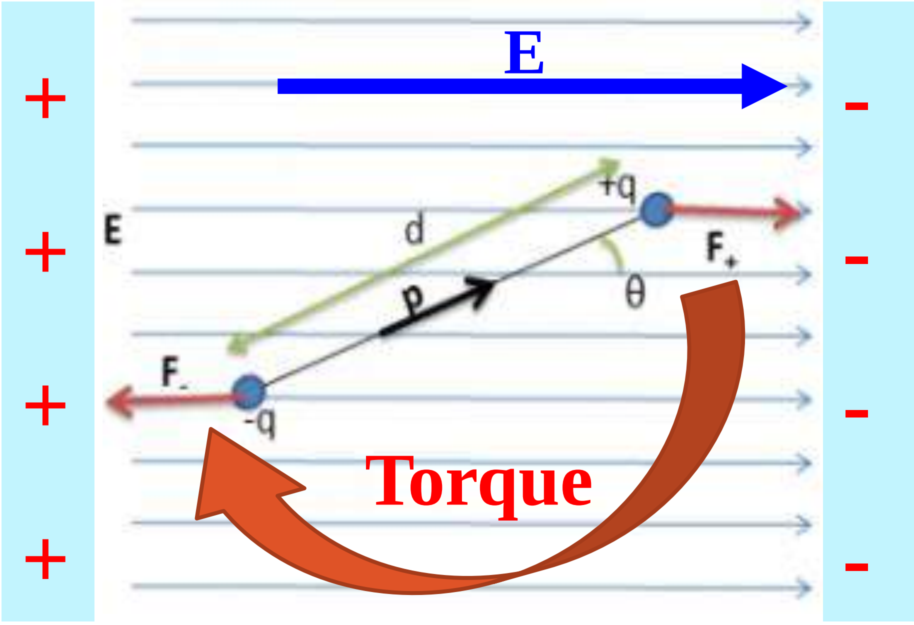
Torque $\tau = pXE = pEsin\theta\hat{n}$

$\theta = 0^0 \rightarrow \tau = 0\ ,\theta = 90^0 \ \rightarrow \tau_{max} = pE$

Electric potential energy $\Delta U = -p.E = -pEcos\theta$

$\theta = 0^0 \ \rightarrow \Delta U_{min} = -pE, \theta = 90^0 \ \rightarrow \Delta U = 0,$

$\theta = 180^0 \ \rightarrow \Delta U_{max} = +pE$



Worked out Examples-V

Topic: Electric potential , Potential energy and Torque on Electric dipole

1) Two charges 4 μC and 7 C are placed 4.5 m apart. Find mutual potential energy of the system.

Solution: $q_1 = 4\ \mu C$, $q_2 = 7\ \mu C$, r = 4.5

Formula : $U = \frac{q_1 q_2}{4\pi\varepsilon_0 r} = \frac{(9X10^9)(4X10^{-6})(7X10^{-6})}{4.5}$

$U = \mathbf{5.6\ X\ 10^4\ N}$

2) Two charged +3 μC and -3 μC are situated at a distance 5 mm in a uniform electric field $2x10^6$ V/m, angle between dipole and electric field is 90^0. Find torque produced on the system.

Solution: q = 3 μC= $3x10^{-6}$ C , d = 5mm = $5x10^{-3}$ m, E= $2x10^6$ V/m

Formula : $\tau = pXE$, p = qd

$\tau = qd\ X\ Esin\theta = 3x10^{-6} \times 5x10^{-3} \times 2x10^6\ sin90^0$

$\tau = \mathbf{0.03\ N.m}$

Assignment-V

Topic: Electric potential , Potential energy and Torque on Electric dipole

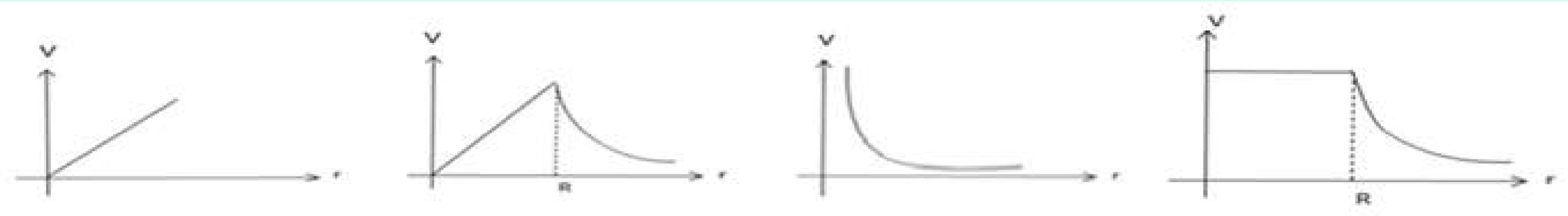
1) An electric dipole placed with its axis inclined at an angle to the direction of a uniform electric field experiences [ ]

(a) A force but no torque (b) a torque but no force

(c) a fore as well as a torque (d) neither force nor a torque

2) Choose the correct graphical representation for potential due to a charge conducting sphere

(a) (b) (c) (d) [ ]



3) Electric field inside a charged hollow sphere is [ ]

(a) uniform (b) maximum at center (c) maximum inside the surface (d) zero

Answers: (1Q : **b**), (2Q: d) , (3Q: **d**)

APPLICATIONS

Electrostatics is the study of electric fields in static equilibrium.

- Van de Graaff generator,
- Photocopiers, Laser printers, Ink-jet printers
- Smoke Precipitators and **Electrostatic** Air Cleaning.

REFERENCE BOOKS

- Fundamentals of Physics: **Halliday/Resnick/Walker Wiley India Edition 2007**
- Introduction to Electrodynamics by **David J. Griffith**
- Electromagnetic theory and electro dynamics by **Sathya Prakash**
- Concepts of physics by **HC Varma Part II**
- Engineering Physics by **R.K Gaur and S.L Gupta**
- University Physics by **Young and Freeman, Pearson Education**
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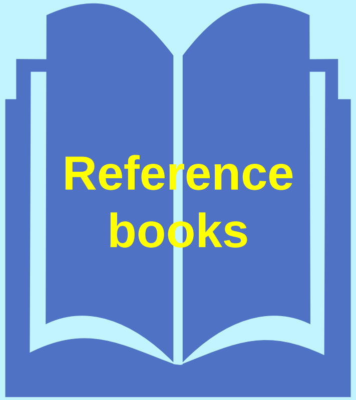


SUMMARY

- Electric charges: Positive, Negative , charge of one electron = 1.6 X 10^{-19} C
- Unlike charges attracted and like charged repeal with each other
- Coulomb's law: $\mathbf{F} = \frac{k(q_1 q_2)}{r^2}$
- Electric field strength $\mathbf{E} = \frac{F}{q}$
- Tangent drawn at any point on electric field line gives direction of electric field at that point.
- Electric flux: $\varnothing_E = \oint \boldsymbol{E} \cdot d\boldsymbol{S} =$ E S cos θ
- Gauss's law (Maxwell's first equation): $\varnothing_{\mathbf{E}} = \oint \mathbf{E} \cdot \mathbf{dS} = \frac{q_{enclosed}}{\varepsilon_0}$, $\nabla . E = \frac{\rho}{\varepsilon_0}$, $\nabla . D = \rho$
- Applications of Gauss's law: Electric field due to different charge distributions
- Conservative nature of electrostatic field, irrotational field $\oint \mathrm{E} \cdot \mathrm{dl} = \nabla \times \mathrm{E} = 0$
- Electric potential: V = $\frac{W}{q}$, V= Ed
- Relation between electric field and electric potential: $V = -\int \mathbf{E} \cdot \mathbf{dl}$, E = - grad V = -∇ V
- Potential energy of system of charges $\mathbf{U(r)} = \frac{1}{4\pi\varepsilon_0}\left[\frac{q_1 q_2}{r_{12}} + \frac{q_2 q_3}{r_{23}} + \frac{q_1 q_3}{r_{13}}\right]$
- Torque acting on electric dipole placed in uniform E, $\mathbf{p} = \mathbf{q}\ \mathbf{d}$,, $\boldsymbol{\tau} = \boldsymbol{p} X \boldsymbol{E}$, $\Delta U = -\boldsymbol{p}.\boldsymbol{E}$

SUMMARY (Important formulas)

- Electric field due to an infinitely long charge distribution: $E = \frac{\lambda}{2\pi\varepsilon_0 r}$
- Electric field due to an infinitely **conducting** sheet of charge: $E = \frac{\sigma}{\varepsilon_0}$
- Electric field due to an infinitely **non conducting** sheet of charge: $E = \frac{\sigma}{2\varepsilon_0}$
- Electric field due to a uniformly charged cylinder:

  Inside sphere: $E = \frac{\lambda r}{2\pi\epsilon o R^2}$, Out side Sphere: $E = \frac{\lambda}{2\pi\epsilon o\, r}$
- Electric field due to a **spherical charge distribution**:

  Inside sphere: $\mathbf{E} = \frac{\mathbf{1}}{\mathbf{4\pi\varepsilon_0}}\ \mathbf{X}\ \frac{\mathbf{qr}}{\mathbf{R^3}}$, On sphere: $E = \frac{1}{4\pi\varepsilon_0}\ X\ \frac{q}{R^2}$, Out side Sphere: $E = \frac{1}{4\pi\varepsilon_0}\ X\ \frac{q}{r^2}$
- Electric potential due to a **spherical charge distribution** :

  Inside sphere: $V = \frac{1}{4\pi\varepsilon_0}\ X\ \frac{q}{R}$, On sphere: $V = \frac{1}{4\pi\varepsilon_0}\ X\ \frac{q}{R}$, Out side Sphere: $V = \frac{1}{4\pi\varepsilon_0}\ X\ \frac{q}{r}$
- Electric field due to a charged **spherical conductor**:

  Inside sphere: $\mathbf{E = 0}$, On sphere: $E = \frac{1}{4\pi\varepsilon_0}\ X\ \frac{q}{R^2}$, Out side Sphere: $E = \frac{1}{4\pi\varepsilon_0}\ X\ \frac{q}{r^2}$
- Potential due to a charged **spherical conductor**:

  Inside sphere: $V = \frac{1}{4\pi\varepsilon_0}\ X\ \frac{q}{R}$, On sphere: $V = \frac{1}{4\pi\varepsilon_0}\ X\ \frac{q}{R}$, Out side Sphere: $V = \frac{1}{4\pi\varepsilon_0}\ X\ \frac{q}{r}$

CPGET – Previous year questions

1) Electric field at a point inside a uniformly charged sphere is **(CPGET -2020)**

(a) Zero (b) $\frac{q}{4\pi\varepsilon_0 a^3}$ (c) $\frac{qr}{4\pi\varepsilon_0}$ (d) $\frac{qr}{4\pi\varepsilon_0 a^3}$

2) Q_1 and Q_2 Coulomb and r =1 m, ($\frac{1}{4\pi\varepsilon_0} = 9x10^9$) then the force between the charges is

(a) $18x10^9$ N (b) $9x10^9$ N (c) $0.9x10^9$ N (d) $10x10^9$ N **(CPGET -2020)**

3) A spherical drop of water carrying a charge of $3x10^{-6}$ C has a potential of 500 Volts at its surface. What is the radius of the drop? **(CPGET -2020)**

(a) 54 m (b) 64 m (c) 540 m (d) 640 m

4) The electric field strength at a distance ‘r’ due to infinite line of charge density λ is

(a) $(\frac{1}{4\pi\varepsilon_0})(\frac{2\lambda}{r})$ (b) $(\frac{1}{4\pi\varepsilon_0})(\frac{\lambda}{r})$ (c) $(\frac{1}{4\pi\varepsilon_0})(\frac{\lambda}{2r})$ (d) $(\frac{1}{4\pi\varepsilon_0})(\frac{4\lambda}{r})$ **(CPGET -2018)**

Answers: (1Q : d), (2Q: **b**) , (3Q: **c**), (4Q: **a**)

CPGET – Previous year questions

5) How many electrons are there in one coulomb of charge? **(CET-2017)**

(a) 6.023×10^{23} (b) 6.023×10^{20} (c) 6.023×10^{18} (d) 6.023×10^{15}

6) The Gauss law for electric fields in a homogenous medium in absence of charges is **(CET-2017)**

(a) $\nabla . E = \frac{\rho}{\varepsilon_0}$ (b) $\nabla . D = \rho$ (c) $\nabla . E = 0$ (d) $\nabla^2 E = \frac{\rho}{\varepsilon_0}$

7) Which of the following is a vector quantity? **(CET-2017)**

(a) Electric charge (b) Electric potential (c) Electric field (d) Electric flux

8) A region is specified by the potential V = 5x +4y – 10 z then the electric field is (i, j, k are unit vectors)

(a) 5i +4j +10k (b) 5i-4j+10k (c) -5i-4j-10k (d) -5i-4j+10k

9) The Maxwell's equation $\oint E \cdot dS = \frac{q}{\varepsilon_0}$ is **(CET-2015)**

(a) Gauss law of electricity (b) Faraday's law

(c) Gauss law of magnetism (d) Ampere's law

Answers: (5Q : **c**), (6Q: **c**) , (7Q: **c**), (8Q : **d**), (9Q: **a**)

IIT JAM – Previous year questions

1) In terms of the basic units of mass (M), length (L) time (T) and charge (Q), the dimensions of electric permittivity of vacuum (ε_0) are **(JAM -2007)**

(a) $M^{-1}L^{-3}T^2Q^2$ (b) $ML^2T^{-1}Q^{-2}$ (c) LTQ^{-1} (d) $LT^{-1}Q^{-1}$

2) A hollow thin spherical shell of radius R is given a charge Q. The electric field at a point x (0 < x <R) is **(JAM – 2005)**

(a) $\frac{Q}{4\pi\varepsilon_0 R^2}$ (b) $\frac{Q}{4\pi\varepsilon_0 x^2}$ (c) $\frac{Q}{4\pi\varepsilon_0 x}$ (d) zero

3) An electric field in a region is given by $\bar{E}(x,y,z) = ax\,\hat{\imath} + cz\,\hat{\jmath} + 6by\hat{k}$. For which values of a, b and c does this represent an electrostatic field? **(JEST -2021)**

(a) 13, 1, 12 (b) 17, 6, 1 (c) 13, 1 ,6 (d) 45, 6, 1

4) Equipotential surfaces corresponding to a particular charge distribution are given by $4x^2 + (y-2)^2 + z^2 = V_i$ where the values of V_i are constants. The electric field $\vec{E}$ at the origin is

(a) $\vec{E} = 0$ (b) $\vec{E} = 2\hat{x}$ (c) $\vec{E} = 2\hat{y}$ (d) $\vec{E} = -4\hat{y}$ **(JAM -2011)**

Answers: (1Q : **c**), (2Q: **b**) , (3Q : **d**), (4Q : **d**)

IIT JAM – Previous year questions

5) Two-point charges $+q_1$ and q_2 are fixed with a finite distance d between them. It is desired to put a third charge q_3 in between these two charges on line joining them so that the charge q_3 is in equilibrium. This is **(JAM -2005)**

(a) possible only if q_3 is positive

(b) possible only if q_3 is negative

(c) possible irrespective of the sign of q_3

(d) not possible at all

6) If the electrostatic potential at point (x,y) is given by V = (2x+ 4y) volts, electrostatic energy density at that point (J/m^3) is **(JAM -2008)**

(a) $5\varepsilon_0$ (b) $10\,\varepsilon_0$ (c) $20\,\varepsilon_0$ (d) $\frac{1}{2}\,\varepsilon_0(2x+4y)^2$

7) If $\overrightarrow{E_1} = xy\,\hat{\imath} + 2yz\hat{\jmath} + 3xz\,\hat{k}$ and $\overrightarrow{E_2} = y^2\,\hat{\imath} + (2xy + z^2)\hat{\jmath} + 2yz\,\hat{k}$ **(JAM-2013)**

(a Both are impossible electrostatic fields.

(b) Both are possible electrostatic fields

(c) Only $\overrightarrow{E_1}$ is a possible electrostatic field

(d) Only $\overrightarrow{E_2}$ is a possible electrostatic field

8) A small charged spherical shell of radius 0.01 m at a potential of 30 V. The electrostatic energy of the shell is **(JAM 2014)**

(A) 10^{-10} J (B) 5×10^{-10} J (C) 5×10^{-9} J (D) 10^{-9} J

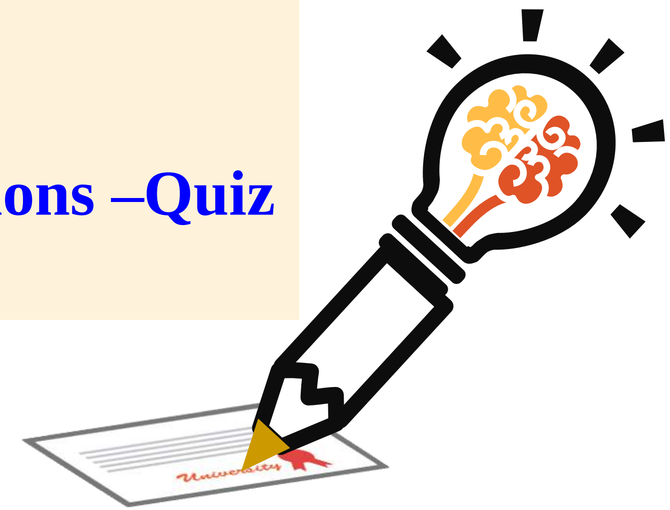
Answers: (5Q : **c**), (6Q: **b**) , (7Q : **d**), (8Q: **b**)

TSWRDCW: Physics PG Entrance (Electrostatics) -Quiz

https://forms.gle/FfkYe8tkRDF5QApUA

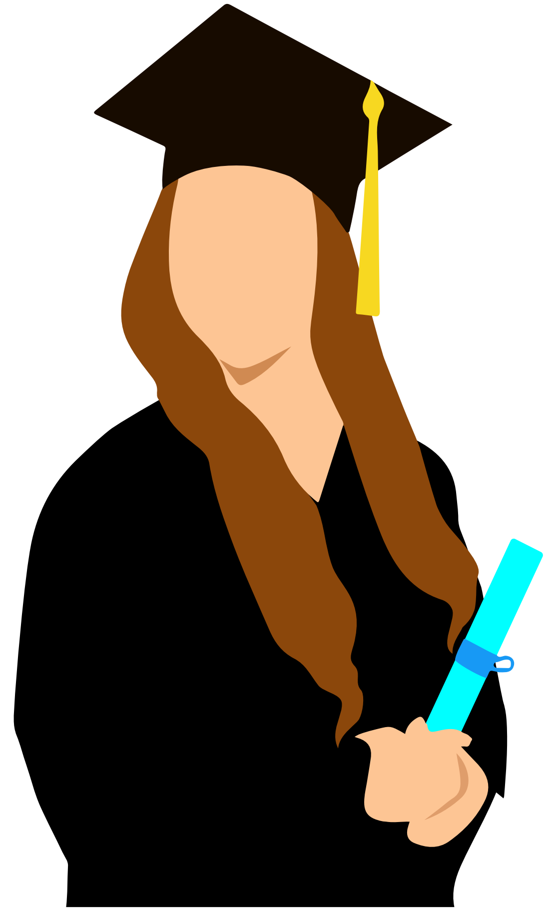
TSWRDCW: CPGET, JAM Physics Previous questions –Quiz

https://forms.gle/hE8Kg3AxbEjnybPT6



ARMED FORCES PREPARATORY DEGREE COLLEGE FOR WOMEN

THANK YOU



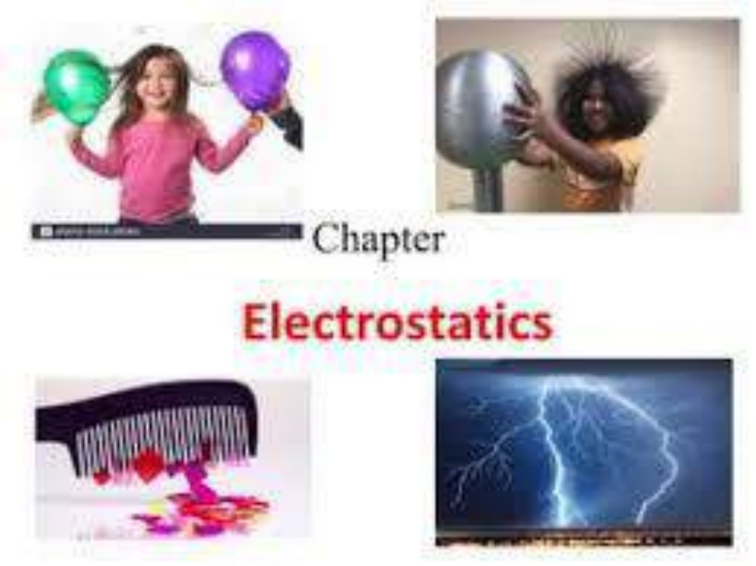
BEST OF LUCK

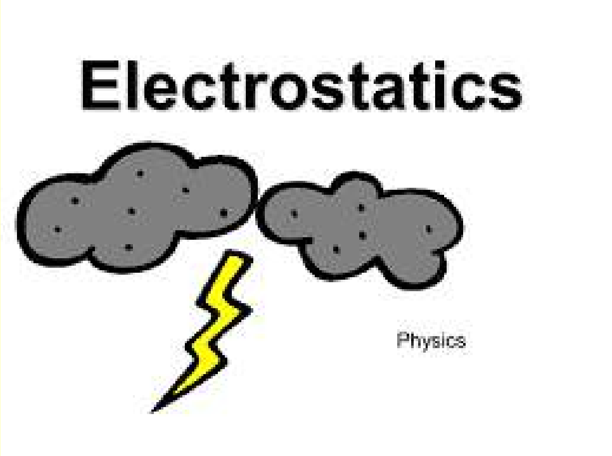
TSWRAFPDCW, Bhongir

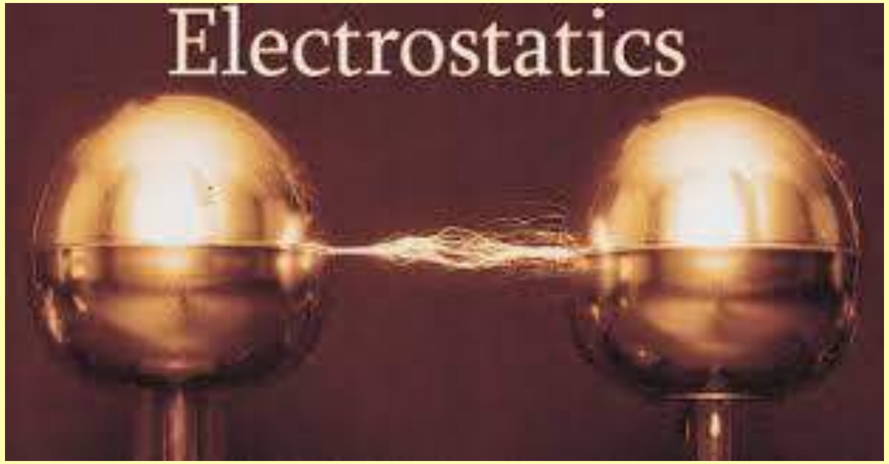
PAPER: ELECTROMAGNETISM

Topic: Electrostatics

K. SPANDANA
HOD, Department of Physics
TSWRAFPDCW, Bhongir







Objectives

- Introduction to Electrostatics
- Examples on Electrostatics
- Basic properties of Electric charges
- Electric field
- Concept of electric field lines and electric flux
- Gauss's law (Integral and differential forms)
- Application to linear, plane and spherical charge distributions.
- Conservative nature of electric field **E**, irrotational field.
- Electric Potential-Concept of electric potential
- Relation between electric potential and electric field
- Potential energy of a system of charges.
- Energy density in an electric field.
- Calculation of potential from electric field for a spherical charge distribution.
- Applications of Electrostatics

Pre Test

1) What is electrostatics physics?
2) What are the two types of electrostatic forces?
3) Mention the properties of Electrostatic field lines.
4) What does Coulomb's law state?
5) What are the applications of Electrostatics?
6) How Electric field is calculated for different shapes?

Multiple choice questions

1) If the electric field is uniform. Then [ ]

(a) Its magnitude is same but direction is not same
(b) Its magnitude is not same but direction is same
(c) Its magnitude and direction remains same
(d) Its magnitude and direction are not same

2) A proton and an electron are place in a uniform electric field [ ]

(a) Their acceleration will be equal
(b) The magnitudes of their acceleration will be equal
(c) The electric force acing on them will be equal
(d) The magnitude of forces will be equal

3) Find the force experienced by a chloride ion having 2 electrons removed, when placed in an electric field of intensity 5 N/C. [ ]

(a) $1.6x10^{-18}$ N (b) $3.2x10^{-18}$ N (c) $12.8x10^{-19}$ N (d) 8 N

4) The energy density in the electric field created by a point charge falls off with the distance from the point charge as [ ]

(a) $1/r$ (b) $1/r^2$ (c) $1/r^3$ (d) $1/r^4$

5) A charge of 6 μC in an electric field is acted on by a force 3 N. The potential gradient at that point is [ ]

(a) 10^5 V/m (b) $2x10^{-6}$ V/m (c) $5x10^5$ V/m (d) $18x10^{-6}$ V/m

Introduction

Electrostatics is a branch of physics, which deals with the phenomena and properties of stationary or slow-moving electric charges.

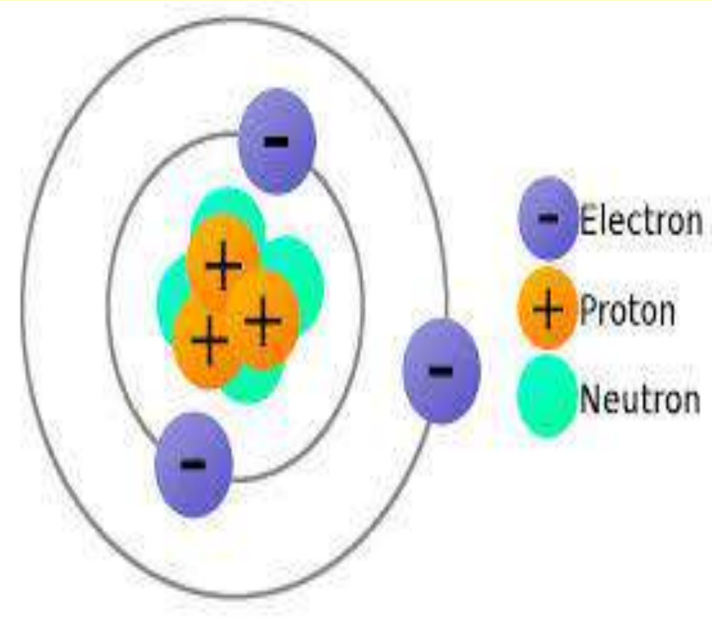
Electrostatics is the study of forces between charges, as described by Coulomb's Law.

Everyday life examples of electrostatics

- Thunder and Lighting.
- Rubbing balloons on hair and sticking to the wall
- The attraction of paper to a charged scale.
- The damage of electronic components during manufacturing
- Photocopier & laser printer operation
- When we comb our hair on a dry day and bring the comb close to tiny pieces of paper, we note that they are swiftly attracted by the comb. This is due to Electrostatic phenomena.

Electric charge

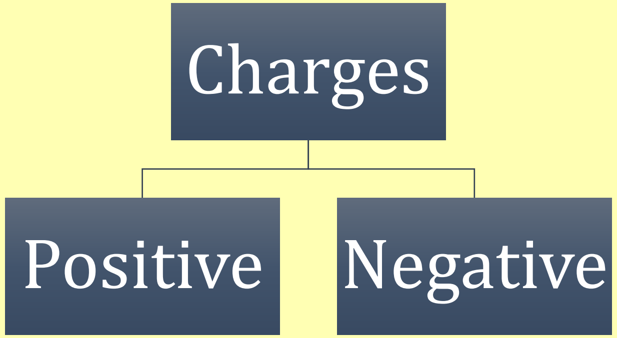
Every substance is made up of atoms.
Atom consists of protons, neutrons, electrons.
Charge is a scalar quantity.
Units: Coulomb , C
Dimensional formula : [AT]

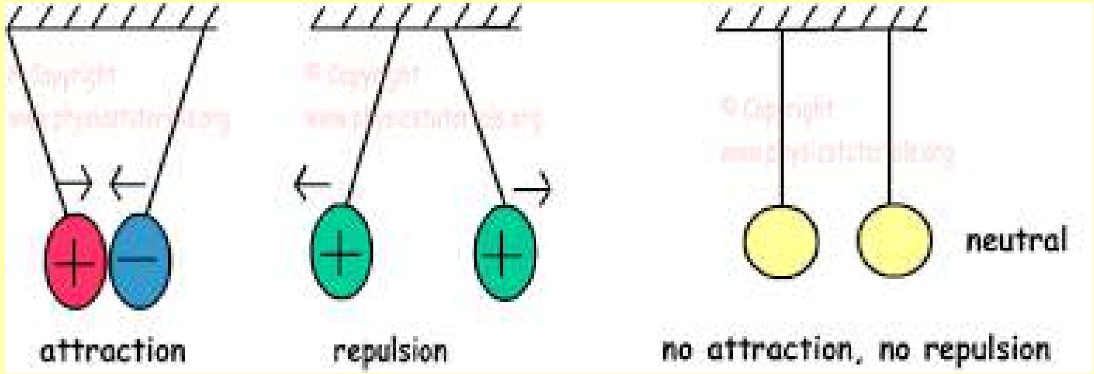


Protons = +ve charge
Electron = -ve charge
Neutron = 0 charge

	Mass	Charge
Proton	1.673 X 10^{-27} kg	**+ 1.6 X 10^{-19} C**
Neutron	1.675 X 10^{-27} kg	0
Electron	9.1 X 10^{-31} kg	**- 1.6 X 10^{-19} C**

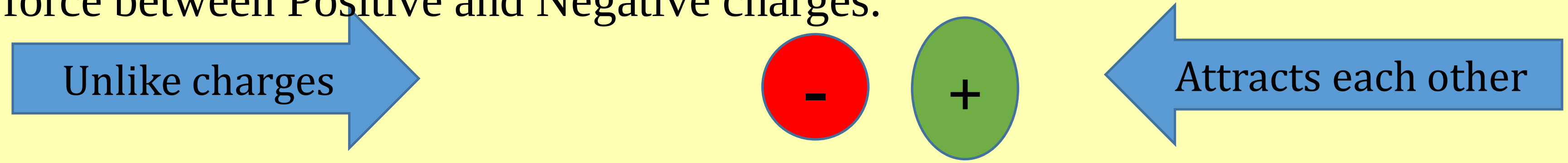
Charge is a physical property of a matter that experiences a force when placed in electromagnetic field.





- Unlike charges are attract with each other.

  There is attract force between Positive and Negative charges.



- Like charges are repeal with each other.

  There is repulsive force between two positive charged and negative charges.

Properties of charge

Charge quantization:

Charge on any substance can be written as integral multiple of a certain minimum electric charge.

$$Q = +/- ne \quad \text{(n is integer)}$$

Charge is conserved:

Electric charge can neither be created nor be destroyed but can be transferred from one material to the other.

Additivity of charges:

The total charge of a body is the algebraic sum of all the charges on the body. Charge is a scalar quantity.

Worked out Examples-I

Topic: Electric charge

1) What is the charge of Lithium Nucleus?

Solution:

Li atomic number = 3

Number of Protons n = 3

Charge of Proton e= 1.6×10^{-19} C

Q = ne

Q = 3x 1.6 $\times 10^{-19}$ **= 4.8×10^{-19} C**

Assignment -I

Topic: Electric Charge

1. What is the charge of Gold Nucleus?

2. How many number of electrons added to isolated conductor to get charge on its surface is 3.612×10^{-19} C.

3. What is the charge of Nucleus with atomic number 4?

4. When 10^{20} electrons are removed from the neutral material, then the electric charge present on it will be (Charge of electron = 1.6×10^{-19} C) [ ]

   (a) - 16 C (b) + 16 C (c) - 1.6 C (d) + 1.6 C

THANK YOU

TSWRAFPDCW, Bhongir

Paper : ELECTROMAGNETIC THEORY

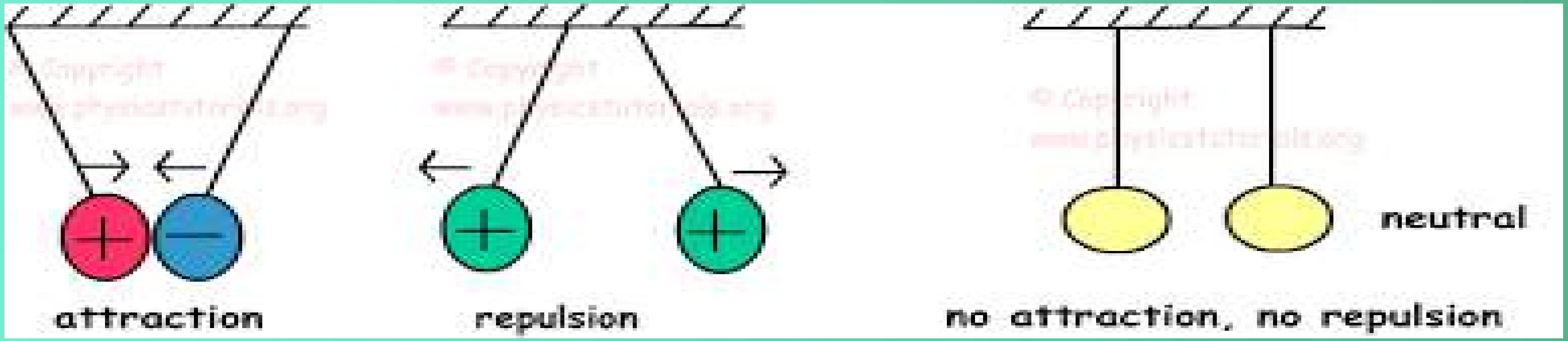
Topic : **ELECTROMAGNETIC INDUCTION**

K. SPANDANA
HOD, Department of Physics
TSWRAFPDCW, Bhongir

OBJECTIVES

- Basics of Electrostatics
- Basics of Magnetostatics
- Faraday’s law
- Ampere’s law
- Fleming’s left hand rule
- Force between two parallel current carrying conductors
- Application of Electromagnetic Induction (Maglev trains)
- History of maglev trains
- Maglev trains theory and technology
- Working principle of maglev trains
- Comparison between conventional trains & maglev trains
- Scope of research
- Summery

Basics of Electrostatics



How do charge behaves?

Unlike charges attract with each other

Unlike charges + - Attracts each other

Like charges repel with each other

- Like charges repel -

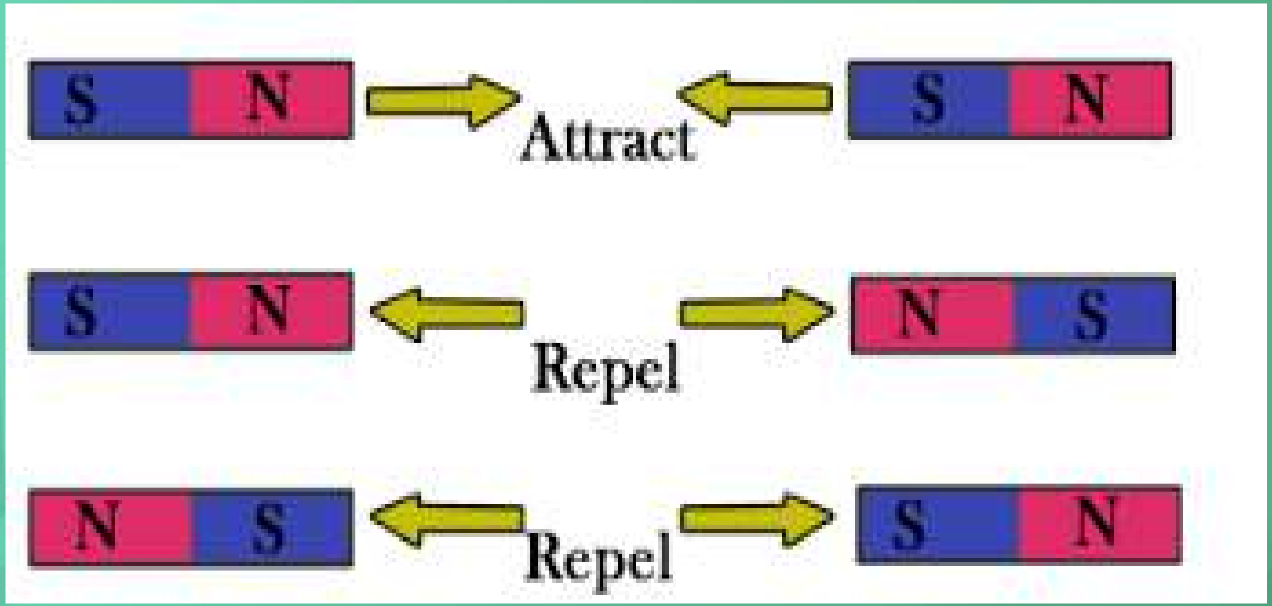
+ Like charges repel +

Basics of Magnetostatics

- Magnet contains North and South poles
- Individual poles does not exist

Like poles repel

Unlike poles attracts

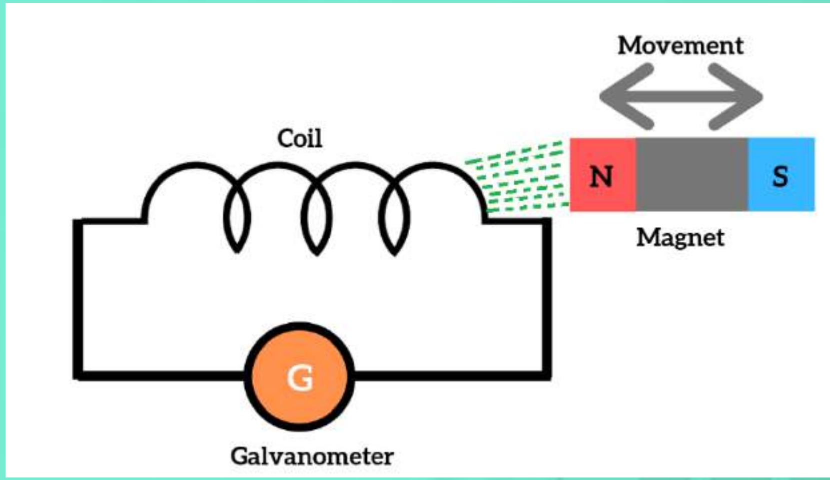


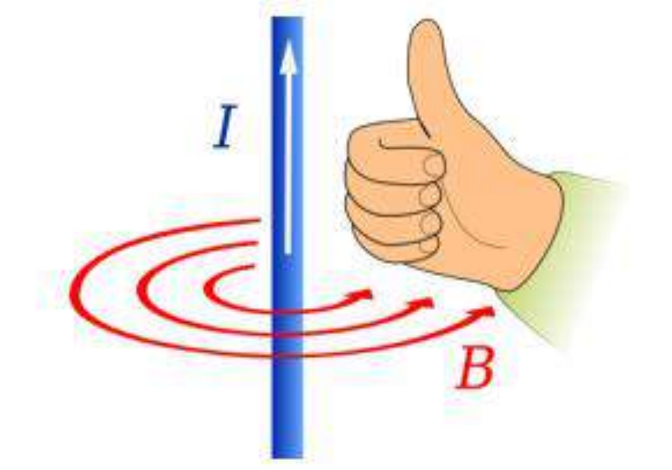
Important laws in EM theory

Faraday's law:
Current induced in a coil when it is exposed to a changing magnetic field.

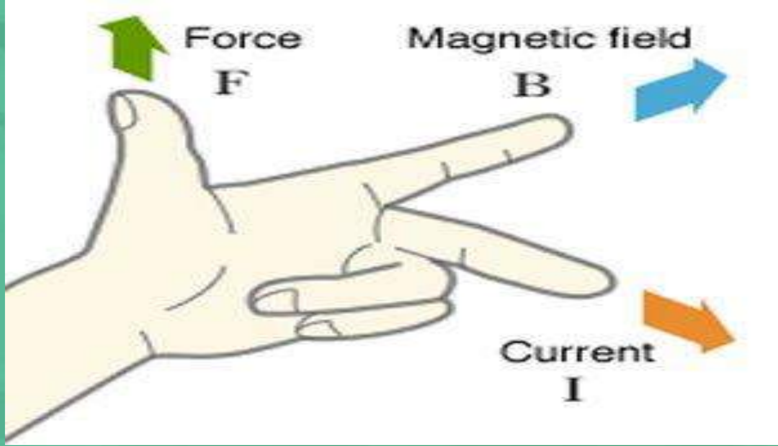
Ampere's law:
Magnetic field exist in current flowing in a conductor.

Force on a current caring conductor





Right hand thumb rule

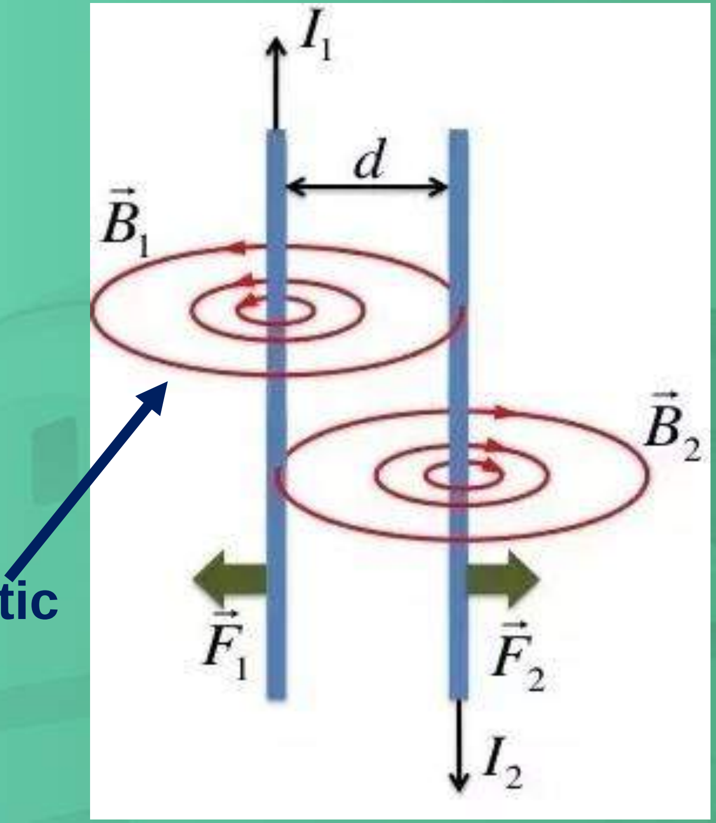


Fleming 's left hand rule

Force between two parallel current carrying conductors

Parallel conductors carrying current in opposite direction **repel each other**

Current



Magnetic field

Rail

Application of Electromagnetic induction (Maglev trains)

MODE OF TRANSPORTATION

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CONVENTIONAL MODE OF TRANSPORT

Cost

Pollution

Time

Weather

Energy source

SOLUTION

MAGLEV TRAINS

Fast, comfortable, pollution free, energy efficient, weather proof

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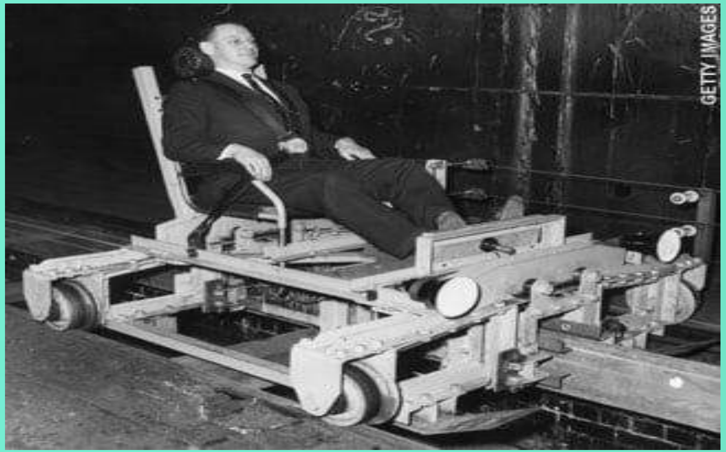
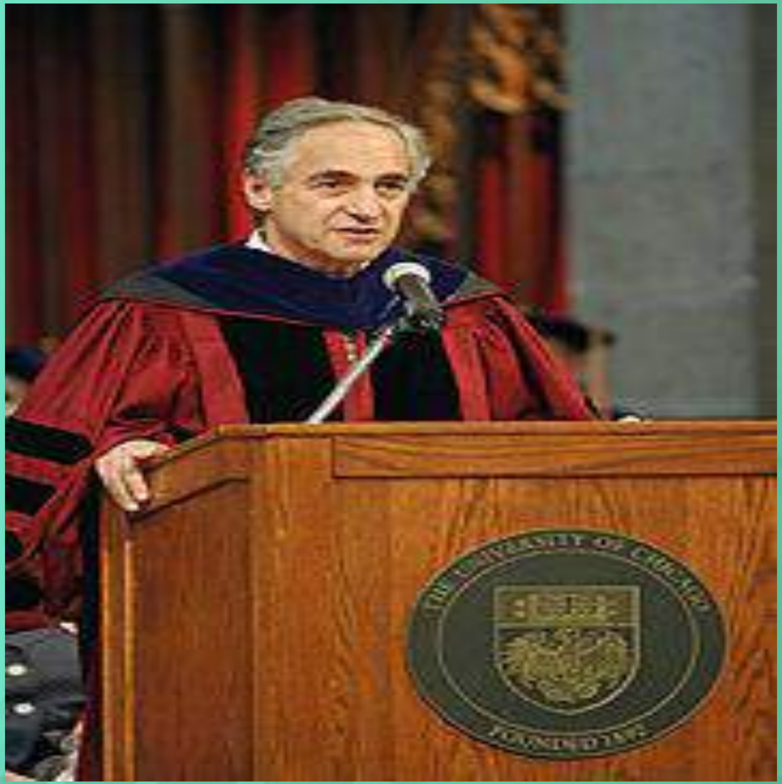
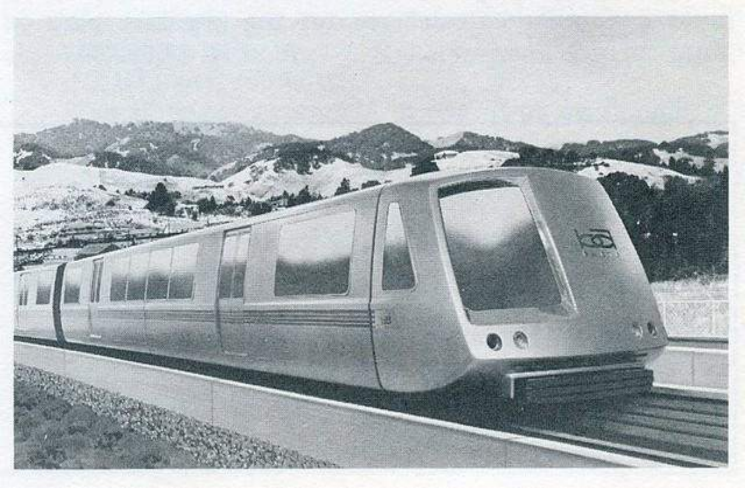
HISTORY OF MAGLEV TRAINS



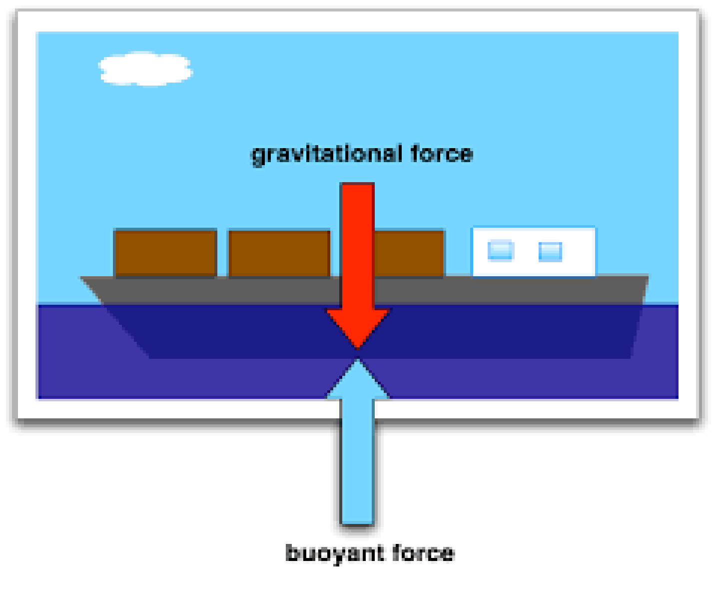


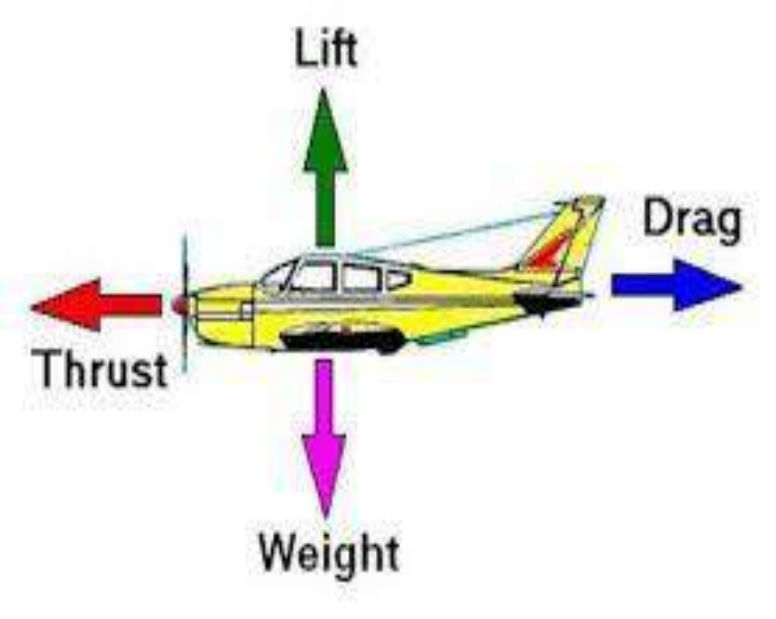


Eric Roberts Laithwaite
British Electrical Engineer

FATHER OF MAGLEV

MAGLEV TRAINS THEORY





Buoyant levitation **Aerodynamic levitation** **Aerodynamic levitation**

Maglev = Magnetic + Levitation

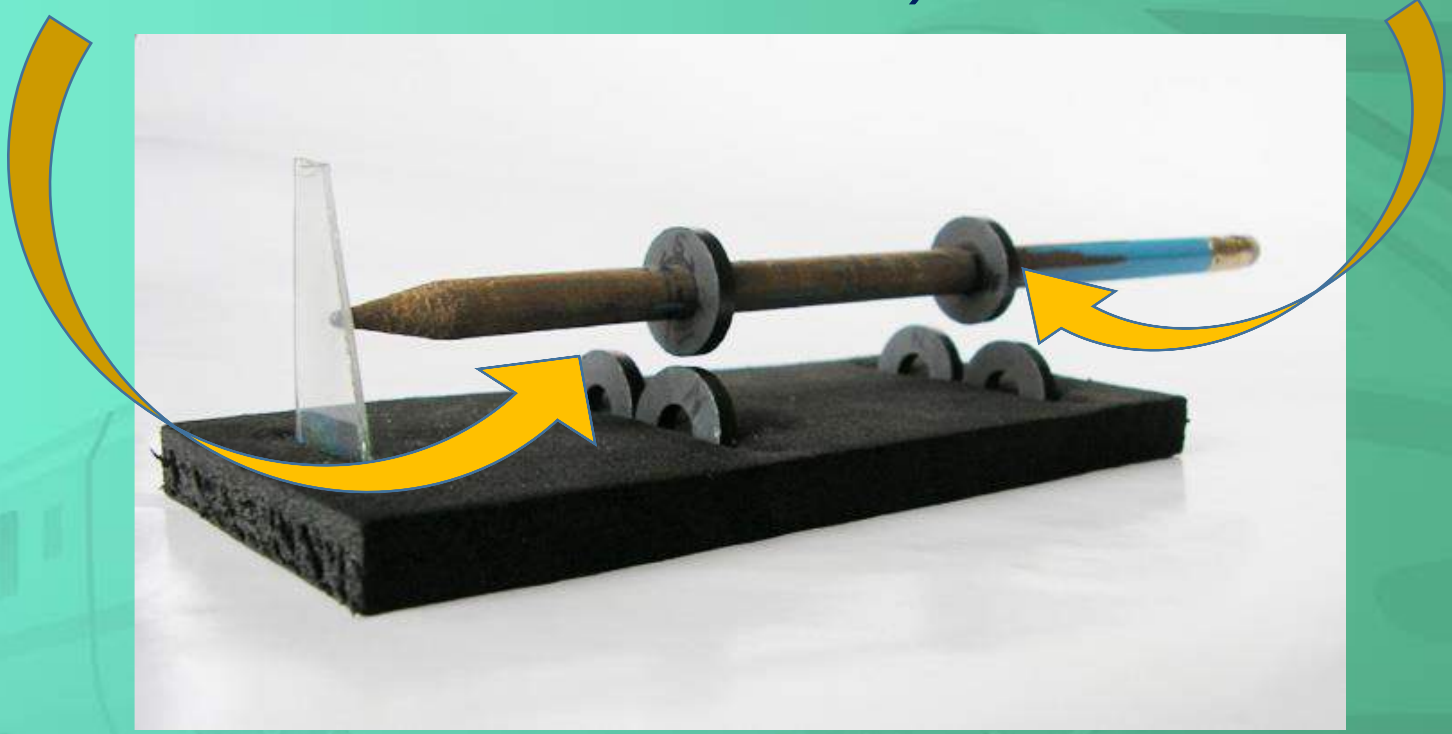
MAGLEV TRAINS THEORY

Initial thought towards Maglev trains:

It has two sets of Magnets

1) To repel and push train up off track

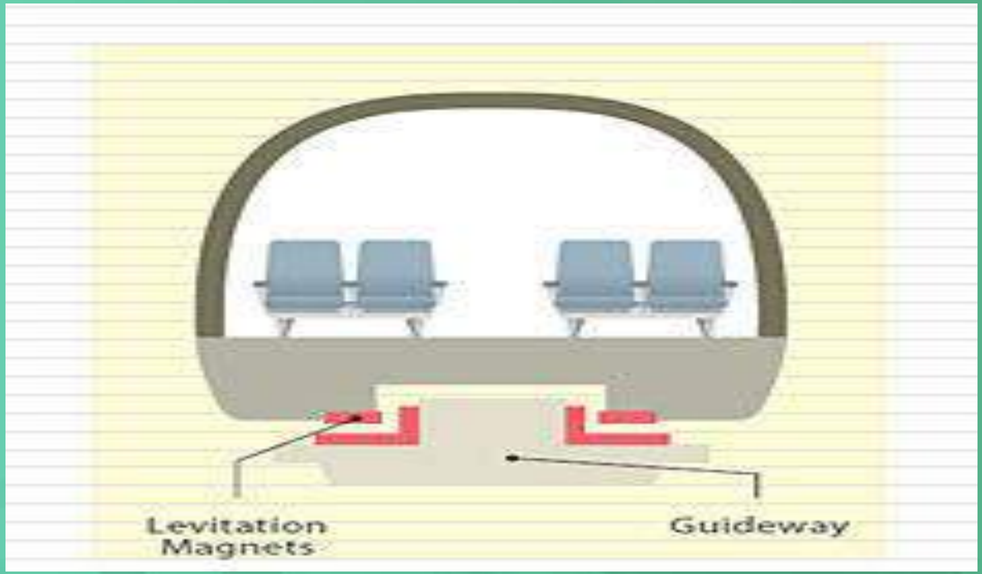
2) To move elevated train ahead

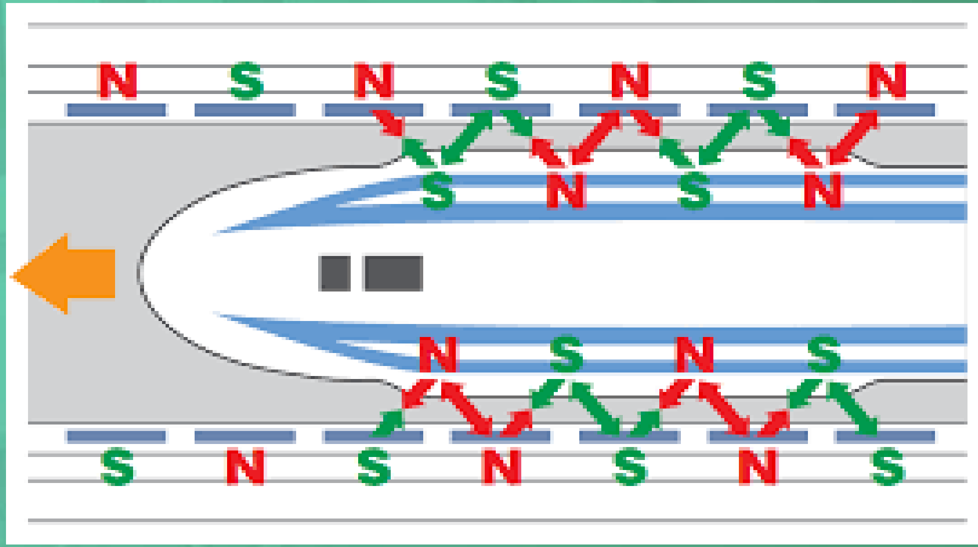


BASIC PRINCIPLE OF MAGLEV TRAINS

Maglev train functions:

- Levitation
- Propulsion
- Lateral guidance





LEVITATION

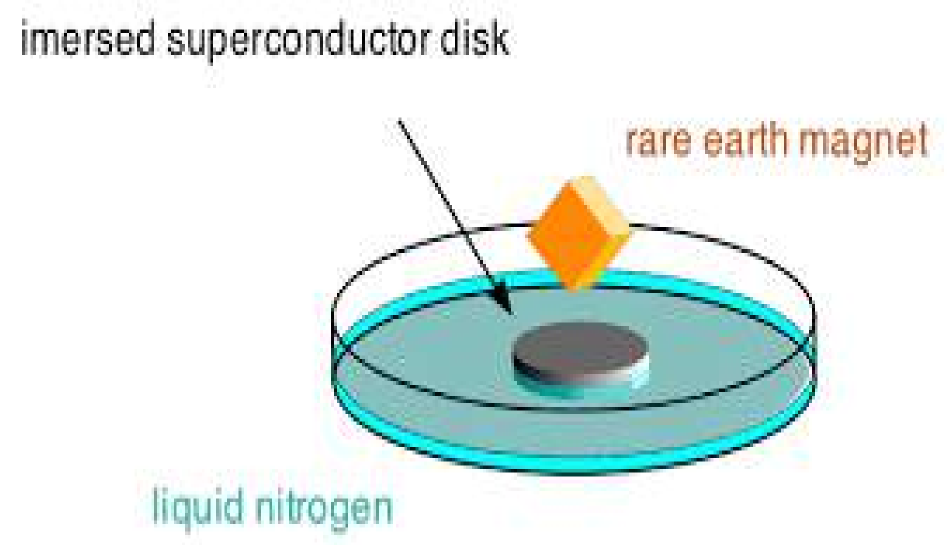
1) ELECTRODYNAMIC SUSPENSION (EDS)

2) ELECTROMAGNETIC SUSPENSION (EMS)

ELECTRODYNAMIC SUSPENSION:

Super conductors:

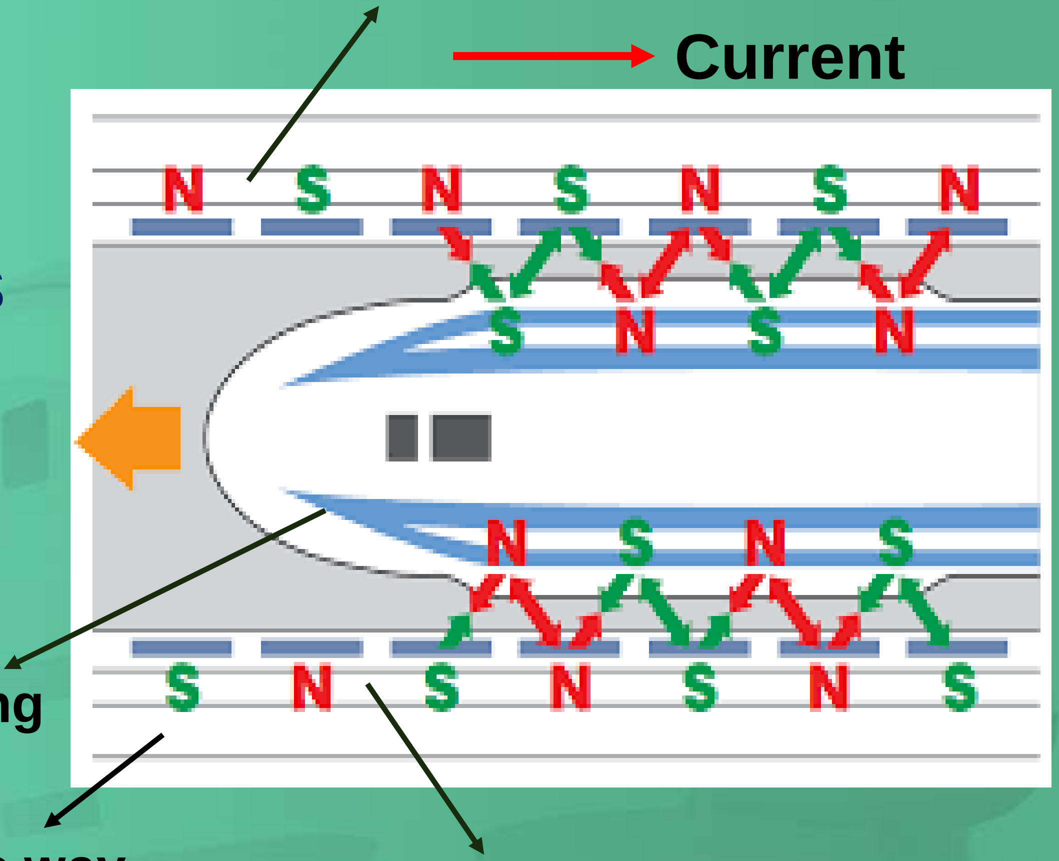
- Zero resistance
- Perfect diamagnet
- Exhibit Meissner Effect



Magnetic levitation with super conductor

PROPULSION

- Electromagnet coils placed on guide walls.
- Alternating current passes through electromagnet coils.
- It creates a magnetic field that attracts and repeals the superconducting magnets.
- **As a result train moves in forward direction.**

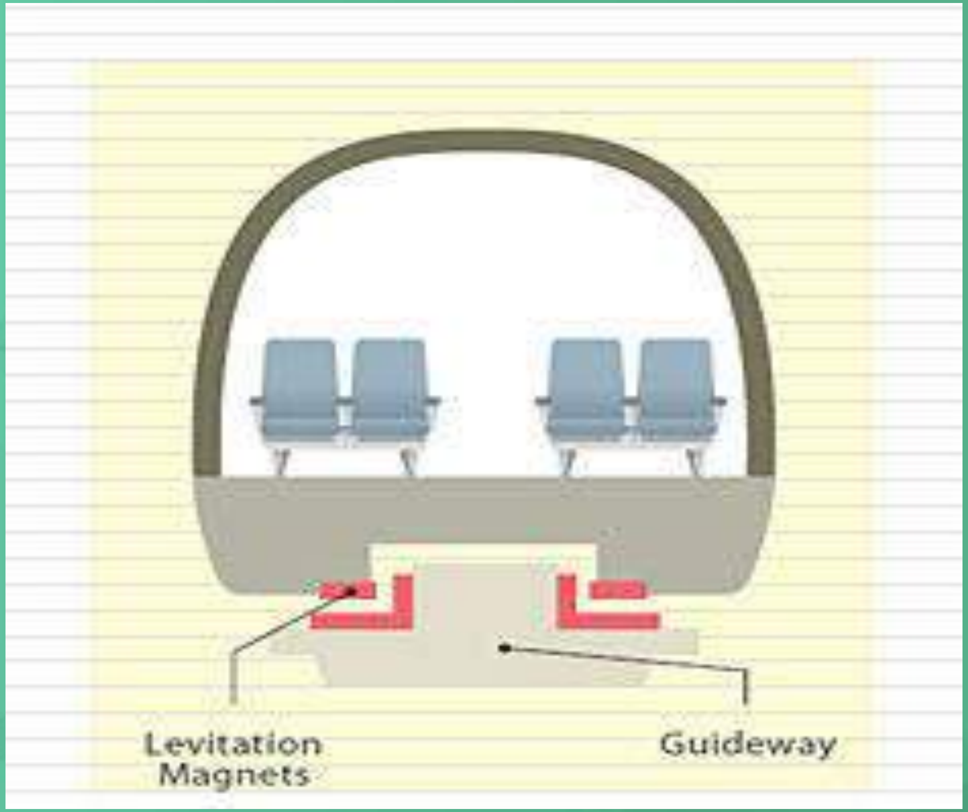


LATERAL GUIDANCE

When one side of train nears the side of the guideway
Super conducting magnet on the train induces two forces

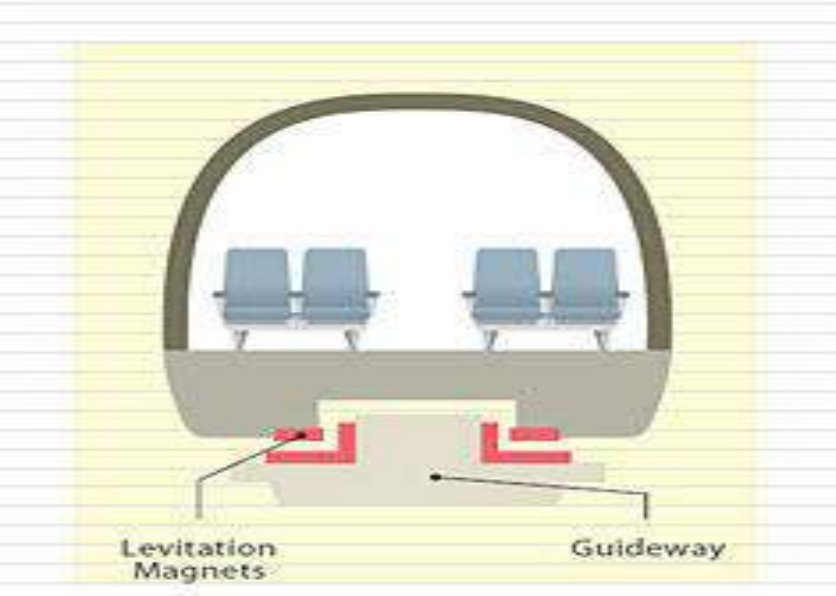
- Repulsive force from the levitation coils on the side closer to the train.
- Attractive force from the coils on the farther side.

This keeps the train in the centre



ELECTRODYNAMIC SUSPENSION (EDS)

- Current is induced due to passing of superconducting magnets through levitation coils.
- Induced current creates magnetic filed.
- Force in track is created by induced magnetic field in coils.
- Train pushed in upward direction by magnetic force and Levitate 10 cm above the track.



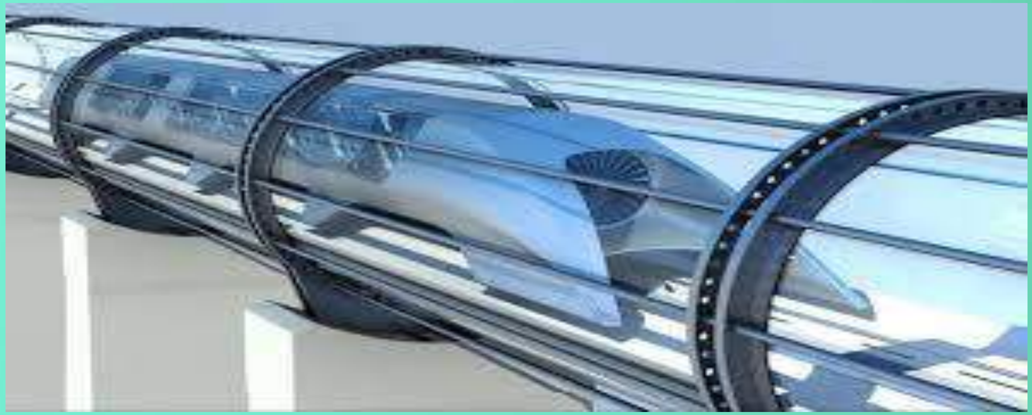
Comparison between Conventional trains & Maglev trains

FEATURE	CONVENTIONAL TRAIN	MAGLEV TRAIN
SPEED	Limited speed	High Speed
MAINTENANCE	High maintenance	Low maintenance
ALL WEATHER OPERATION	Effected by weather conditions.	Unaffected by snow, severe cold, rain or high winds.
EFFICIENCY	It affected by rolling resistance due to contact with track.	No rolling resistance due to lack of contact between track & vehicle. **High power efficiency**

SCOPE OF RESEARCH

ARMED FORCES PREPARATORY DEGREE COLLEGE FOR WOMEN

HYPERLOOP TRAINS



MAGLEV TRAINS

HYPERLOOP TRAINS: Vactrains

Hyperloop train is Maglev train placed in vacuum tube to eliminate air drag force.

ARMED FORCES PREPARATORY
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THANK YOU

Basic Computer Skills (BCS)

B.Sc, BA, B.COM
Semester –II
Noncore

K. SPANDANA
HOD, Department of Physics
TSWRAFPDCW, Bhongir

Syllabus

Paper AEC1 (a): BASIC COMPUTER SKILLS

Hours Per Week: 2 **Credits:** 2
Exam Hours: 1 ½ **Marks:** 40U+10I

Objective: *to impart a basic level understanding of working of a computer and its usage.*

UNIT I: UNDERSTANDING OF COMPUTER AND WORD PROCESSING:

Knowing computer: What is Computer, Basic Applications of Computer; Components of Computer System, Central Processing Unit (CPU), VDU, Keyboard and Mouse, Other input/output Devices, Computer Memory, Concepts of Hardware and Software; Concept of Computing, Data and Information; Applications of IECT; Connecting keyboard, mouse, monitor and printer to CPU and checking power supply.

Operating Computer using GUI Based Operating System: What is an Operating System; Basics of Popular Operating Systems; The User Interface, Using Mouse; Using right Button of the Mouse and Moving Icons on the screen, Use of Common Icons, Status Bar, Using Menu and Menu-selection, Running an Application, Viewing of File, Folders and Directories, Creating and Renaming of files and folders, Opening and closing of different Windows; Using help; Creating Short cuts, Basics of O.S Setup; Common utilities.

Understanding Word Processing: Word Processing Basics; Opening and Closing of documents; Text creation and Manipulation; Formatting of text; Table handling; Spell check, language setting and thesaurus; Printing of word document.

UNIT II: SPREAD SHEET, PRESENTATION SOFTWARE & INTRODUCTION TO INTERNET, WWW AND WEB BROWSERS:

Using Spread Sheet: Basics of Spreadsheet; Manipulation of cells; Formulas and Functions; Editing of Spread Sheet, printing of Spread Sheet.

Basics of presentation software: Creating Presentation; Preparation and Presentation of Slides; Slide Show; Taking printouts of presentation / handouts.

Introduction to Internet, WWW and Web Browsers:

Introduction to Internet: Basic of Computer networks; LAN, WAN; Concept of Internet; Applications of Internet; connecting to internet; What is ISP; Knowing the Internet; Basics of internet connectivity related troubleshooting.

World Wide Web: Search Engines; Understanding URL; Domain name; IP Address; Using e-governance website.

Web Browsing: Software, Communications and collaboration: Basics of electronic mail; Getting an email account; Sending and receiving emails; Accessing sent emails; Using Emails; Document collaboration; Instant Messaging; Netiquettes.

SUGGESTED READINGS:

1. Introduction to Computers, Peter Norton, Mc GrawHill , 2012.
2. Using Information Technology, Brian K williams, StaceyC.Sawyer, Tata Mc GrawHill.

Web Resources:

1. https://online.stanford.edu/courses/soe-ycscs101-sp-computer-science-101
2.https://www.extension.harvard.edu/open-learning-initiative/intensive-introduction- computer-science.

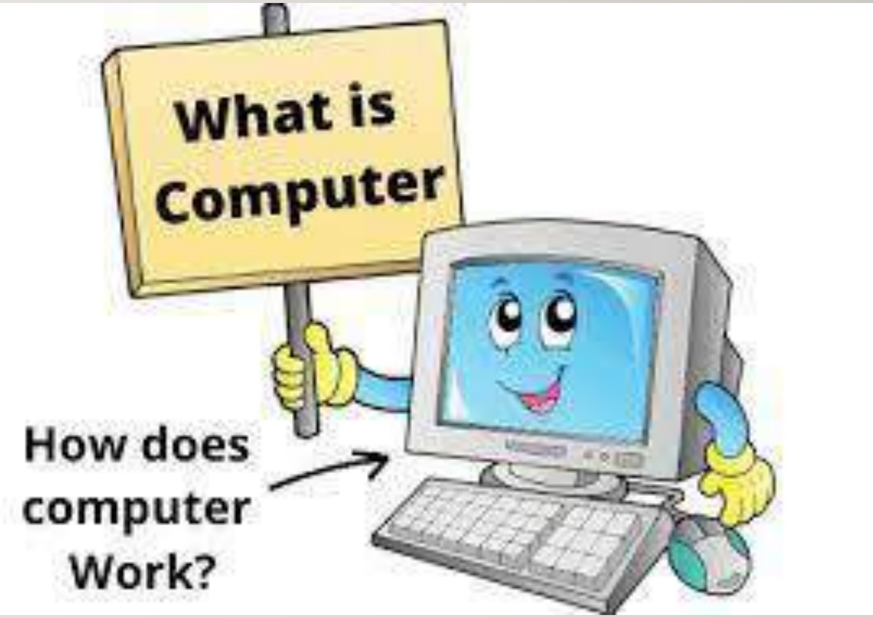
UNIT- I

Understanding Of Computer And Word Processing

Knowing about computer

What is computer?

Introduction: The term computer is derived from the Latin word compute, which means to calculate. A computer is a tool and partner in every sphere of human life and activity. Computers are bringing many changes in industry, government, education, medicine, scientific research, law, social service.

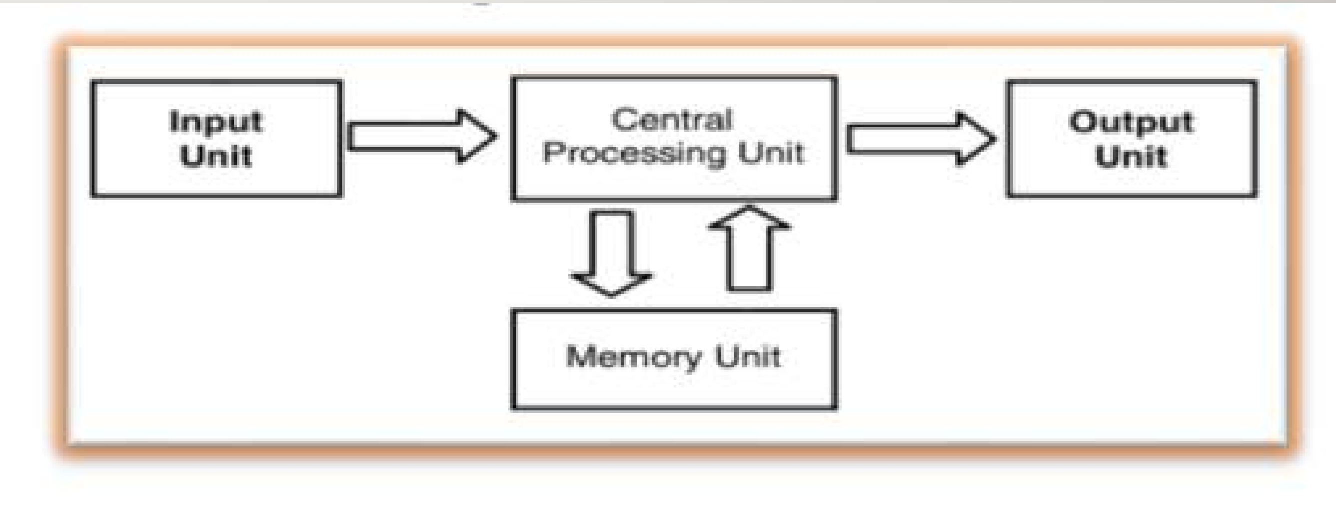


Definition: A Computer is an electronic device that processes data and converts it into information that is useful to people

Basic components of a computer system

The basic components of a computer can be classified into **four main units**:

1. Input Unit.
2. Central Processing Unit
3. Memory Unit
4. Output Unit



Input Devices

The devices that are used to enter data and instructions into the computer are known as Input devices.

It includes Keyboard, Mouse,
touchscreens,
Joysticks,
barcode readers,
scanners

Input Devices (Keyboard)

A keyboard is the primary input device.
It can be used to enter the text input.
A standard keyboard contains about 100 keys.
It contains Typing keys, numeric keypad, Control keys, function keys, cursor keys and special purpose keys.
The computer keyboard uses the QWERTY key arrangement.

Input devices (Mouse)

A Mouse is a graphical input device.
You can move the mouse around a surface and controls the pointer.
By using the mouse, you can perform:

I. Clicking
II. Double-Clicking
III. Dragging
IV. Right Clicking

Physical Mouse

Optical Mouse

There are two types of Mouse's:

1. Physical Mouse
2. Optical Mouse

Input devices

Touch Screen: A touch screen is a type of screen that allows you to input by touching its icons.

Joystick: A Joystick is a game controller. It is a swivelling lever. It is well suited for playing video games.

Scanner: A scanner is an input device. It can scan a document or an image into the computer's memory.

Input devices

Microphone: A Microphone enables you to input your voice or music as data. Microphones are useful for audio and video conferencing.

Barcode readers Barcode readers are one of the most widely used input devices. They can read the bar codes on the products.

Output Devices

he devices that can display the resulting information to the user are known as **Output devices.**

- ❖ Monitors
- ❖ Printers
- ❖ Speaker
- ❖ Headphone
- ❖ Projector

Monitors and Printers are commonly used output devices

Output Devices (Monitor)

Monitor is a commonly used output device.
It is also called as Visual Display Unit(VDU).
It provides a visual display of data.

Monitors are of different types:

1. CRT(Cathode Ray Tubes)
2. LCD(Liquid Crystal Display)
3. LED(Light Emitting Diode)

CRT

LCD

LED

Output Devices (Printer)

A Printer is an output device that prints text or images on paper.
Printers are useful to create 'hard copy' of data.

Printers are of two types:

1. Impact printers
2. Non-impact printers.

Impact printers: Impact printers can print by striking the paper. Example: Line printers, dot-matrix printers.

Non-impact printers: Non-impact printers do not strike the paper. Example: laser printers, inkjet printers.

Impact printer

Non -impact printer

Differences Between Impact and Non-Impact Printers

1. Impact Printers: Impact printers these Printers use an Electro-mechanical mechanism. An impact printer refers to all those printers whose printing heads touch the paper. His mechanism uses hammers or pins to strike against a ribbon and paper to print the text or image.

2. Non -Impact Printers: These printer uses ink and special electrical machines for producing outputs. Non – impact printers are all those printers whose printing heads do not touch paper. A non impact printer forms characters and image on a piece of paper without actually striking the paper.

S. N.	Features	Impact printers	Non-Impact printers
1	**Mechanism**	It produces print on paper by striking mechanism.	It produces print on paper with a non-striking mechanism . it uses Electro static or thermal mechanism.
2	**Working**	It uses pins, hammers or wheel to strike against an inked ribbon to print on a paper.	It uses laser, spray of special ink, or heat and pressure to print on paper.
3	**Color output**	impact printers has no color capacity	Non-Impact printers can print clear color, good for printing pictures
4	**Cost**	Impact printers are normally less expansive.	Non-Impact printers are more expansive.
5	**Graphics Image**	Except of dot matrix printer, these printers can not print graphics images	These printer can easily print graphical images
6	**Tools**	Impact printers use special inked ribbons to produce print on paper when print head strikes.	Non-Impact printers use toner or cartridge for printing on paper.
7	**Speed**	Impact printers are low speed printers.	Non-Impact printers are very fast. They can print many pages per minute.
8	**Sound effects or Noise**	Impact printers are high noise level because they strike print head.	Non-Impact printers do not make a noise level because they do not use striking mechanism in which print head strikes on ribbon and paper etc.
9	**Character style**	The character style can not be changed in the impact printer (except of dot matrix)	It can print different types of characters form busing the individual printer
10	**Copy print**	Impact printers can produce multiple copies of the text.	Non impact printers can produce only a single copy of the text
11	**Technology**	Impact printers use old printing technologies.	Non impact printers use latest printing technologies.
12	**Examples**	Dot matrix, Daisy wheel printers, Drum Printers and Chain Printers etc.	Laser printers, Inkjet printers and Thermal Printers etc.

Comparison Chart Between Impact & Non-Impact Printers

Output Devices

Plotters: Plotters are the output devices. They can print the data or images on a large sized papers.

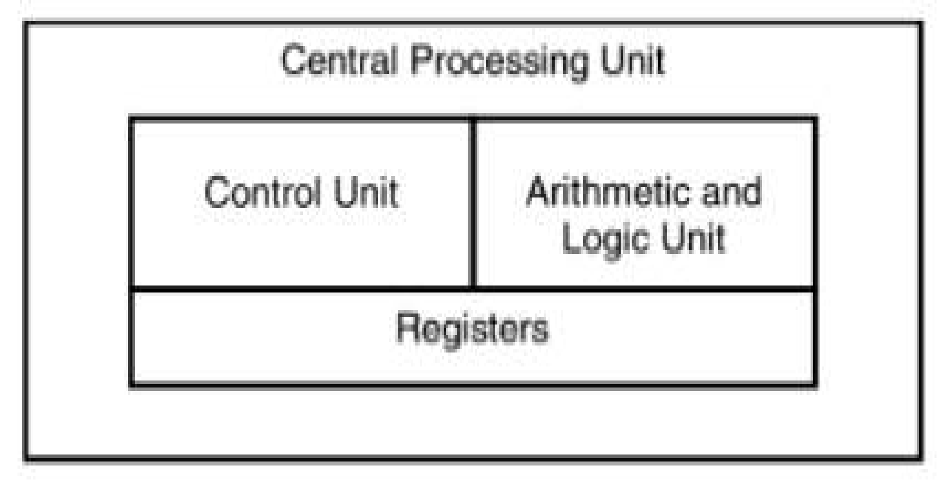
Speakers: Speakers are output devices that allow you to hear sound from your computer. Computer speakers are just like stereo speakers.

Plotters

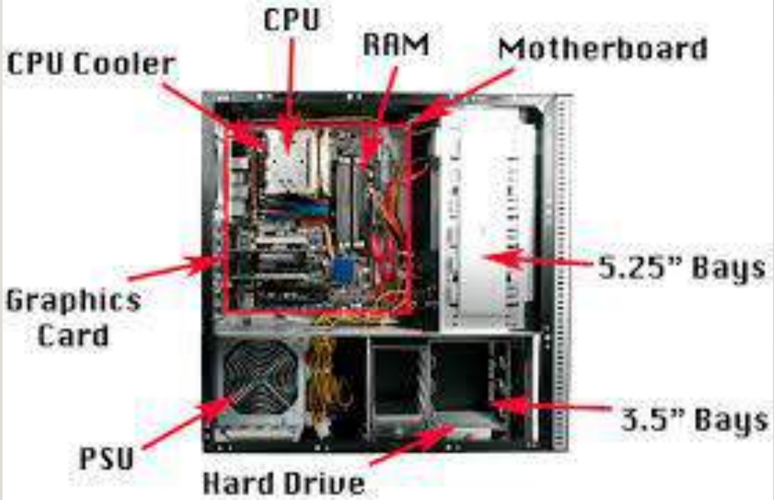

Speakers

Central Processing Unit (CPU)

CPU is the brain of any computer system.
It Coordinates all computer operations and Perform arithmetic and logical operations on data. The CPU consists of arithmetic and logic units, control unit and internal memory (registers).



- ❖ The Control unit controls all the operations.
- ❖ The arithmetic and logic units performs addition, subtraction, division and multiplication and some logical operations.



Memory Unit

The electronic storage are of a computer is known as Memory.
Memory is useful to hold / store data and the instructions.

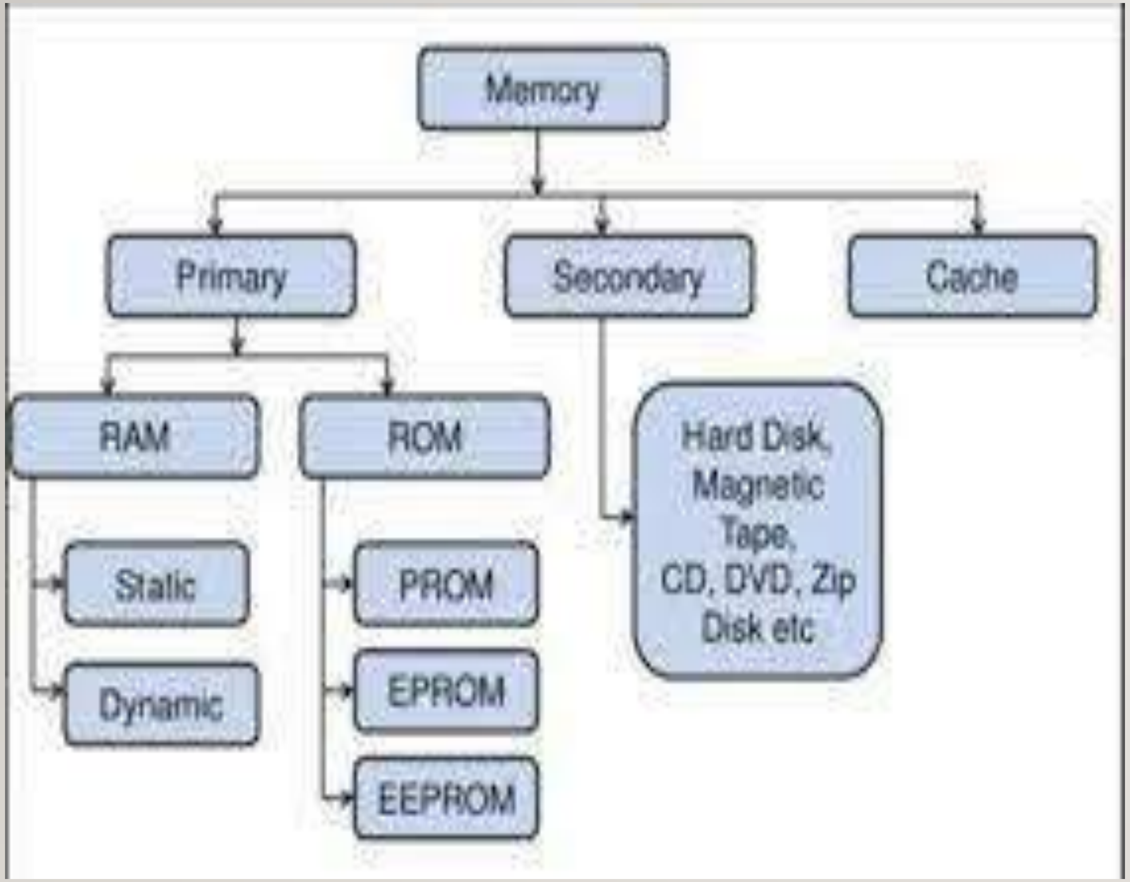
Computers memory is of two types:

Primary Memory (or)Main Memory
Secondary Memory

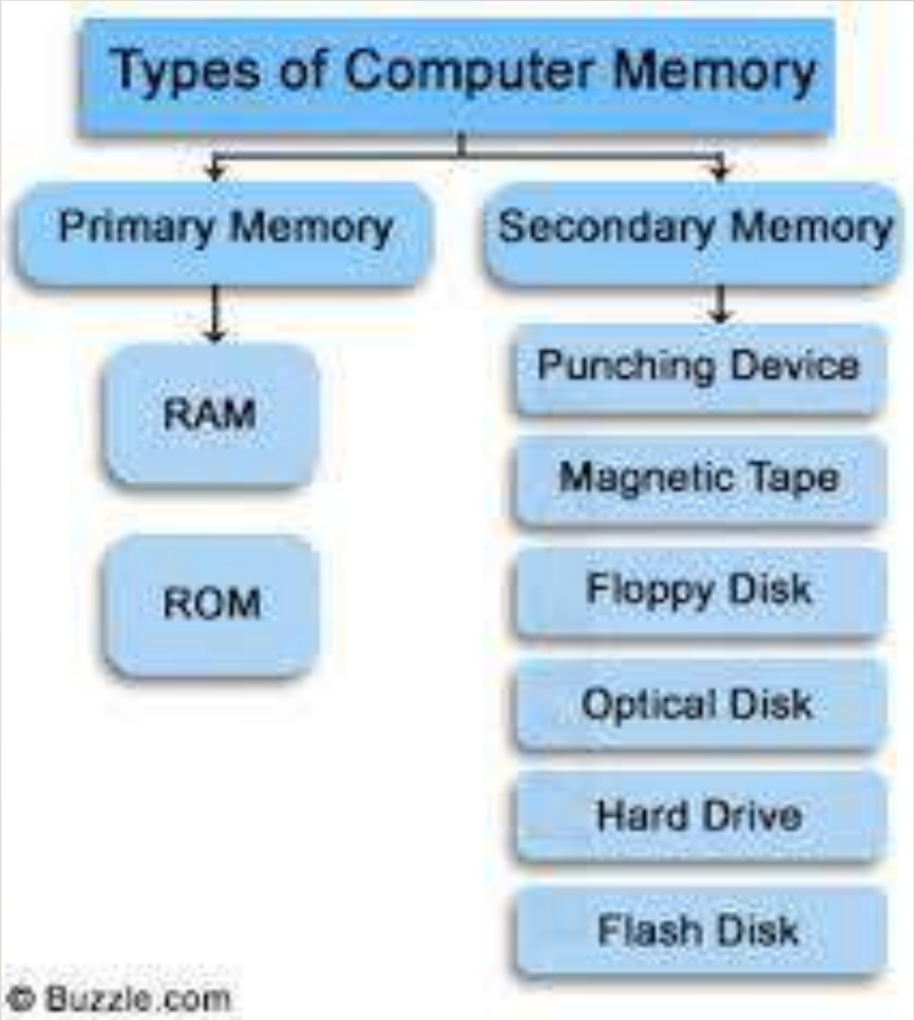
Main memory stores the programs and data that are currently being used by the computer.
It holds data and programs temporarily.

Secondary memory stores the data permanently.
It is also known as auxiliary memory. It is much less expensive.

Memory Unit



Memory
Primary
Secondary
Cache
RAM
ROM
Static
Dynamic
PROM
EPROM
EEPROM
Hard Disk, Magnetic Tape, CD, DVD, Zip Disk etc



Types of Computer Memory
Primary Memory
Secondary Memory
RAM
ROM
Punching Device
Magnetic Tape
Floppy Disk
Optical Disk
Hard Drive
Flash Disk
© Buzzle.com

Primary Memory

Primary Memory is also called as main memory.
There are different types of memory.

I. Random Access Memory (RAM)
II. Read Only Memory (ROM)

RAM	ROM
1. Temporary Storage.	1. Permanent storage.
2. Store data in MBs.	2. Store data in GBs.
3. Volatile.	3. Non-volatile.
4.Used in normal operations.	4. Used for startup process of computer.
5. Writing data is faster.	5. Writing data is slower.

Difference between RAM and ROM

RAM

ROM

Random Access Memory (RAM)

RAM is the main memory for a computer.

- ❖ RAM can be used for both reading and writing.
- ❖ When we switch off a computer, then the data on RAM will be erased.
- ❖ It is a volatile memory.

TYPES OF RAM:

There are two types of RAM:

1) Dynamic RAM 2) Static RAM.

Dynamic RAM (DRAM): Its data has to be refreshed after every few milliseconds. DRAM has higher storage capacity. It is cheaper than Static RAM.

Static RAM (SRAM): Its data need not be refreshed. SRAM has higher speed. It is costlier.

Read Only Memory (ROM)

ROM is computer's internal memory.

- ❖ It contains some pre-loaded programs.
- ❖ The programs on ROM are helpful for booting.

There are different types of RAM: 1. PROM 2. EPROM 3. EEPROM

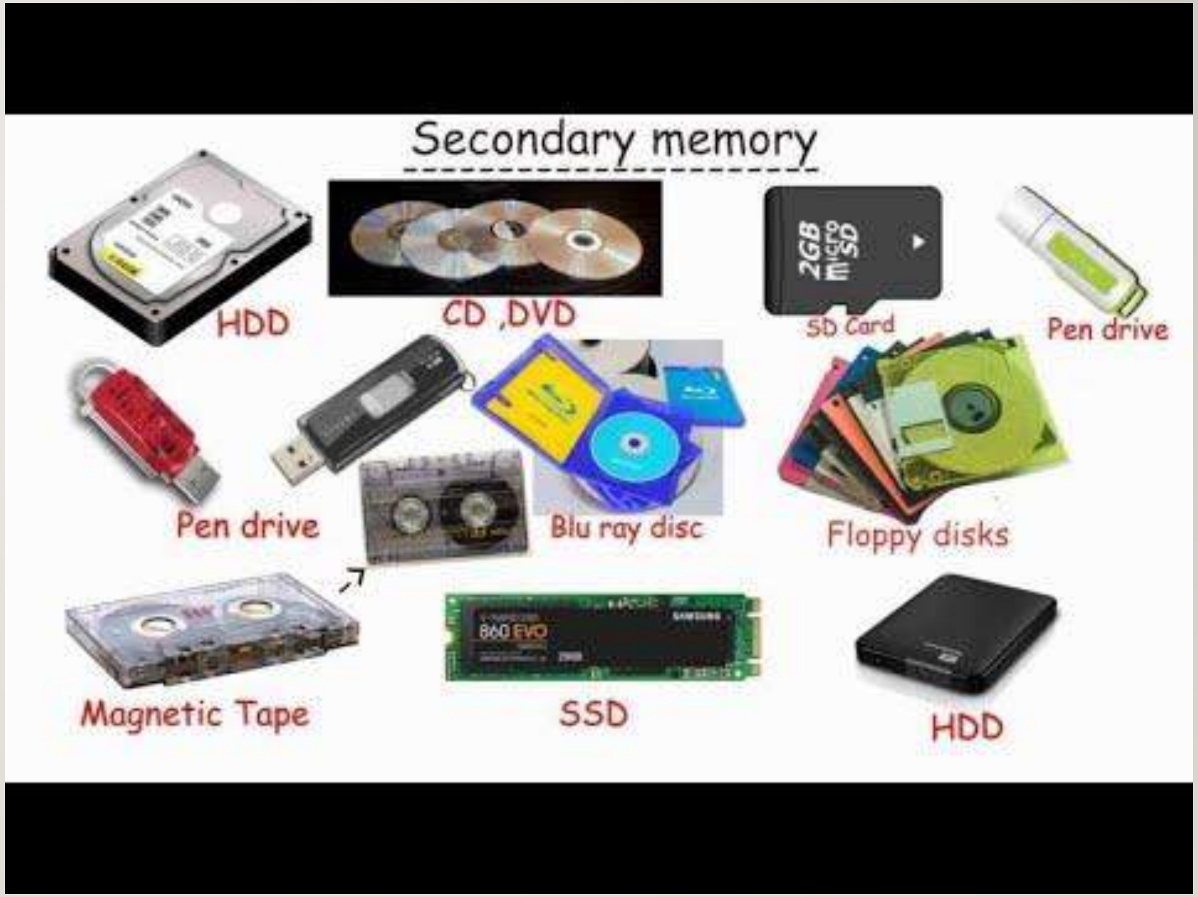
PROM: It is a Programmable Read Only Memory. PROM allows us to write our own BIOS (Basic Input Output System) programs. But these programs can be written only once.

EPROM: It is Erasable Programmable Read Only Memory. EPROM allows us to write our own BIOS programs. These programs can be erased by using an ultraviolet light.

EEPROM: It is an Electrically Erasable Programmable Read Only Memory. EEPROM allows us to write our own BIOS programs. It can be erased by exposing it to an electrical voltage.

Secondary Memory/Storage devices

Secondary memory is a large, non-volatile memory.
It stores the data and instructions permanently.
Some of the commonly used secondary storage devices are **hard disks, magnetic tapes, floppy disks and CDROM.**



Secondary Memory (Hard Disk)

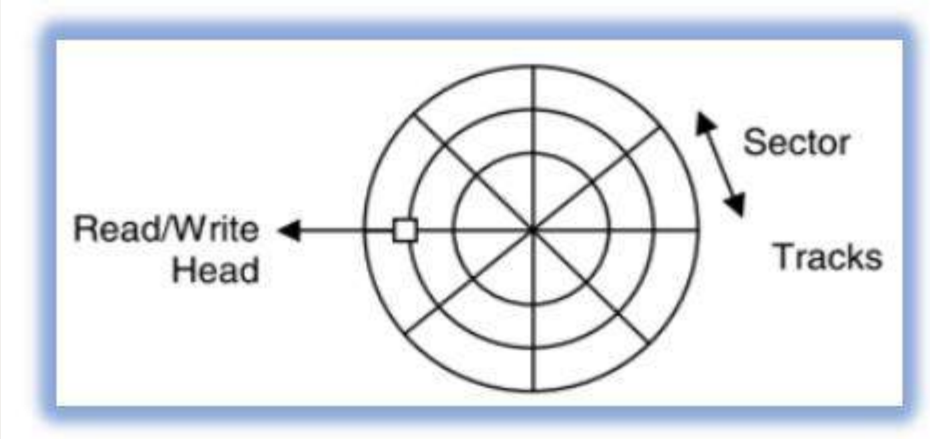
Hard Disk: Hard disk is a magnetic disk. It can store computer data and instructions.

It is a direct-access storage medium.

A hard disk contains some Tracks and Sectors to store the data.

The arrangement of tracks and sectors on a disk is known as its 'format'.

Now a days the hard disk in a PC has nearly 1 Tera Byte capacity.



Secondary Memory

Magnetic Tape: A magnetic tape is a thin tape with a coating of magnetic strip. It is used for recording the data.
Magnetic tape is a serial access medium. Magnetic tapes are generally used for backup.

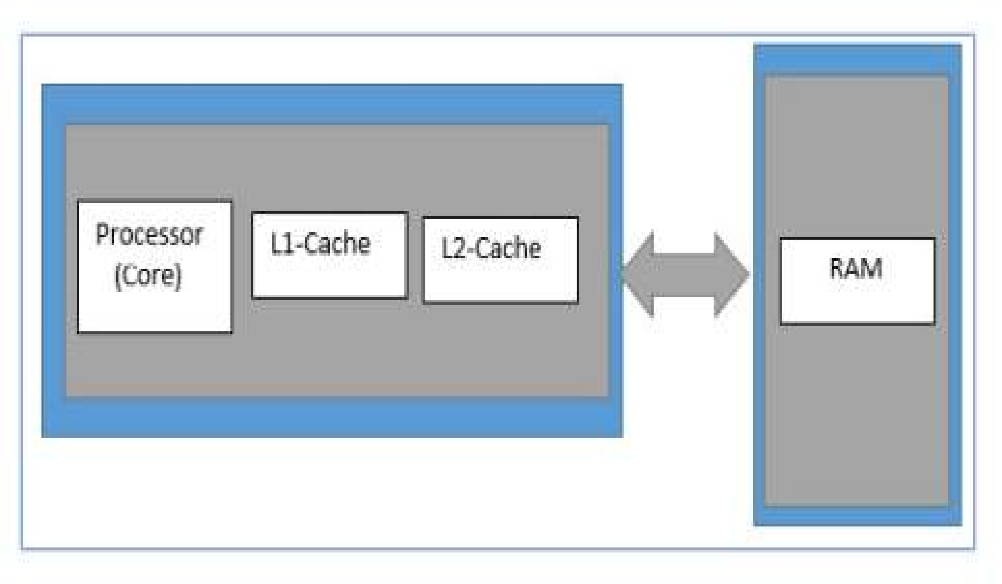
Floppy Disk: A Floppy disk is a thin circular disk used for data storage. It is a soft magnetic disk that can be enclosed in a protective sheet. It contains tracks and sectors. A floppy has 3.5" in size. Some floppy disks would be 5.25" in size. A 3.5" floppy disk can hold 1.44 MB of data.

Compact Disk: Compact disk is a secondary memory device that can be written by lasers. It is a random access storage medium. It is also known as read/write CD-ROM. It is a popular and cheap method for storage.

CACHE Memory

A Cache is a fast responding, small memory chip attached between CPU and Main memory.

1. CACHE memories are accessed faster than RAM.
2. It is used to store programs currently using by the CPU.
3. So cache memory makes main memory to work faster.
4. A Cache is available in limited capacity (in Kilo Bytes)



CACHE is of 3 Types:

- Level-1 Cache
- Level-2 Cache
- Level-3 Cache

REGISTERS

Registers are the high speed storage areas within a CPU. They are also called as **CPU's Working Memory**. They are useful to the CPU during the execution of the instructions.

There are different types of registers:

Accumulator (ACC): It can store the results of arithmetic and logical operations

Instruction Register (IR): It contains the current instruction.

Program Counter (PC): It contains the address of the next instruction.

Memory Address Register (MAR): It contains the address of the next location in memory.

Memory Buffer Register (MBR): It temporarily stores the data from memory.

Data Register (DR): It stores the Operands and other data.

Operating systems (OS)

Operating System (OS) is system software.
A program that acts as an intermediary between a user of a computer and the computer hardware.
A set of programs that coordinates all activities among computer hardware resources.

Objectives of OS: OS has two main objectives:
(1) To make the computer system convenient and easy to use.
(2) To use the computer hardware in an efficient way.

Examples of OS:
Microsoft Disk Operating System (MS-DOS),
Windows XP, Windows 7, Windows 8, Windows 10,
UNIX, Linux, Mac, Android

Functions of OS

1. Process Management
2. Memory Management
3. File Management
4. Device Management
5. Protection and Security
6. User interface

Process management

A process is a unit of work.
A process can be created, executed and stopped by the operating system. A process may have 5 states:

I. New State
II. Ready State
III. Running State
IV. Waiting State
V. Terminated State

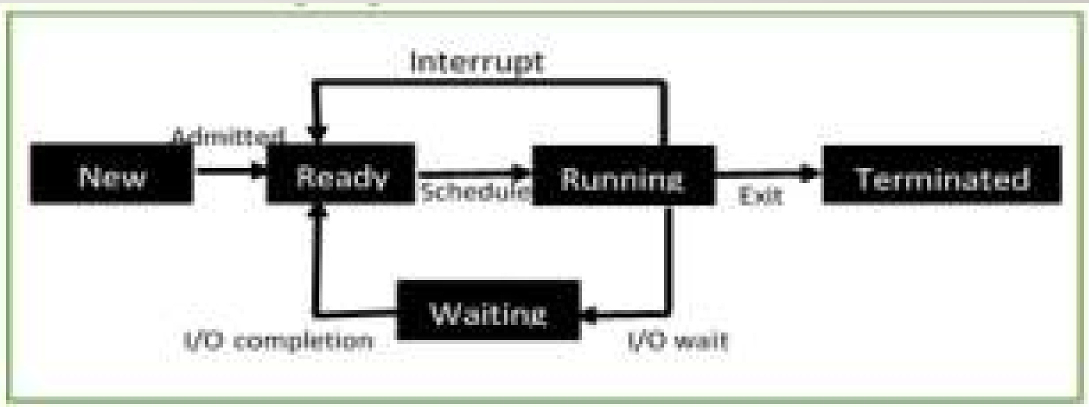


Figure: Five State Process Model

Functions of OS

Memory Management: Every process requires some memory.
OS performs the memory management functions like:
I. Allocate memory II. Free memory
III. Re-allocate memory IV. Maintaining the memory usage details.

File Management: A file is a collection of related information. OS manages a collection of files and directories. It can create and delete files.

Device Management: OS controls and manages the devices connected to the computer. It can communicate with the devices by using device driver software.

Protection and Security: OS protects the resources of the system. It provides the basic protection like user authentication, encryption, backup, etc.

User interface: OS provides an interface between the user and computer. It allows the user to interact with the application and the hardware.

Types of Operating Systems

OS are of the following types:

1. Single User -Single Tasking Operating Systems
2. Single User -Multitasking Operating Systems
3. Multi User Operating Systems
4. Multiprocessing Operating Systems
5. Real time Operating Systems
6. Embedded Operating Systems

Word Processing

The process of using a computer to create, edit, format and print documents is known as Word Processing.

To perform word processing, a computer, a special program called a word processor and a printer are required.

A word processor is an application program that enables the user to create a document, format it, store it, display it and print it on a printer.

- Microsoft Word is the most widely used word processing software.
- WordPerfect and open Office Writer, Libre Office Writer are some other word processers.
- Office Web Apps or Google Docs are the Web-based word processors.

Microsoft Word 2013 is a word-processer that is used to create professional-looking documents such as reports, resumes, letters, memos, and newsletters.

- Word processors have a variety of uses in the business, home, and education.
- In Business word processing is used for:
- * Letters and letterhead * Memos *Documents.
- In the home word processing is used as educational, planning, dealing with assignments.
- Examples: * letter writing * résumé/CV creation.
- In education word processing is used the production of assignments, notes, exams, and for practicing its uses!

Microsoft Word

Microsoft Word 2013 is a word-processing program that is used to create professional-looking documents such as reports, resumes, letters, memos, and newsletters.

Features of word processing: Word processors/Microsoft Word has the following features:

1. **Text Manipulation**: It allows us to change the appearance of a document by changing words, sentences and paragraphs.
2. **Document Formatting:** It allows us to format the documents. Formatting improves the readability of documents.
3. **Graphics:** It allows us to insert Pictures or graphics in a document.
4. **Tabs:** It allows us to setup the text on a page in the exact position.
5. **Tables:** It allows us to insert tables in a document. The data in a table can be sorted, formatted, etc.
6. **Mail Merge:** Mail merge allows the user to merge a list of names and addresses to a single letter that can be sent it to different people.
7. **Spell Checking**: It allows the user to check the words for correct spelling.

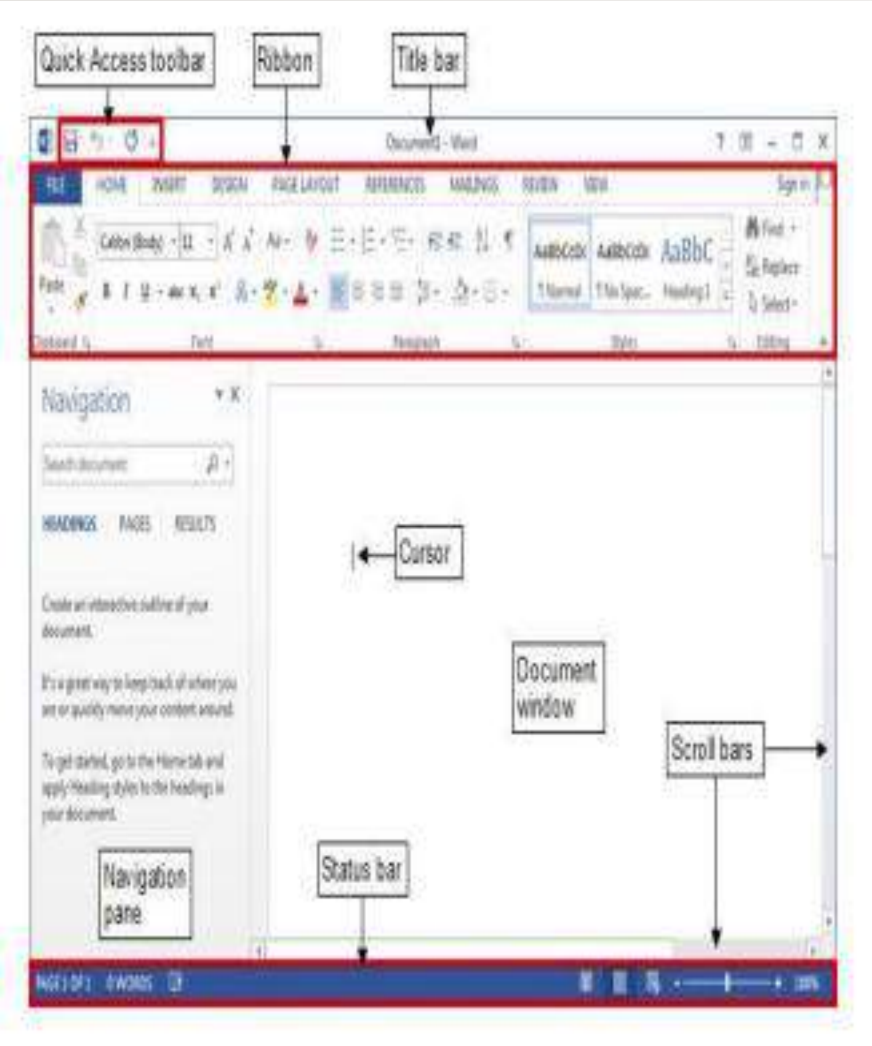
Collaborative Editing: It allows two people to simultaneously work on one document as a team.

Starting Word

You can start Word 2013 from the Start menu.
→To start Word 2013 from the Start menu:

1. Click the Start button → All Programs→ Microsoft Office 2013→Word 2013.
   It shows the Start screen.
2. In the right pane, click Blank document.
   It opens a new, blank document.

Parts of a MS-WORD window



Menus and Tool bars: The old menu system has been replaced by the Ribbon and the Office button in the latest versions of Word.

Title bar: It appears at the top of the window. It displays the title of the document. It also shows the buttons to minimize, restore,/maximize, and close the window.

Quick Access toolbar: It appears on the left side of the Title bar and contains frequently used commands.

Ribbon: It appears below the Title bar. It consists of a set of tabs with related commands/Menus.

Navigation pane: It appears on the left side of the window. It enables you to navigate long documents, search for specific text.

Document window: It displays the contents of the document.

Cursor: It is a blinking pointer that indicates where the text will be inserted.

Scroll bars: It enable you to scroll through the document.

Status bar: It appears at the bottom of the window. It displays information about the document

Creating Documents

An MS-Word document can be created by using the following procedure:

1. Select and Click on Word 2013
2. Select Blank document

- It opens a new document for you to enter your content.

3. You can also create a new document by pressing CTRL + N keys.

Saving Documents

After creating a document, you can save it.

To save a new document:

1. Click on the File tab
2. Then, click on Save As→ It opens the Save As page window.

Select a location to save the file

4. Type a File name.
5. Click the Save button.

NOTE: 1.Word 2013's file format is called Word Document. This format has the .docx file extension.
2.You can also save a document in the Word 97-2003 format with the .doc file. This format works with earlier versions of Word.

Closing Documents

You can close a document after finishing working on it.
To close a document:
1. Click the File tab
2. Then click Close.
3. Or, press Ctrl+W.

Opening Documents

You can locate and open an existing document.
To open a document:
1. Click the File tab
2. Then click Open. Or, press Ctrl+O.
• It opens a list of recently used documents.
3. Locate your document and then click the Open button.

Previewing and Printing Documents

To preview and print a document:
1. Click the File tab
2. Then click Print. Or, press Ctrl+P.
• It displays print settings
3. Change the print settings as you like.
To print the document, click the Print button.

Editing Documents

Most documents require some editing. You may perform basic tasks such as selecting, deleting, copying, and moving text, and undoing and redoing changes.

Selecting Text

To select text:

1. To select a word, double-click anywhere in the word.
2. To select a sentence, hold down the Ctrl key and click anywhere in the sentence.
3. To select a paragraph, triple-click anywhere in the paragraph
4. To select the entire document press Ctrl+A.

Deleting Text

To delete text: Select the text that you want to delete, and then press the Delete key.

Moving and Copying Text

You can copy or move the text into a location.

To move or copy text:

1. Select the text that you want to move or copy.
2. Select Home tab and do one of the following:
    - To move text, click the Cut button. Or, press Ctrl+X.
    - To copy text, click the Copy button. Or, press Ctrl+C.
3. Place the cursor in the required position.
4. Then, Click the Paste button. Or, press Ctrl+V.

Undoing and Redoing Changes

Whenever you make a mistake, you can easily reverse it with the Undo command.

The Redo command allows you to restore the undone actions.

To undo an action: Click the Undo button. Or, press Ctrl+Z.

To redo an action: Click the Redo button. Or, press Ctrl+Y

Formatting Documents

Formatting is a feature that enhances the appearance of a document. Text formatting includes font, font size, font color, and etc.

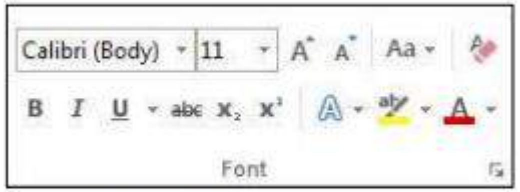


Figure: Font group

Changing the Font and Font Size and color

A font defines the style of text lettering. The default font in Word 2013 documents is Calibri and the default font size is 11 points.

To change the font:

1. Select the text that you want to format.
2. Click the Font arrow and select the desired font from the list.

To change the font size:

1. Select the text that you want to format.
2. Click the Font Size arrow and select a font size from the list.

To change the font color:

1. Select the text that you want to format.
2. Click the Font Color arrow and select a color.

Different formatting features in MS-Word Word 2013 has a number of features to format a document. The following are some formatting features:

Name	Description
B Bold	Makes the selected text bold (**example**).
I Italic	Italicizes the selected text (*example*).
U Underline	Draws a line under the selected text (<u>example</u>).
abc Strikethrough	Draws a line through the middle of the selected text (~~example~~).

Name	Description
x_2 Subscript	Creates small letters below the text baseline (example).
x^2 Superscript	Creates small letters above the line of text (example).
A Text Effects.	Applies a visual effect (such as a shadow, glow, or reflection) to the selected text.
Aa Change Case	Changes the selected text to uppercase, lowercase.

Formatting Paragraphs

Paragraph formatting is the layout of a paragraph on the page. You can change a paragraph alignment, line spacing, and the space before and after it.

Changing Paragraph Alignment Paragraph alignment refers to the position of a paragraph between the left and right margins

Name	Description
Align Left	Aligns the text at the left margin. This is the default alignment.
Center	Centers the text between the left and right margins.
Align Right	Aligns the text at the right margin.
Justify	Aligns the text at both the left and right margins.

To change the alignment of a paragraph:

1. Select the paragraph that you want to align.
2. On the Home tab, in the Paragraph group, click the desired alignment button.

Headers and Footers

Headers and footers are the areas in the top and bottom margins of each page.

- You can insert text or graphics in headers and footers.
- For example, you can add the document title, page numbers, the author's name, or a logo.
- A header and footer appears on every page.

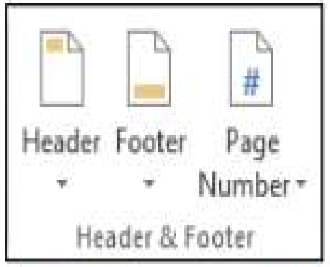


Figure: Header and Footer group

To insert a header or footer:

1. Click Insert tab
2. Then select the Header & Footer group and click on the Header or Footer button. Then it opens the header and footer area in the document.
3. Type the required text in the header area.
4. Type the required text in the footer area.
5. Apply the required Formatting features to the header and footer.
6. After finishing, Click on Close header and footer.

Inserting Page Numbers:

Page numbers are the most common type of header or footer.

To insert page numbers:

1. Click Insert tab
2. Then select the Header & Footer group and click on the Header or Footer button.
   - Then it opens the header and footer area in the document.
3. Select Insert Page Number arrow.
4. Click on the required style. • It will insert the page numbers at the specified position.
5. After finishing, Click on Close header and footer

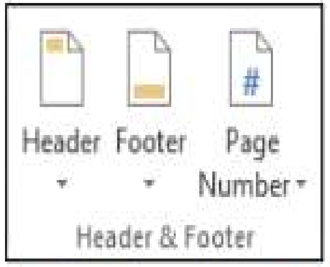
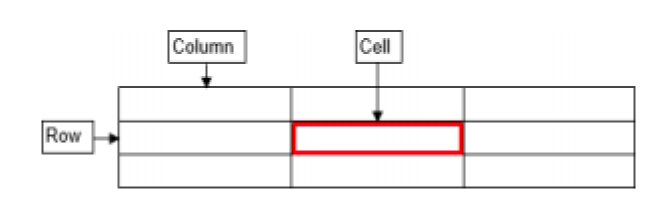


Figure: Header and Footer group

Working with Tables

Tables are commonly used to organize and present data. A table is made up of horizontal rows and vertical columns. Inserting Tables Word 2013 makes it quick and easy to insert a tab.



Inserting Tables

Word 2013 makes it quick and easy to insert a table into a document.

To insert a table:

1. Click in the document where you want to insert the table.
2. Select the Insert tab
3. Select the Tables group and click the Table button
4. Select the desired numbers of rows and columns.
5. It will insert the table.

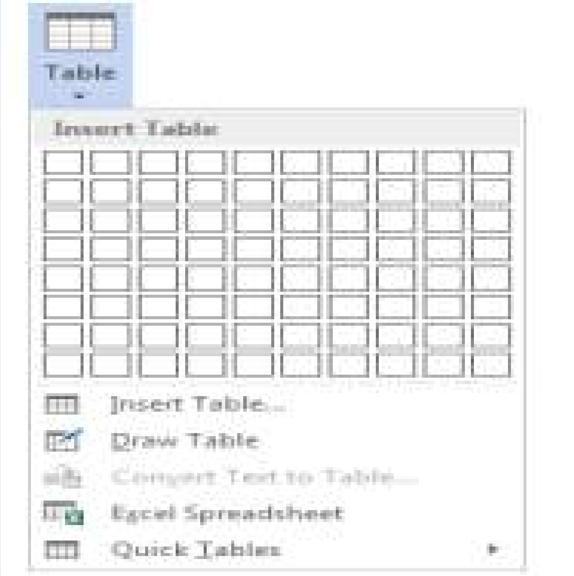


Figure: Table menu

Working with Images

Images can add visual interest to documents. Word 2013 allows you to insert images of .gif, .jpg, .png, .bmp, etc. into a document.

To insert an image:

1. Click in the document where you want to insert the image.
2. On the Insert tab, click on the Pictures button .
3. It will display an Insert Picture dialog box,
4. Locate and select the desired image and then click the Insert button.

Mail Merge

The mail merge is a process that combines a document with a data source to produce personalized documents.

Document contains the text and graphics. Data source contains the addresses of the recipients.

The mail merge process in Word 2013 has the following steps:

- ☐ Select the document type and main document.
- ☐ Connect the main document to a data source and define the recipients list.
- ☐ Add merge fields to the main document.
- ☐ Preview the results and complete the merge.

To perform mail merge:

1. Create a new blank document and type your letter.
2. Select Mailings tab and click on Start Mail Merge button.
3. Then click Step-by-Step Mail Merge Wizard.
4. It displays the Mail Merge pane. It has the following 6 steps:

Mail Merge

Step 1 of 6: Select document type and select the Letters option.
Step 2 of 6: Select starting document and select the Use the current document option.
Step 3 of 6: Select recipients, select Type a new list option and then click the Create link.

- Type the information of the recipients and save it.
- Click the Next link.

Step 4 of 6:
click in the document and insert a merge field.
Step 5 of 6:
Click Preview your letters, click the Next button
Step 6 of 6:
Select Merge and click on Print.

The following figure shows mail merge process:

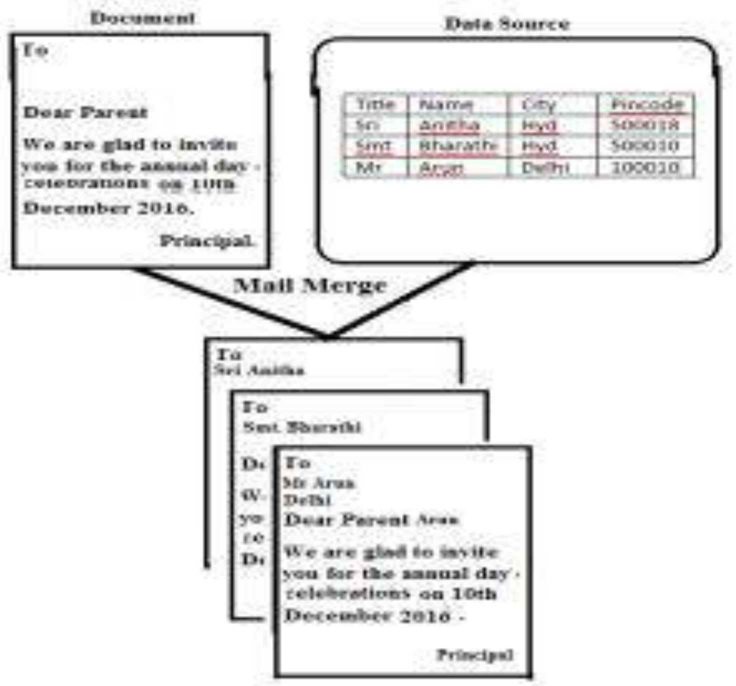


Figure: **Mail merge Process**

Macro

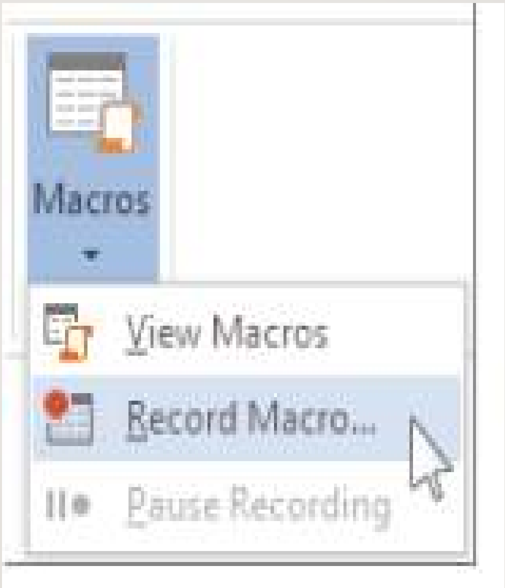
Definition: A macro is a series of actions.
You can use it to automate a repeated task. So that you can run the macro when you have to perform that task. It saves time for us.

Creating/Recording a Macro:

The following are the steps to record a macro:

1. Click View > Macros > Record Macro.
2. Type a name for the macro.
3. To assign your macro to a button, click Button.
4. Select new macro and click Add.
5. Click Modify.
6. Choose a button image, type the name you want, and click OK twice.
7. Now record the steps.
8. To stop recording, click View > Macros > Stop Recording.

- The button for your macro appears on the Quick Access Toolbar.



Run a macro

You can run a macro by:

- Clicking the button on the Quick Access Toolbar
- Pressing the keyboard shortcut.
- Run the macro from the Macros list.

Steps to run a macro:

1. Click View > Macros > View Macros.
2. Select your Macro name from the list.
3. Click Run.

Disadvantages of Macros:

Some macros can give security problems. Sometimes hackers can introduce a destructive macro in a file that can spread a virus on your computer.