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SCHOOL EDUCATION DEPARTMENT
VELLORE DISTRICT

+2 PHYSICS (EM)

LEARNING MATERIAL
(2024 - 2025)

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+2 PHYSICS LEARNING MATERIAL (2024 - 2025)

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CONTENTS

UNIT 1. ELECTROSTATICS

2 MARK - QUESTIONS AND ANSWERS :

1. State coulomb"s law in electrostatics. Give its vector form

- The electrostatic force is directly proportional to the product of the magnitude of the two point charges and is inversely proportional to the square of the distance between them. (i.e)

$$\vec{F} = K \frac{q_1 q_2}{r^2} \hat{r}$$

2. What is meant by quantisation of charges?

- The charge 'q' of any object is equal to an integral multiple of this fundamental unit of charge 'e' (i.e) $q = ne$

3. State Gauss law in electrostatics.

- The total electric flux through a closed surface $\Phi_E = \frac{Q}{\epsilon_0}$ Here Q is the net charge enclosed by the surface and ϵ_0 is the permittivity of free space.

4. What is an electric dipole? Give few examples.

- Two equal and opposite charges separated by a small distance constitute an electric dipole. **Examples :** Water **(H_2O)**, ammonia **(NH_3)**, **HCl** and **CO.**

5. What is the general definition of electric dipole moment? Give its unit.

- The magnitude of the electric dipole moment is equal to the product of the magnitude of one of the charges and the distance between them. (i.e) p = **q x 2a**
- Its unit is ***coulomb meter*** **(C m).**

6. Define "Electrostatic potential". Give its unit.

- The electrostatic potential at a point is equal to the work done by an external force to bring a unit positive charge with constant velocity from infinity to that point in the region of the external electric field.
- Its unit is ***volt*** **(V).**

7. What is an Equipotential Surface?

- An equipotential surface is a surface on which all the points are at the same electric potential.

8. Define Electrostatic potential energy . Give its unit.

- Electrostatic potential energy for system of charges is equal to the work done to arrange the charges in the given configuration.
- Its unit is ***joule*** **(J).**

9. Define electric field. Give its unit.

- The electric field at a point is defined as the force experienced by a unit charge placed at that point. $\vec{E} = \frac{\vec{F}}{q_0}$ Its unit is NC^{-1} (or) $V m^{-1}$

10. Define Electric flux. Give its unit.

- The number of electric field lines crossing a given area kept normal to the electric field lines is called electric flux. $\phi_E = \int \vec{E} . \vec{dA}$
- Its unit is Nm^2C^{-1}

11. What are non polar molecules? Give examples

- A non polar molecule is one in which the centers of the positive and negative charges coincide.
- It has no permanent dipole moment. **Examples : O_2, H_2, CO_2.**

12. What are polar molecules ? Give examples.

- A polar molecule is one in which the centers of the positive and the negative charges are separated. They have a permanent dipole moment. **Examples: N_2O, H_2O, HCl, NH_3.**

13. What is corona discharge (or) action at points ?

- Leakage of electric charges from the sharp edge of the charged conductor is called corona discharge or action at points.

14. Define capacitance of a capacitor. Give its unit.

- The capacitance C of a capacitor is defined as the ratio of the magnitude of charge on either of the conductor plates to the potential difference existing between them . (i.e) $C = \frac{Q}{V}$
- Its unit is ***farad*** **(F)** or **C V $^{-1}$**

15. Why is it safer to be inside a car than standing under a tree during lightning?

- The metal body of the car provides electrostatic shielding, since the electric field inside is zero.
- During lightning the electric discharge passes through the body of the car.

16. The electric field lines never intersect. Justify.

- If two lines cross at a point, then there will be two different electric field vectors at the same point.
- If some charge is placed at the intersection point, then it has to move in two different directions at the same time, which is physically impossible. Hence electric field lines do not intersect.

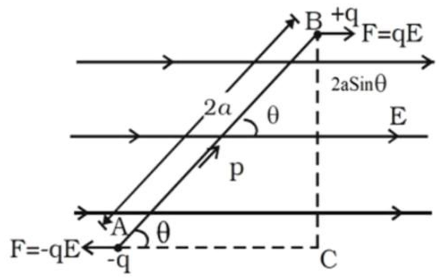
17. What is dielectric strength?

- The maximum electric field the dielectric can withstand before it breakdowns is called dielectric strength.
- The dielectric strength of air is $3 \times 10^{6}\ V m^{-1}$.

3 MARK - QUESTIONS AND ANSWERS :

1. Derive an expression for torque experienced by an electric dipole placed in the uniform electric field.

- Consider an electric dipole AB placed in an uniform electric field E at an angle θ.
- The force on **+q = qE** ; The force on **-q = − qE.**
- Due to these two forces the dipole experiences a torque.
- **Torque (τ) = qE x 2a sinθ**
- Since **(p = 2qa)** $\tau = pE \sin\theta$.
- In vector notation, $\vec{\tau} = \vec{p} \times \vec{E}$



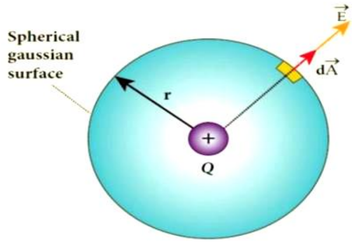
2. Obtain an expression for electric potential at a point due to a point charge.

- Consider a point charge $+q$ at origin. 'P' be a point at a distance 'r' from
- Electric potential at P, $V = -\int_{\infty}^{r} \vec{E} \cdot \vec{dr}$
- By definition, at P the electric field,
- $\vec{E} = \frac{1}{4\pi\varepsilon_0} \frac{q}{r^2} \hat{r}$
- $V = -\int_{\infty}^{r} \frac{1}{4\pi\varepsilon_0} \frac{q}{r^2} \hat{r} \cdot \vec{dr}$
- $V = \frac{q}{4\pi\varepsilon_0 r}$

3. Obtain Gauss's law from Coulomb's law.

- A positive point charge Q is surrounded by an imaginary sphere of radius r. Then the total electric flux through the closed surface of the sphere.
- $\phi_E = \oint \vec{E} . \vec{dA} \cos\theta = \oint E\, dA$ ------(1) (Here $\theta = 0$ then $\cos 0 = 1$)
- E is uniform on the surface of the sphere

  $\phi_E = E\oint dA$ ------------------(2)



- Substitute $E = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$; $\oint \vec{dA} = 4\pi r^2$

  $\phi_E = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2} \times 4\pi r^2 = \frac{Q}{\varepsilon_0}$
- $\phi_E = \frac{Q}{\varepsilon_0}$ This is Gauss's law. So we can able to derive Gauss's law from Coulomb's law.

4. Derive an expression for energy stored in capacitor .

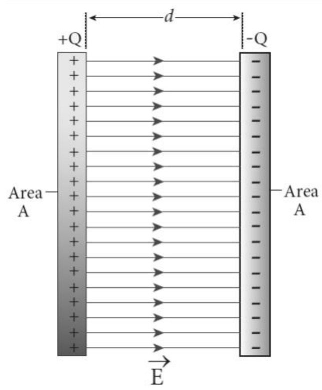
- The work done to transfer $'dQ'$ amount of charge

  $dW = V\, dQ = \frac{Q}{C}\, dQ$ ($V = \frac{Q}{C}$)
- The total work done to charge a capacitor,

  $W = \int_0^Q \frac{Q}{C}\, dQ = \frac{Q^2}{2C}$
- This work done is stored as electrostatic energy of the capacitor,

  $U = \frac{Q^2}{2C}$ (or) $U = \frac{1}{2} CV^2$

5. Derive an expression for capacitance of parallel plate capacitor.



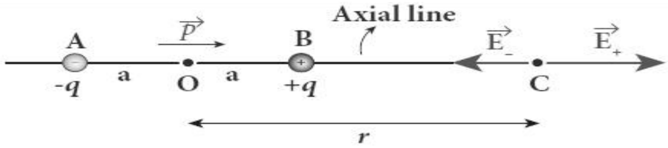
- Consider a capacitor consisting of two parallel plates each of area 'A' separated by a distance 'd'.
- Let 'σ' be the surface charge density of the plates $\sigma = \frac{Q}{A}$
- The electric field between the plates $E = \frac{\sigma}{\varepsilon_0} = \frac{Q}{A\varepsilon_0}$
- The potential difference between the plates $V = E\, d = \frac{Q}{A\varepsilon_0}\, d$
- The capacitance of the capacitor $C = \frac{Q}{V}$; $C = \frac{\varepsilon_0 A}{d}$

<u>5 MARK - QUESTIONS AND ANSWERS :</u>

1. Calculate the electric field due to a dipole on its axial line.

- AB – dipole, O – it's midpoint, C – a point on axial line AB= 2a, OC = r
- Electric field at C due to **+q**,

  $\vec{E_+} = \frac{1}{4\pi\varepsilon_0}\frac{q}{(r-a)^2}\hat{p}$



- Electric field at C due to $-q$,

  $\vec{E_-} = -\frac{1}{4\pi\varepsilon_0}\frac{q}{(r+a)^2}\hat{p}$
- The total electric field at 'C' due to dipole is

  $\vec{E_{tot}} = \vec{E_+} + \vec{E_-}$

  $\vec{E_{tot}} = \frac{q}{4\pi\varepsilon_0}\left[\frac{1}{(r-a)^2} - \frac{q}{(r+a)^2}\right]\hat{p}$

  $\vec{E_{tot}} = \frac{q}{4\pi\varepsilon_0}\left[\frac{(r+a)^2-(r-a)^2}{(r-a)^2\,(r+a)^2}\right]\hat{p}$

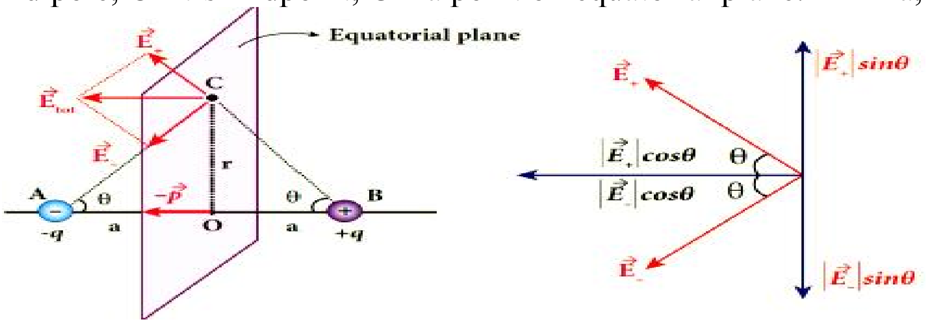
$$\overrightarrow{E_{tot}} = \frac{q}{4\pi\varepsilon_0}\left[\frac{4ra}{(r^2-a^2)^2}\right]\hat{p} \qquad \because \ r >> a \cdot (r^2-a^2)^2 \approx r^4,$$

$$\overrightarrow{E_{tot}} = \frac{1}{4\pi\varepsilon_0}\frac{2\vec{p}}{r^3} \qquad \because \ \vec{p} = 2aq\ \hat{p}$$

- **The direction of $\vec{E}$ is in the direction of $\vec{p}$.**

2. Calculate the electric field due to a dipole on its equatorial line.

- AB – dipole, O- it's midpoint, C – a point on equatorial plane. AB=2a, OC = r



- Electric field C due to + q (along BC)

$$\left|\overrightarrow{E_+}\right| = \frac{1}{4\pi\varepsilon_0}\frac{q}{(r^2+a^2)} \text{ --------------- (1)}$$

- Electric field C due to - q (along CA)

$$\left|\overrightarrow{E_-}\right| = \frac{1}{4\pi\varepsilon_0}\frac{q}{(r^2+a^2)} \text{ --------------- (2)}$$

- Here $\left|\overrightarrow{E_+}\right|$ $\left|\overrightarrow{E_-}\right|$
- Resolve $\left|\overrightarrow{E_+}\right|$ and $\left|\overrightarrow{E_-}\right|$ in to two components.
- Here the perpendicular components $\left|\overrightarrow{E_+}\right| \sin\theta$ and $\left|\overrightarrow{E_-}\right|$ $\sin\theta$ are equal and opposite will cancel each other.
- But the horizontal components $\left|\overrightarrow{E_+}\right| \cos\theta$ and $\left|\overrightarrow{E_-}\right|$ $\cos\theta$ are equal and same direction ($-\hat{p}$) will be added up to given total electric field. Hence

$$\overrightarrow{E_{tot}} = -2\left|\overrightarrow{E_+}\right| \cos\theta\ \hat{p} \text{ ------------ (3)}$$

Here, $\cos\theta = \frac{a}{(r^2+a^2)^{1/2}}$ ------------ (4)

- Substitute equation (1), (4) to (3)

$$\overrightarrow{E_{tot}} = -\frac{2aq}{4\pi\varepsilon_0 (r^2+a^2)^{3/2}}\hat{p} \qquad r >> a \text{ then}$$

$$\overrightarrow{E_{tot}} = -\frac{\vec{p}}{4\pi\varepsilon_0 r^3} \qquad \because \ \vec{p} = 2aq\ \hat{p}$$

- **The direction of $\overrightarrow{E_{tot}}$ is opposite to the direction of $\vec{p}$.**

3. Derive an expression for electrostatic potential due to electric dipole.

- Consider an electric dipole AB along X - axis. Let 'P' be the point at a distance 'r' from its midpoint 'O'
- Electric potential at P due to +q

$$V_1 = \frac{1}{4\pi\varepsilon_0}\frac{q}{r_1}$$

- Electric potential at P due to −q

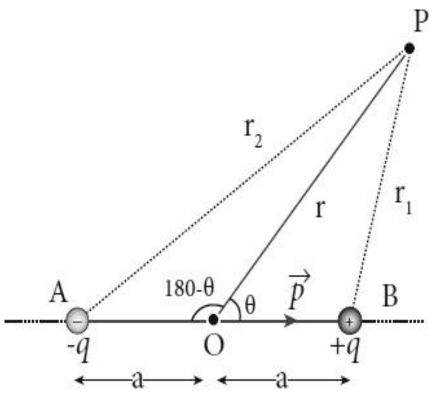
$$V_2 = \frac{-1}{4\pi\varepsilon_0}\frac{q}{r_2}$$

- Then total potential at 'P' due to dipole is

$$\mathbf{V} = \boldsymbol{V_1} + \boldsymbol{V_2}$$

$$\mathbf{V} = \frac{\mathbf{q}}{\mathbf{4\pi\varepsilon_0}}\left(\frac{\mathbf{1}}{\mathbf{r_1}} - \frac{\mathbf{1}}{\mathbf{r_2}}\right)$$

$$\frac{1}{r_1} = \frac{1}{r}\left(1 + \frac{a\cos\theta}{r}\right) \text{ and, } \frac{1}{r_2} = \frac{1}{r}\left(1 - \frac{a\cos\theta}{r}\right)$$



$$\mathbf{V} = \frac{1}{4\pi\varepsilon_0}\frac{p\cos\theta}{r^2} \qquad (\because \ p = 2aq)$$

$$\mathbf{V} = \frac{1}{4\pi\varepsilon_0}\frac{\vec{p}\cdot\vec{r}}{r^2} \qquad (\because \ \vec{p}\cdot\hat{r} = p\cos\theta)$$

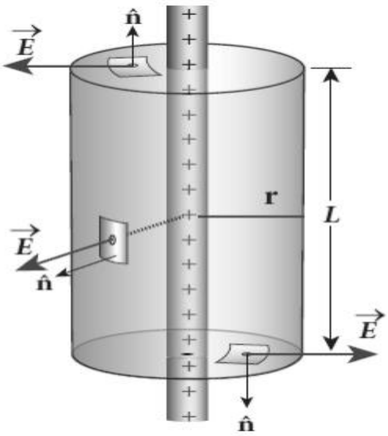
- **Special cases:**

θ=0⁰	$V = \frac{1}{4\pi\varepsilon_0}\frac{p}{r^2}$
θ=180⁰	$V = -\frac{1}{4\pi\varepsilon_0}\frac{p}{r^2}$
θ=90⁰	**V =0**

4. Obtain an expression for electric field due to an infinitely long charged wire.

- Total charge enclosed by the closed surface
- $Q_{encl} = \lambda L$ - **(1)**
- The electric flux for the curved surface:

$$\phi_E = \int_{\substack{Curved\\surface}} \boldsymbol{E}.\boldsymbol{dA}\cos\theta = \boldsymbol{E}(2\pi r L) \ [\theta = 0]$$



- The electric flux for top and bottom surfaces: $\phi_E = 0$
- Then the total electric flux $\phi_E = \mathrm{E}(2\pi r\mathrm{L})$ - - - - - **(2)**
- According to Gauss law, $\phi_E = \frac{Q}{\varepsilon_0}$ - - - - - - - - - **(3)**
- Substitute equation **(1)** and **(2)** in **(3)**

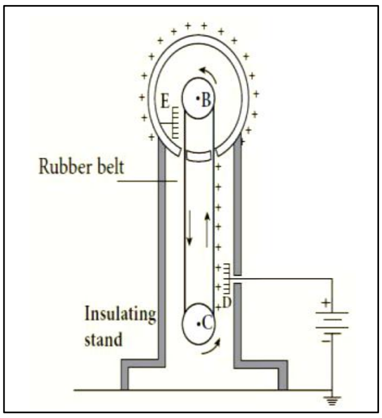
$$\mathrm{E}(2\pi r\mathrm{L}) = \frac{\lambda L}{\varepsilon_0}$$

$$\mathbf{E} = \frac{\lambda}{2\pi\varepsilon_0 r} \quad \text{(or)} \quad \vec{E} = \frac{1}{2\pi\varepsilon_0}\frac{\lambda}{r}\hat{r}$$

- The direction of **E** is perpendicular to wire If **λ > 0**, then pointing outward, if **λ < 0,** then pointing inward.

5. Explain in detail the construction and working of Van de Graff generator.

- <u>**Principle**</u> : Electrostatic induction and Action at points

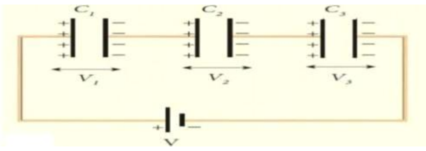
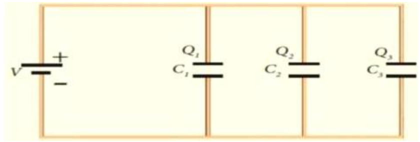


- <u>**Construction:**</u>
  1. A - Large hollow spherical conductor
  2. B,C- Pulleys. A silk belt runs over the pulleys
  3. C is driven by a motor.
  4. D, E – comb shaped conductors placed near B and C.
  5. D is connected to positive of $\mathbf{10^4}$ **V** power.
- <u>**Working:**</u>
  - **Ionization near D**: Positive charges stick to moving silk belt.

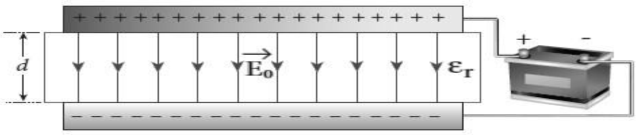
- **Electrostatic induction near E:** Positive charges are induced on either side of comb E
- **Corona Discharge in the belt**: The negative charges nullify the positive charges in the belt. Thus the sphere acquires charge until the outer surface reaches $\mathbf{10^7\,V}$.
- **Reducing Leakage:** The machine is enclosed in a gas filled Steel chamber at high pressure.

❖ **Uses:** To accelerate positive charges for nuclear disintegration.

6. Derive the expression for resultant capacitance, when capacitors are connected in series and in parallel.

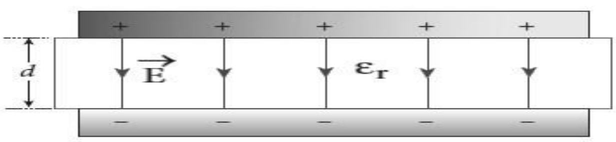
Capacitors in series	Capacitors in parallel
	
Each capacitor has same amount of charge (Q). But potential difference across each capacitor will be different. $V = V_1 + V_2 + V_3$	Each capacitor has same potential difference (V). But charges on each capacitor will be different . $Q = Q_1 + Q_2 + Q_3$
$V = \frac{Q}{C_S}$; $V_1 = \frac{Q}{C_1}$; $V_2 = \frac{Q}{C_2}$; $V_3 = \frac{Q}{C_3}$	$Q = C_P\, V$; $Q = C_1 V$; $Q = C_2 V$; $Q = C_3 V$
$\frac{Q}{C_S} = \frac{Q}{C_1} + \frac{Q}{C_2} + \frac{Q}{C_3}$	$C_P V = C_1 V + C_2 V + C_3 V$
$\frac{1}{C_S} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$	$C_P = C_1 + C_2 + C_3$

7. Explain in detail the effect of introducing a dielectric medium between the plates of a parallel plate capacitor, when the capacitor is disconnected from the battery.



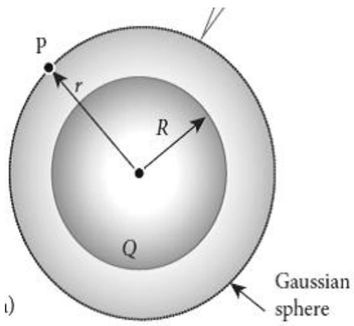
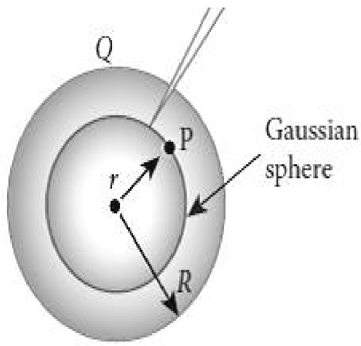
Quantity	Connected battery and before introducing dielectric	After Dis Connecting battery and after introducing dielectric
Charge	Qo	Qo
Voltage	V_o	V
Electric field	E_o	E
Capacitance	$C_0 = \frac{Q_0}{V_0}$	$C = \mathcal{E}_r \frac{Q_0}{V_0} = \mathcal{E}_r C_0$

❖ Effect of dielectric medium between the plate



Quantity	Value	Effect of dielectric When $\mathcal{E}_r > 1$	
Electric field	$\mathbf{E} = \frac{\mathbf{E_0}}{\boldsymbol{\varepsilon}_\mathbf{r}}$	$\mathbf{E < E_0}$	Decreased
Potential difference	$\mathbf{V} = \frac{\mathbf{V_0}}{\boldsymbol{\varepsilon}_\mathbf{r}}$	$\mathbf{V} < \boldsymbol{V_0}$	Decreased
Capacitance	$\mathbf{C} = \boldsymbol{\varepsilon}_\mathbf{r}\mathbf{C_0}$	$\mathbf{C} > \boldsymbol{C_0}$	Increased
Energy	$\mathbf{U} = \frac{\mathbf{U_0}}{\boldsymbol{\varepsilon}_\mathbf{r}}$	$\mathbf{U} < \boldsymbol{U_0}$	Decreased

8. Obtain an expression for electric field due to a uniformly charged spherical shell.

<table>
<tr><th>At a point outside the shell</th><th>At a point on the surface of the shell</th><th>At a point inside the shell</th></tr>
<tr><td>R -radius of spherical shell</td><td>R -radius of spherical shell</td><td>R -radius of spherical shell</td></tr>
<tr><td>Gaussian surface :
Sphere with radius r</td><td>Gaussian surface :
Sphere with radius r</td><td>Gaussian surface :
Sphere with radius r</td></tr>
<tr><td>$\mathbf{r > R}$</td><td>$\mathbf{r = R}$</td><td>$\mathbf{r < R}$</td></tr>
<tr><td>
</td><td></td><td>
</td></tr>
<tr><td>According to Gauss's law
$\oint_{\text{Gaussian surface}} \vec{E}.\vec{dA} = \frac{Q}{\varepsilon_0}$

$\oint dA = 4\pi r^2$
$Q_{in} = Q$

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

$E = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$</td><td>According to Gauss's law
$\oint_{\text{Gaussian surface}} \vec{E}.\vec{dA} = \frac{Q}{\varepsilon_0}$

$\oint dA = 4\pi r^2$
$Q_{in} = Q$

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

Substitute r = R

$E = \frac{1}{4\pi\varepsilon_0}\frac{Q}{R^2}$</td><td>According to Gauss's law
$\oint_{\text{Gaussian surface}} \vec{E}.\vec{dA} = \frac{Q}{\varepsilon_0}$

$\oint dA = 4\pi r^2$
$Q_{in} = 0$

Substitute
$E\ (4\pi r^2) = \frac{0}{\varepsilon_0}$

$E = 0$</td></tr>
</table>

2.CURRENT ELECTRICITY

1. Define current density and give its unit.

- ✧ Current flowing per unit area of cross section of the conductor **J =** $\frac{I}{A}$ Its Unit is **Am^{-2}**

2. Define electrical resistivity and give its unit.

- ✧ Resistance offered to the current flow by a conductor of unit length having unit area of cross section. $\boldsymbol{\rho = \frac{RA}{l}}$ Its unit is **Ω m** (ohm meter).

3. Define temperature co-efficient of resistivity.

- ✧ It is defined as the ratio of increase in resistivity per degree rise in temperature to its resistivity at $\mathbf{T_0}$. Its unit is **per °C.**

4. State the Principle of potentiometer.

- ✧ The emf of a cell is directly proportional to balancing length. ie.. $\mathcal{E} \propto l$

5. State Joule's law of heating

- ✧ Heat librated by Joule's heating effect, **H=I^2 R t**
  - square of the current (H ∝ I^2)
  - Resistance of the conductor (H ∝ R)
  - time of flow(H ∝ t)

6. What is Seeback effect?

- ✧ In a closed circuit consisting of two dissimilar metals, when the junctions are maintained at different temperatures an emf (potential difference) is developed. This phenomenon is called Seeback effect.

7. What is Thomson effect?

- ✧ If two points in a conductor are at different temperatures the density of electrons at these points will differ and as a result the potential difference is created between these two points.
- ✧ Hence heat is evolved or absorbed throughout the conductor. This is called Thomson effect.

8. What is Peltier effect?

- ✧ When an electric current is passed through a circuit of a thermocouple, heat is evolved at one junction and absorbed at the other junction. This is known as Peltier effect.

9. State Ohm's law.

- ✧ At a Constant temperature, the steady current flowing through a conductor is directly proportional to the potential difference between the two ends of the conductor.

10. What are the properties of the substance used as heating element?

- ✧ An alloy of nickel and chromium called Nicrome is used as heating element. It has
  - a high specific resistance
  - high melting point
  - heated to very high temperature without oxidation

5 - MARK QUESTIONS AND ANSWERS :

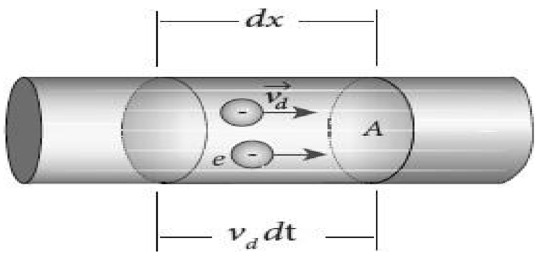
1. Describe the microscopic model of current and obtain general form of ohm's law.

- ✧ Number of electrons per unit volume in a conductor = **n**
- ✧ Cross sectional area of a conductor = **A**
- ✧ Drift Velocity of an electron = v_d
- ✧ Time taken to travel dx distance = **dt**.

  $$dx = v_d\, dt$$

- ✧ Total Charge in the volume element

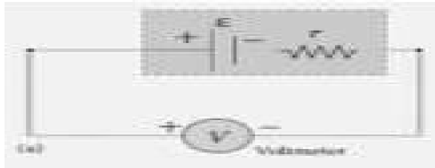
  $$dQ = (n\,A\,v_d\,dt)e$$



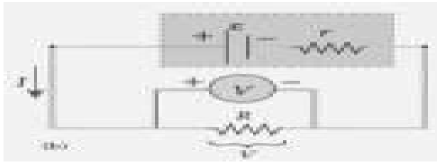
- ✧ Current $\mathbf{I} = \frac{dQ}{dt}$ $\mathbf{I} = nAv_d e$
- ✧ Current density $\vec{J} = \frac{I}{A} = -n\frac{e^2\tau}{m}\vec{E}$ (or) $\vec{J} = -\sigma\vec{E}$ (or) $\vec{J} = \sigma\vec{E}$

2. Explain the determination of the internal resistance of a cell using voltmeter.

- ✧ When the electric circuit is open, the reading in voltmeter(v), is equal to the electro motive force ($\boldsymbol{\varepsilon}$)



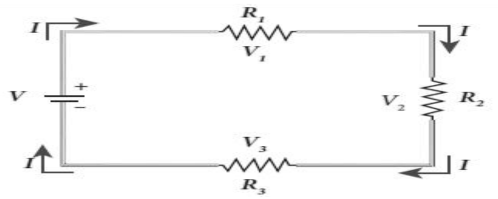
- ✧ $\mathbf{V = \mathcal{E}}$ - - - - - - -**(1)**
- ✧ Potential drop across R is **V = IR - - - (2)**
- ✧ **V = Ɛ - Ir (or) Ir = Ɛ - V - - - - - (3)**



- ✧ **Eq (3 ÷ 2)** $\frac{Ir}{IR} = \frac{\mathcal{E} - V}{V}$
- ✧ Internal resistance $\mathbf{r} = \left(\frac{\mathcal{E} - V}{V}\right) \mathbf{R}$

3. Explain the equivalent resistance of a series and resistor network.

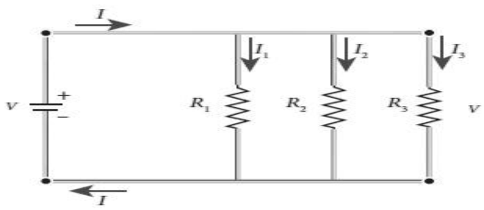
- ✧ R_1, R_2 and R_3 are resistances connected in series
- ✧ V - Potential difference applied; I-Current in series , I – Same but V – different



- ✧ $\mathbf{V = V_1 + V_2 + V_3}$
- ✧ $\mathbf{V = IR_S}$; $\mathbf{V_1 = IR_1}$; $\mathbf{V_2 = IR_2}$; $\mathbf{V_3 = IR_1}$
- ✧ $\mathbf{IR_S = IR_1 + IR_2 + IR_3}$
- ✧ Effective Resistance $\mathbf{R_S = R_1 + R_2 + R_3}$

4. Explain the equivalent resistance of a Parallel resistor network.

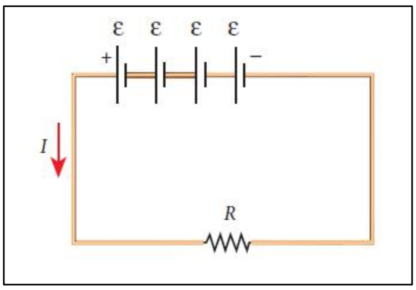
- ✧ R_1, R_2 and R_3 are resistances connected in Parallel
- ✧ V - Potential difference applied; I-Current in series , V – Same; but I different



- ✧ $\mathbf{I = I_1 + I_2 + I_3}$; $\mathbf{I = \frac{V}{R_P}}$
- ✧ $\frac{V}{R_P} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$
- ✧ $\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

5. Explain series connections in cells.

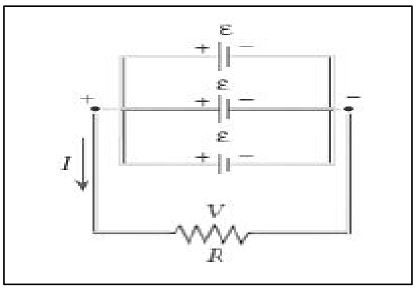
- ✧ <u>**Cells in Series:**</u> n cells having internal resistance **r** and emf **Ɛ** are connected in series.
- ✧ Total emf = **nƐ**
- ✧ Total resistance = **nr + R**



- ✧ Current in the circuit $\mathbf{I} = \frac{n\mathcal{E}}{nr + R}$
- ✧ **If r <<** R, $\mathbf{I} = \frac{n\mathcal{E}}{R}$
- ✧ **If r >>** R, $\mathbf{I} = \frac{\mathcal{E}}{r}$

6. Explain parallel connections in cells.

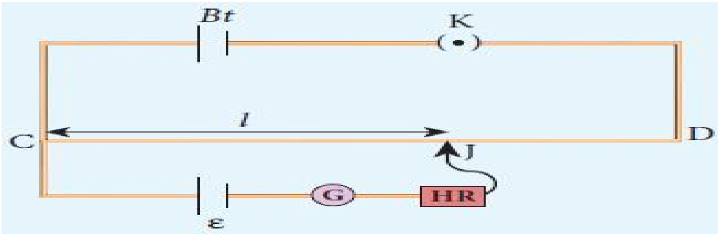
- ✧ <u>**Cells in Parallel:**</u> n cells having internal resistance **r** and emf **Ɛ** are connected in series.
- ✧ Total emf = nƐ
- ✧ Total resistance = $\frac{r}{n}$ + **R**



- ✧ Current in the circuit $\mathbf{I} = \frac{n\mathcal{E}}{r + nR}$
- ✧ **If r <<** R, $\mathbf{I} = \frac{\mathcal{E}}{R}$
- ✧ **If r >>** R, $\mathbf{I} = \frac{n\mathcal{E}}{r}$

7. Explain the Principle of a Potentiometer.

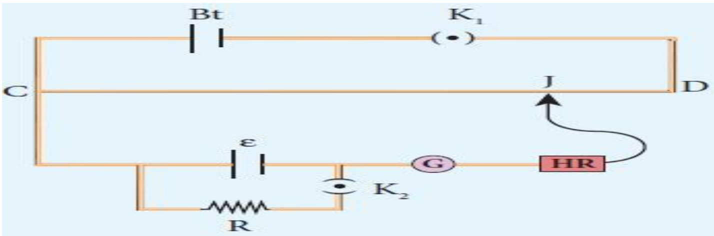
- **<u>Primary circuit</u>:** The battery (Bt), key (k) and Potentiometer wire (CD) are Connected in Series to form Primary Circuit.
- **<u>Secondary circuit:</u>** The Positive terminal of a cell of emf $\mathcal{E}$ is connected to the point C and negative is connected to the Jockey J through a galvanometer G and a high resistance HR. This forms a secondary circuit.



- Potential difference across **CJ** = $I\,r\,l$
- emf of the cell = potential difference across CJ
- $\varepsilon = I\,r\,l$
- $\mathcal{E} \propto l$ (Since I, r are constants)

8. Explain the determination of the internal resistance of a cell using potentiometer.

- **<u>Primary circuit</u>:** Potentiometer is connected in series with battery **(Bt)** and Key **(K_1)**.
- **<u>Secondary circuit:</u>** The cell whose internal resistance is to be calculated is connected in parallel with resistance box **R** and key K_2 is open.



- According to the principle of Potentiometer $\varepsilon \propto l_1$ -------(1)
- When the key K_2 is closed, the balancing length l_2 is determined $\frac{\varepsilon R}{R+r} \propto l_2$ ------(2)
- **Eq (1) ÷ Eq (2) we get**

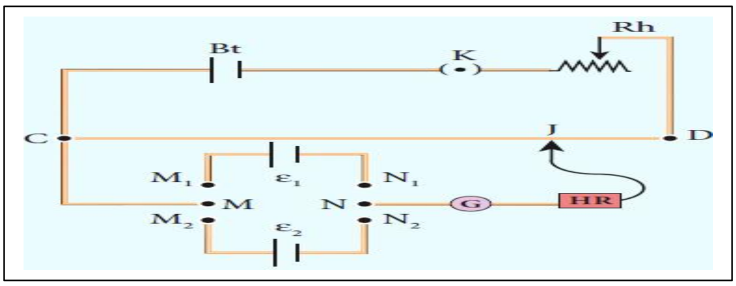
$$r = \left(\frac{l_1 - l_2}{l_2}\right) R \text{---------}(3)$$

- Substituting **R_1**, l_1, l_2 in **equation 3,** the internal resistance 'r' can be calculated.

9. How the emf of two cells are compared using potentiometer?

- **<u>Primary circuit</u>:** The battery **(Bt),** key **(k)** and Potentiometer wire **(CD)** are Connected in Series to form Primary Circuit.
- **<u>Secondary circuit:</u>** The end **C** is connected to one terminal **M** of **DPDT** switch and another central terminal N is connected to jockey through a galvanometer **G** and high resistance **HR**.
- The cell whose emf $\mathcal{E}_1$ and $\mathcal{E}_2$ to be compared are connected to M_1N_1 and M_2N_2 of **DPDT** switch. The cell of emf $\mathcal{E}_1$ and $\mathcal{E}_2$ is included in the secondary circuit. The balancing length l_1 and l_2 is found by adjusting jockey for zero deflection.

- $\mathcal{E}_1 = Irl_1$
- $\mathcal{E}_2 = Irl_2$
- $\frac{\mathcal{E}_1}{\mathcal{E}_2} = \frac{l_1}{l_2}$



10. Obtain the condition for bridge balance in wheatstone's bridge.

- ✧ Applying Kirchhoff's current rule to junction B and D respectively.

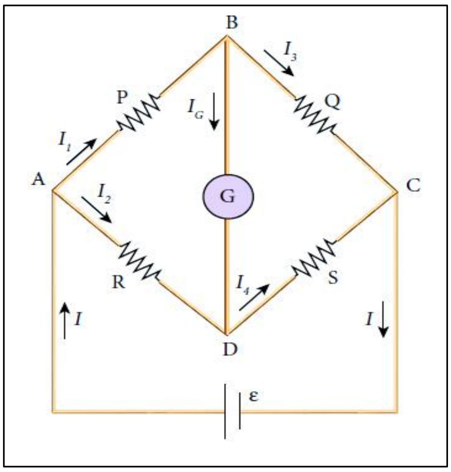
$I_1 - I_G - I_3 = 0$ -- (1)

$I_2 + I_G - I_4 = 0$ -- (2)

- ✧ Applying Kirchhoff's voltage rule to loop ABDA & BCDB. We get

$I_1P + I_GG - I_2R = 0$ -- (3)

$I_3Q - I_GG - I_4S = 0$ -- (4)



- ✧ Substitute $I_G = 0$ in equation (1) (2) (3) &(4)

$I_1 = I_3$ -- (5)

$I_2 = I_4$ -- (6)

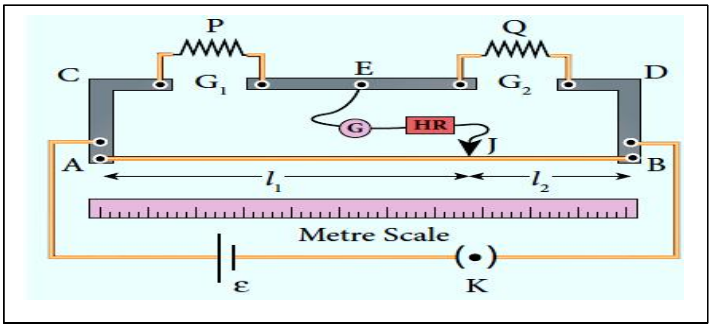
$I_1P = I_2R$ -- (7)

Eq (7) ÷ (8) $\frac{I_1 P}{I_3 Q} = \frac{I_2 R}{I_4 S}$

- ✧ Using equations (5) and (6) $\frac{P}{Q} = \frac{R}{S}$

11. Explain the determination of unknown resistance using metre bridge.

- ✧ Meterbridge is another form of Wheatstone"s bridge.
- ✧ In the gap G_1 unknown resistance P,
- ✧ In the gap G_2 standard resistance Q .
- ✧ The position of the jockey on the wire is adjusted so that the galvanometer shows zero deflection.



- ✧ The resistances corresponding to AJ (l_1) and JB (l_2) of the bridge wire form the resistances 'R' and 'S' of the wheatstone's bridge

$$\frac{P}{Q} = \frac{R}{S} = \frac{r\,AJ}{r\,JB}$$ (r- resistance per unit length)

$$\frac{P}{Q} = \frac{AJ}{JB} = \frac{l_1}{l_2}$$

- ✧ Unknown resistance **P = Q** $\frac{l_1}{l_2}$
- ✧ Specific resistance of the material of the wire

$$\rho = \frac{PA}{l} = \frac{P\pi r^2}{l}$$

UNIT 3 MAGNETISM AND MAGNETIC EFFECT OF CURRENT

2 MARK - QUESTIONS AND ANSWERS :

1. **Define Magnetic flux. Give its unit.**
   - The number of magnetic field lines crossing per unit area is called magnetic flux
     $\Phi_B = \vec{B}.\vec{A} = BA\cos\theta$ S.I unit of magnetic flux is ***weber (Wb)***
   - Its dimensional formula is ***[$ML^2T^{-2}A^{-1}$]***

2. **State Coulomb's inverse law of magnetism.**
   - The force of attraction or repulsion between two magnetic poles is directly proportional to the product of their pole strengths and inversely proportional to the square of the distance between them.

$$\vec{F} = \frac{\mu_0}{4\pi}\frac{Q_{mA}Q_{mB}}{r^2}\hat{r}$$

3. **State tangent law.**
   - When a magnetic needle or magnet is freely suspended in two mutually perpendicular uniform magnetic fields, it will come to rest in the direction of the resultant of the two fields.
     $B = B_H \tan\theta$

4. Define curie temperature.
   - At a particular temperature, ferromagnetic material becomes paramagnetic. This temperature is known as Curie temperature ***(T_C).***

5. State Fleming's left hand rule.
   - Stretch out forefinger, the middle finger and the thumb of the left hand such that they are in three mutually perpendicular directions.
     - **Forefinger -** direction of magnetic field
     - **Middle finger -** direction of the electric current
     - **Thumb -** direction of the force experienced by the conductor.

6. Define one ampere.
   - One ampere is defined as that constant current when it is passed through each of the two infinitely long parallel straight conductors kept at a distance of one metre apart in vacuum causes each conductor to experience a force of 2×10^{-7} newton per metre length of the conductor.

7. How the current sensitivity of a galvanometer can be increased?
   - By increasing the number of turns **(N)**
   - By increasing the magnetic induction **(B)**
   - By increasing the area of the coil **(A)**
   - By decreasing the couple per unit twist of the suspension wire .

8. State Ampere's circuital law.
   - It state that the line integral of magnetic field over a closed loop is μ_o times net current enclosed by the loop. $\oint \vec{B}.\vec{dl} = \mu_0 I_0$

9. What are the limitations of cyclotron?
   - The speed of the ion is limited.
   - Electron cannot be accelerated.
   - Uncharged particles cannot be accelerated.

3 - MARK QUESTIONS AND ANSWERS :

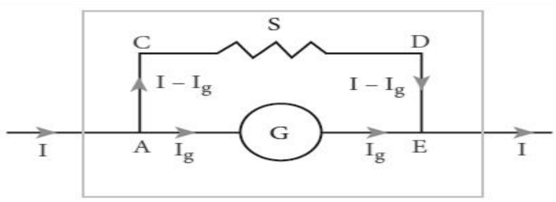
1. How is a galvanometer converted into an ammeter?

- A galvanometer is converted into an ammeter by connecting a low resistance called shunt in parallel with the galvanomete

$$V_{galvanometer} = V_{shunt}$$

$$(I - I_g)\, S = I_g\, R_g$$

$$S = \frac{I_g}{(I - Ig)} R_g$$



Ammeter

- Let R_a be the resistance of ammeter, then

$$\frac{1}{R_{eff}} = \frac{1}{R_g} + \frac{1}{S} \qquad R_{eff} = \frac{R_g\, S}{R_g + S} = R_a$$

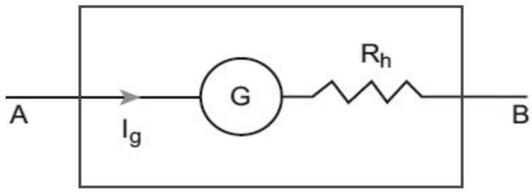
- An ideal ammeter has zero resistance.

2. How is galvanometer converted into a voltmeter ?

- A galvanometer is converted in to voltmeter by connecting high resistance inseries with the galvanometer.
- Here the current in the electrical circuit is same as the current passing through the galvanometer.

$$I_g = I$$

$$I_g = \frac{V}{R_g + R_h}$$



Voltmeter

$$R_g + R_h = \frac{V}{I_g}$$

- Let R_v be the resistance of voltmeter, then

$$R_v = R_g + R_h$$

- An ideal voltmeter has infinite resistance.

5 - MARK QUESTIONS AND ANSWERS :

1. **Obtain an expression for magnetic field due to the current carrying wire of infinite length using Ampere's law.**

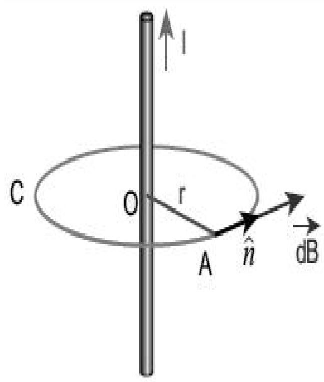
- Consider a straight conductor of infinite length carrying current 'I' Imagine an Amperian circular loop at a distance 'r' from the centre of the conductor.
- From Ampere's circuital law,

$$\oint \vec{B} \cdot \vec{dl} = \mu_0 I$$

$$B \oint dl = \mu_0 I$$

$$B(2\pi r) = \mu_0 I$$

$$B = \frac{\mu_0 I}{2\pi r}$$

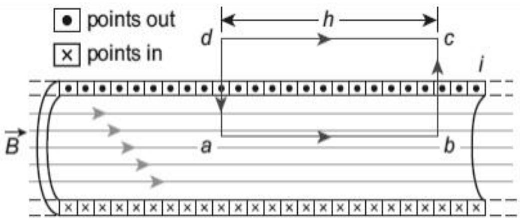


- In vector notation,

$$\vec{B} = \frac{\mu_0 I}{2\pi r} \hat{n}$$

2. Obtain an expression for magnetic field due to long current carrying solenoid.

- Consider a solenoid of length 'L' having 'N' turns.



Magnetic field of a solenoid

- We use Ampere circuital law to calculate the magnetic field at any point inside the solenoid.
- Let as consider an Amperian loop ***'abcd'***
- From Ampere circuital law,

$$\oint \vec{B}\cdot\vec{dl} = \mu_0 I_0 \text{ -------(1)}$$

$$\oint \vec{B}\cdot\vec{dl} = \int_a^b \vec{B}\cdot\vec{dl} + \int_b^c \vec{B}\cdot\vec{dl} + \int_c^d \vec{B}\cdot\vec{dl} + \int_d^a \vec{B}\cdot\vec{dl}$$

- Here $ab = h$.
- If we take large loop such that it is equal to length of the solenoid, we have

$$\oint \vec{B}\cdot\vec{dl} = BL \text{ ---------(2)}$$

- Let 'I' be the current passing through the solenoid of 'N' turns, then

$$I_o = NI \text{ ------------(3)}$$

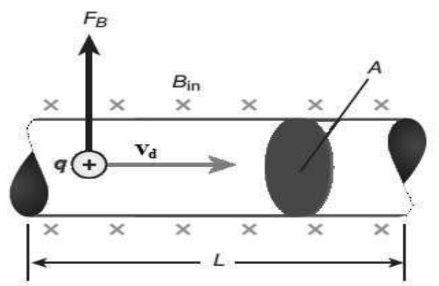
- Put equation (2) and (3) in (1) we get

$$B = \frac{\mu_0 NI}{L} \text{ ----------(4)}$$

- Let 'n' be the number of turns per unit length, then $n = \frac{N}{L}$
- Hence, Magnetic field due to long current carrying solenoid, $B = \mu_0 nI$

3. Obtain an expression for the force on a current carrying conductor placed in a magnetic field.

- Let a current 'I' flows through a conductor of length 'L' and area of cross-section 'A
- Consider a small segment of wire of length '***dl***'



- The relation between current and drift velocity is,

$$I = nAev_d$$

- Average force experienced by the electron in the wire is

$$\vec{f} = -e(\vec{v_d} \times \vec{B})$$

- Total number of free electrons in the small element

$$N = nAdl$$

- Hence Lorentz force on the small element,

$$\vec{dF} = N\vec{f}$$

$$\vec{dF} = -enAdl\,(\vec{v_d} \times \vec{B}) = I\,\vec{dl} \times \vec{B}$$

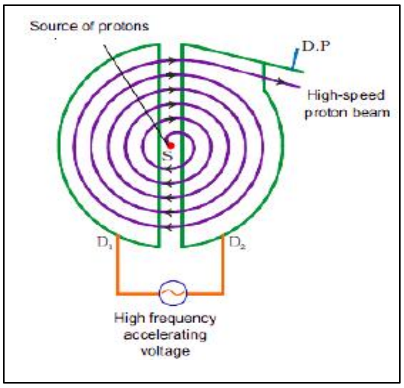
- Therefore, the force in a straight current carrying conductor of length '***l***' placed in a uniformmagnetic field $\vec{F} = \vec{l} \times \vec{B}$
- In magnitude, $F = BIl\sin\theta$

<u>**special case :**</u>

i) If the conductor is placed along the direction of the magnetic field, $\theta = 0^0$ then F = 0.

ii) If the conductor is placed perpendicular to the magnetic field, $\theta = 90^0$ then F= *BIl*=***Maximum***.

4. **Describe the principle, construction and working of Cyclotron.**



❖ **Principle:**

➢ Lorentz force

❖ **Construction:**

➢ It consists two semi circular metal containers called Dees.

➢ The Dees are enclosed in an evacuated chamber and it is kept in a region of uniform magnetic field acts normal to the plane of the Dees.

➢ Dees are connected to high frequency alternating potential difference.

➢ After one semi-circular path in Dee-1, the ion reaches the gap between Dees.

➢ At this time the polarities of the Dees are reversed, so that the ion is now accelerated towards Dee-2 with a greater velocity.

➢ **centripetal force = Lorentz force**

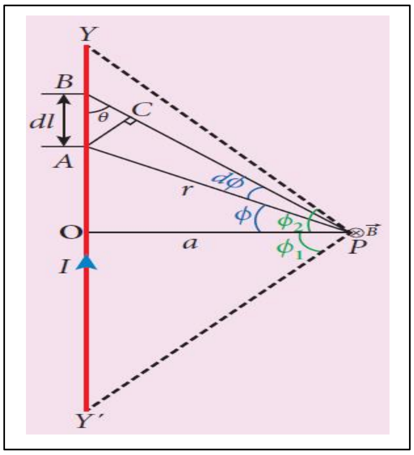
$$\frac{mv^2}{r} = Bqv$$

The radius of the circular path.	$r = \frac{mv}{Bq}$
Time period of the oscillation	$T = \frac{2\pi m}{Bq}$
Frequency of the electrical oscillator	$f = \frac{Bq}{2\pi m}$
kinetic energy of the charged particle	$KE = \frac{B^2q^2r^2}{2m}$

5. **Deduce the relation for magnetic field at a point due to an infinitely long straight conductor carrying current.**

❖ Consider a long straight wire YY' carrying a current I. Let P be a point at a distance 'a' from 'O. Consider an element of length '*dl*' of the wire at a distance '*r*' from point 'O'

❖ **Biot savart law**



$$\vec{dB} = \frac{\mu_0}{4\pi}\frac{I\,dl\,\sin\theta}{r^2}\,\hat{n}$$

$$dl\,\sin\theta = r\,d\phi$$

$$\vec{dB} = \frac{\mu_0}{4\pi}\frac{I\,d\phi}{r}\,\hat{n}$$

Δ^{le} OPA $\quad r = \frac{a}{\cos\phi}$

$$\vec{dB} = \frac{\mu_0 I}{4\pi a}\cos\phi\,d\phi\,\hat{n}$$

$$\vec{B} = \frac{\mu_0 I}{4\pi a}(\sin\phi_1 + \sin\phi_2)\,\hat{n}$$ For an infinitely long straight wire, $\phi_1 = \phi_2 = 90°$

❖ Magnetic field **B** in Magnitude and Vector form

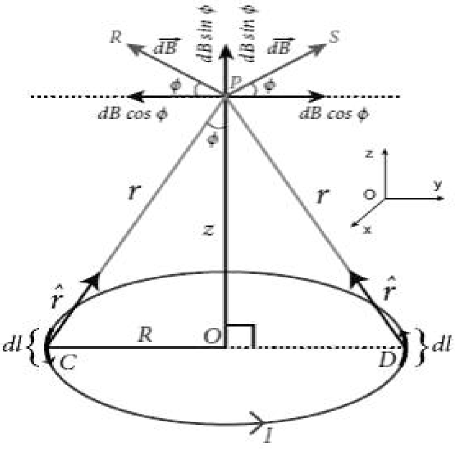
$$B = \frac{\mu_0 I}{2\pi a} \quad ; \quad \vec{B} = \frac{\mu_0 I}{2\pi a}\,\hat{n}$$

6. Obtain a relation for the magnetic field at a point along the axis of a circular coil carrying current.

- Consider a current carrying circular loop of radius R , I be the current flowing through the wire. Let 'P' be the point on the axis at a distance 'z' from centre 'O.
- According to Biot-Savart's law, the magnetic field at P due to the current element.

$$dB = \frac{\mu_0}{4\pi}\frac{I\,dl\ \sin\theta}{r^2} = \frac{\mu_0}{4\pi}\frac{I\,dl}{r^2}\quad [\because\ \theta = 90^0]$$

- The net magnetic field at the point **P**



$$\vec{B} = \int \overrightarrow{dB} = \int dB \sin\phi\ \hat{k}$$

$$\sin\phi = \frac{R}{(R^2+Z^2)^{1/2}}\ ;\ r^2 = (R^2+Z^2)$$

$$\vec{B} = \frac{\mu_0 I}{2}\frac{R^2}{(R^2+Z^2)^{3/2}}\ \hat{k}$$

- If the circular coil contains N turns

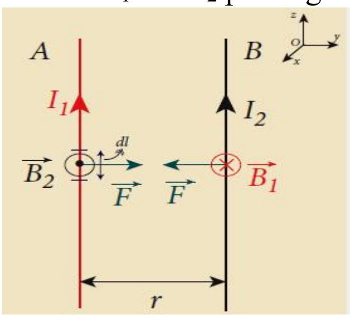
$$\vec{B} = \frac{\mu_0 NI}{2}\frac{R^2}{(R^2+Z^2)^{3/2}}\ \hat{k}$$

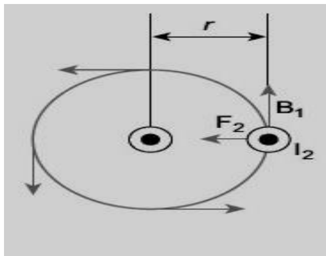
- The magnetic field at the centre of the coil [$\because$ **z = 0**]

$$\vec{B} = \frac{\mu_0 IN}{2R}\ \hat{k}$$

7. Obtain a force between two long parallel current carrying conductors.

- Consider two long straight parallel conductors A and B separated by a distance r are kept in air carrying current I_1 and I_2 passing in the same direction (z - axis) .





Conductor A

- Current in the conductor I_1 , Magnetic filed at r, $B_1 = -\frac{\mu_0 I_1}{2\pi r}\hat{i}$
- Force on the element dl of conductor B $\overrightarrow{dF} = I_2 l \times B_1 = -\frac{\mu_0 I_1 I_2\, dl}{2\pi r}\ \hat{j}$
- Force per unit length of conductor B due to A $\frac{\vec{F}}{l} = -\frac{\mu_0 I_1 I_2}{2\pi r}\ \hat{j}$

- **Conductor B**

- Current in the conductor I_2 , Magnetic filed at r, $B_2 = \frac{\mu_0 I_1}{2\pi r}\hat{i}$
- Force on the element dl of conductor A $\overrightarrow{dF} = I_1 l \times B_1 = \frac{\mu_0 I_1 I_2\, dl}{2\pi r}\ \hat{j}$
- Force per unit length of conductor A due to B $\frac{\vec{F}}{l} = \frac{\mu_0 I_1 I_2}{2\pi r}\ \hat{j}$
- The force experienced by two parallel current carrying conductors is attractive if they carry current in same direction.
- On the other hand, the force experienced by two parallel current carrying conductors is repulsive if they carry current in opposite direction.

UNIT 4. ELECTROMAGNETIC INDUCTION AND ALTERNATING CURRENT

2 -MARK QUESTIONS AND ANSWERS:

1. **State Lenz's law.**
   - Lenz's law states that the direction of the induced current is such that is always opposes the cause responsible for its production. $\varepsilon = -\frac{d\Phi_B}{dt}$
2. **State Fleming's right hand rule.(Generator rule)**
   - The thumb, index finger and middle finger of right hand are stretched out in mutually perpendicular directions .
     - The Index finger - The direction of the magnetic field
     - The thumb - The direction of motion of the conductor
     - The middle finger - The direction of the induced current.
3. **What the methods of producing induced emf ?**
   - By changing the magnetic field **'B'**
   - By changing the area **'A'** of the coil
   - By changing the relative orientation **'θ'** of the coil with magnetic field.
4. **What is called self induction?**
   - The phenomenon of inducing an emf in a coil, when the magnetic flux linked with the coil itself changes is called self induction.
5. **Define the unit of self - inductance (or) Define one henry.**
   - The inductance of the coil is one henry, if a current changing at the rate of $1\ A\ s^{-1}$ induces an opposing emf of $1\ V$ in it.
6. **Define mutual inductance or coefficient of mutual induction.**
   - Mutual inductance is also defined as the opposing emf induced in the one coil, when the rate of change of current through the other coil is $1\ A\ s^{-1}$
   - Its S.I unit is H (or) WbA^{-1} (or) $V\,s\,A^{-1}$
7. **Define mean value or average value of AC.**
   - The average of all values of current over a positive half-cycle or negative half-cycle.
8. **Define RMS value of AC.**
   - The square root of the mean of the squares of all currents over one cycle.
   - $I_{RMS} = \frac{I_m}{\sqrt{2}} = 0.707\ I_m$
9. **What are phasors?**
   - A sinusoidal alternating voltage (or) current can be represented by a vector which rotates about the origin in anti-clockwise direction at a constant angular velocity. Such a rotating vector is called a phasor.
10. **Define electric resonance.**
    - When the frequency of the applied alternating source is equal to the natural frequency of the RLC circuit, then the circuit is said to be in electrical resonance.
11. **Define inductive reactance.**
    - The resistance offered by the inductor in an ac circuit is called inductive reactance and it is given by $X_L = \omega L = 2\pi f L$ Its unit is ohm (**Ω**)
12. **Define capacitive reactance.**
    - The resistance offered by the capacitor is an ac circuit is called capacitive reactance and it is given by $X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C}$ Its unit is ohm (**Ω**)
13. **Why capacitor blocks DC?**
    - For a steady current, frequency f = 0. So $X_C = \infty$. Thus a capacitive circuit offers infinite resistance to the steady current.
14. **Define power factor.**
    - Power factor is defined as the ratio of true power to the apparent power.

15. Define Q - factor or quality factor.

- Q - factor = $\frac{\text{Voltage across L or C at resonance}}{\text{Applied Voltage}}$ (or) Q - factor = $\frac{1}{R}\sqrt{\frac{L}{C}}$

16. Define resonance frequency.

- The frequency at which resonance takes place is called resonant frequency.
- Hence the condition for resonance is : $X_L = X_C$

17. An inductor blocks AC but it allows DC. Why?

- For a steady current, frequency f = 0. So X_L = 0. Thus a inductive circuit offers zero resistance to the steady current.

3 -MARK QUESTIONS AND ANSWERS:

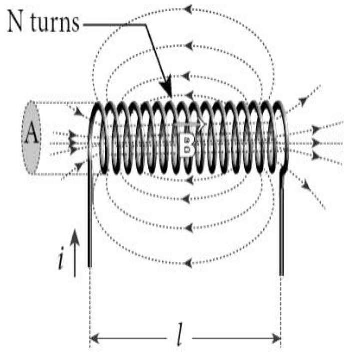
1. Mention the various energy losses in a transformer. How it is minimized?

S. N	Name of losses	Source of losses	Method to minimise
1	Iron loss (i)Hysteresis loss	Transformer core is magnetized and demagnetized repeatedly.	Using steel of high silicon content in making transformer core.
	(ii) eddy loss	Alternating magnetic flux in the core induces eddy currents in it.	Using very thin laminations of transformer core.
2	Copper loss	When an electric current flows through windings, some amount of energy is dissipated due to Joule heating.	Using Wires of larger diameter.
3	Flux leakage	The magnetic lines of primary coil are not completely linked with secondary coil.	winding coils one over the other.

2. Obtain the expression for Self-inductance of a long solenoid.

- Consider a long solenoid of length 'l', area of cross section 'A' having 'N' number of turns
- Let 'n' be number of turns per unit length (i.e.) turn density
- magnetic induction inside solenoid $B = \mu_0 ni$ - - - - -(1)
- The magnetic flux linked with the solenoid is,

$$\Phi_B = BA = \mu_0 ni\ A \text{ - - - - - (2)}$$



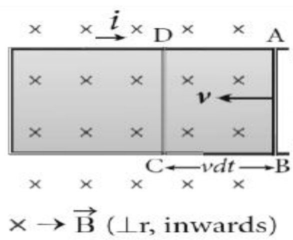
- The total number of turns $N = nl$
- The total magnetic flux linked in N turns (i.e.) flux linkag

$$N\Phi_B = nl\ (\mu_0 ni\ A) = \mu_0 n^2\ Al\, i \text{- - - (3)}$$

- According to definition, $N\Phi_B = Li$ -- - - - - - - (4)
- Compare (3) and (4) $Li = \mu_0 n^2 Al\, i$
- Self-inductance of a long solenoid $L = \mu_0 n^2 Al$

3. How will you induce an emf by changing the area enclosed by the coil.

- Consider a conducting rod of length 'l' moving with a velocity 'v' towards left on a rectangular metallic frame work.
- The whole arrangement is placed in a uniform magnetic field 'B' acting perpendicular to the plane of the coil inwards.



- Changing area enclosed by loop dA = $l\,dx = lv\,dt$
- Changing magnetic flux link with loop $d\phi_B = B\,lv\,dt$
- Magnitude of the induced emf

$$\varepsilon = \frac{d\Phi_B}{dt} = B\,lv$$

4. An inductor of inductance 'L' carries an electric current ' i '. How much energy is stored while establishing the current in it?

- Whenever a current is established in the circuit, the inductance opposes the growth of the current.
- To establish the current, work has to done against this opposition. This work done is stored as magnetic potential energy.

Induced emf $\mathcal{E} = -L\frac{di}{dt}$

- Let 'dW' be the workdone in moving a charge 'dq' $dW = -\mathcal{E}\, i\, dt = L\, i\, di$

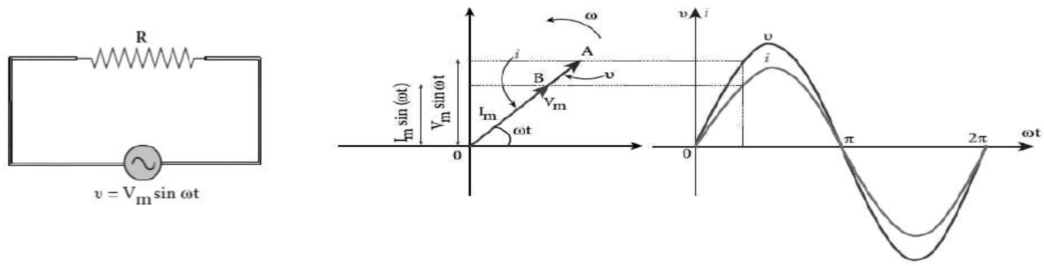
$$W = \int_0^i Li\, di = \frac{1}{2}Li^2$$

- Magnetic potential energy

$$U_B = \frac{1}{2}Li^2$$

5. Find out the phase relationship between voltage and current in a pure resistive circuit.

- Let a pure resistor of resistance 'R' connected across an alternating voltage source 'v'



- The instantaneous value of the alternating voltage is given by,

$$v = V_m \sin\omega t \text{ ----------(1)}$$

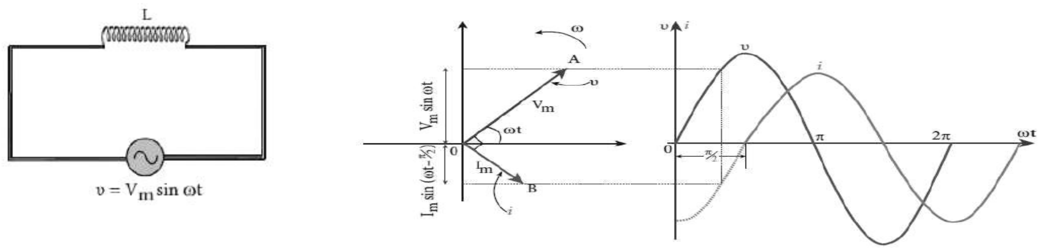
- According to Ohm's law $V_R = iR$ -----------------(2)
- According to Kirchoff's law $v - V_R = 0 \quad v = V_R$ - - - - - - -(3)
- Compare equation (1) & (2) $V_m \sin\omega t = iR$

$$i = \frac{V_m}{R}\sin\omega t$$

- Here, $I_m = \frac{V_m}{R}$ → Peak value of AC
- The applied voltage and the current are in phase with each other.

6. Find out the phase relationship between voltage and current in a pure inductive circuit.

- Let a pure inductor of inductance 'L' connected across an alternating voltage source 'v'



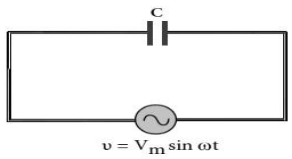
- The instantaneous value of the alternating voltage is given by, $v = V_m \sin\omega t$
- Induced emf $\mathcal{E} = -L\frac{di}{dt}$
- Kirchhoff's loop rule, $v - (-\epsilon) = 0 \quad (or)\ v = -\epsilon$

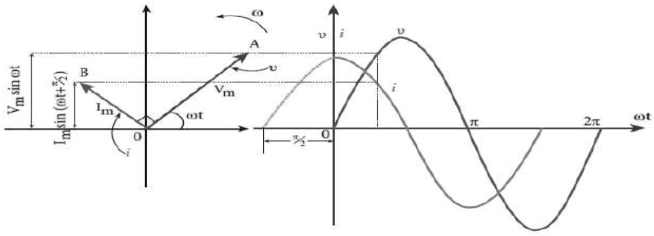
$$V_m \sin\omega t = L\frac{di}{dt}$$

- 'i' be the alternating current flowing in the circuit $i = I_m \sin\left(\omega t - \frac{\pi}{2}\right)$
- Here, $I_m = \frac{V_m}{R}$ → Peak value of **AC**
- It is clear that current lags behind the applied voltage by $\frac{\pi}{2}$

7. Find out the phase relationship between voltage and current in a pure capacitive circuit.

- Let a pure capacitor of capacitance 'C' connected across an alternating voltage source 'v'
- The instantaneous value of the alternating voltage is given by, $v = V_m \sin \omega t$





- Let 'q' be the instantaneous charge on the capacitor. $v = \frac{q}{C}$; $q = Cv$

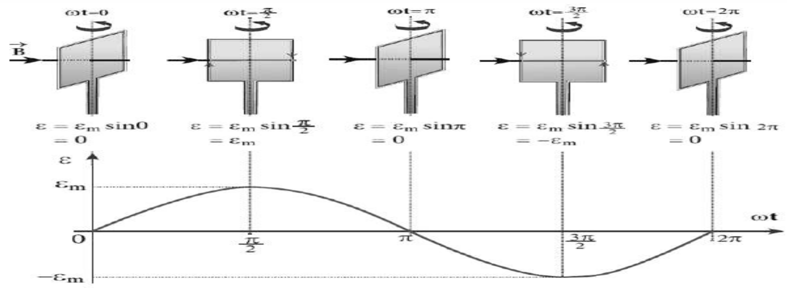
$$q = CV_m \sin \omega t$$

- 'i' be the alternating current flowing in the circuit $i = I_m \sin\left(\omega t + \frac{\pi}{2}\right)$
- Here, $I_m = \frac{V_m}{R}$ → Peak value of AC
- it is clear that current leads the applied voltage by $\frac{\pi}{2}$

<u>5 -MARK QUESTIONS AND ANSWERS:</u>

1. Show mathematically that the rotation of a coil in a magnetic field over one rotation induces an alternating emf of one cycle.

- Consider a rectangular coil of **'N'** turns kept in a uniform magnetic field **'B'**
- The coil rotates with an angular velocity ω about an axis perpendicular to the field.
- The component $(B \sin \omega t)$ parallel to the plane has no role in electromagnetic induction.



$$N\phi_B = NBA\cos \omega t \quad (\because \phi_B = BA\cos \omega t)$$

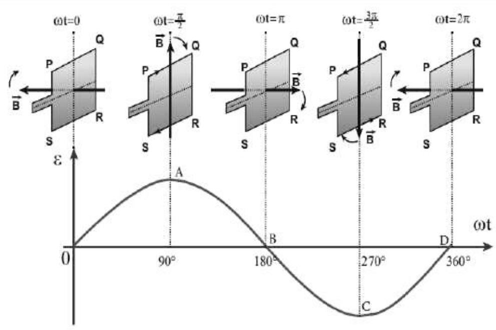
- According to Faraday's law, the emf induced at that instant is $\varepsilon = -\frac{d(N\phi_B)}{dt}$

$$\varepsilon = NBA\omega \sin \omega t$$

- Maximum value of induced emf is $\varepsilon_m = NBA\omega$
- The value of induced emf at any instant is then given by $\varepsilon = \varepsilon_m \sin \omega t$
- Instantaneous current $i = I_m \sin \omega t$

2. Explain the working of a single-phase AC generator with necessary diagram.

- **Principle :** Electromagnetic induction
- **Stator**:
  - The stationary part which has armature windings mounted in generator is called stator.
  - It has two components, namely stator core and armature winding.
- **Rotor:**
  - Rotor contains magnetic field windings.
  - The magnetic poles are magnetized by DC source.

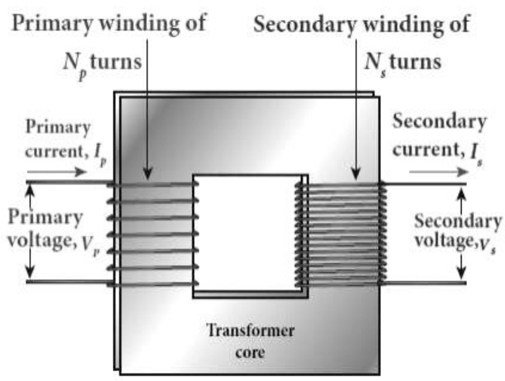


- ❖ **Working:**
  - ➢ The relative motion between a conductor and a magnetic field changes the magnetic flux linked with the conductor which in turn induces an emf and its direction is given by Fleming's right hand rule.

Rotation of field magnet w.r.t initial position	Orientation of field magnet w.r.t coil	Induced emf	Current	Position in graph
0^0	Perpendicular	Zero	No induced current	Point 'O'
90^0	Parallel	Maximum	induced current along **PQRS**	Point 'A'
180^0	Perpendicular	Zero	No induced current	Point 'B'
270^0	Parallel	Maximum	induced current along **SRQP**	Point 'C'
360^0	Perpendicular	Zero	No induced current	Point 'D'

3. Explain the construction and working of a transformer.

- ❖ **Principle :** Mutual induction between two coils.
- ❖ **Construction :**
  - ➢ It consists of two coils of high mutual inductance wound over the same transformer core made up of silicone steel. To avoid eddy current loss, the core is generally laminated. The alternating voltage applied across prim **(P)**, and the output is taken across secondary coil **(S)**
  - ➢ The emf induced in the primary coil **'ϵ_P'**



$$V_P = \epsilon_P = -N_P \frac{d\phi_B}{dt} \text{ -------(1)}$$

  - ➢ The emf induced in the secondary coil **'ϵ_S'**

$$V_S = \epsilon_S = -N_S \frac{d\phi_B}{dt} \text{ ------- (2)}$$

  - ➢ Dividing equation (1) by (2),

$$\frac{V_S}{V_P} = \frac{N_S}{N_P} = \text{K ------------- (3)}$$

K → transformation ratio

  - ➢ For an ideal transformer, **input power = output power**

$$V_P V_S = V_S i_S$$

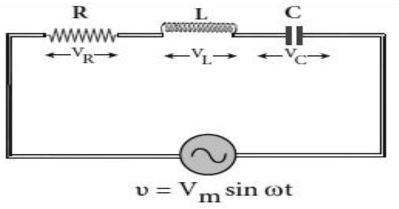
$$\frac{V_S}{V_P} = \frac{N_S}{N_P} = \frac{i_P}{i_S} = \text{K --------(4)}$$

K > 1 step up transformer	***K < 1*** step down transformer
$N_S > N_P$	$N_S < N_P$
$V_S > V_P$	$V_S < V_P$
$i_S < i_P$	$i_S > i_P$

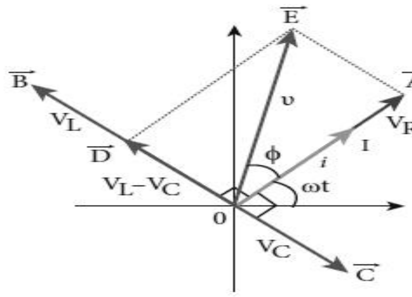
- ❖ The efficiency of a transformer $\eta = \frac{Output\ power}{Input\ power} \times 100\%$

4. Derive an expression for phase angle between the applied voltage and current in a series RLC circuit.

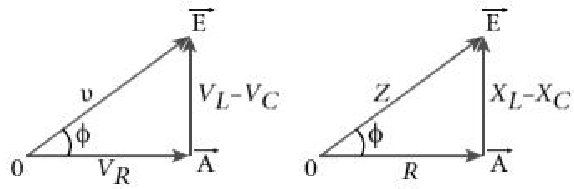
- Consider a circuit containing a resistor of resistance ‘R’, a inductor of inductance ‘L’ and a capacitor of capacitance ‘C’ connected across an alternating voltage source.
- The instantaneous value of the alternating voltage is given by $\boldsymbol{v = V_m \sin\omega t}$



  - $V_R = i R$ (*V_R is in phase with i*)
  - $V_L = i X_L$ (*V_L leads i by* $\frac{\pi}{2}$)
  - $V_C = i X_C$ (*V_C lags i by* $\frac{\pi}{2}$)
  - $\mathbf{v} = \sqrt{\mathbf{V_R}^2 + (\mathbf{V_L} - \mathbf{V})^2}$
  - $\mathbf{v} = \sqrt{\mathbf{i^2R^2} + (\mathbf{iX_L} - \mathbf{iX_C})^2}$
  - $\mathbf{v} = \mathbf{i}\sqrt{\mathbf{R^2} + (\mathbf{X_L} - \mathbf{X_C})^2}$



- ($\boldsymbol{i}$) Current flowing through the RLC circuit
  - $\mathbf{i} = \frac{\mathbf{v}}{\sqrt{\mathbf{R^2} + (\mathbf{X_L} - \mathbf{X_C})^2}}$
  - $\mathbf{i} = \frac{\mathbf{v}}{\mathbf{Z}}$
  - $\mathbf{Z} = \sqrt{\mathbf{R^2} + (\mathbf{X_L} - \mathbf{X_C})^2}$



- **Z** is called impedance of the circuit
- From the phasor diagram, the phase angle between ‘$\boldsymbol{v}$’ and ‘$\boldsymbol{i}$’ is found out by
  - $\tan \boldsymbol{\Phi} = \frac{V_L - V_C}{V_R} = \frac{X_L - X_C}{R}$

UNIT 5 . ELECTROMAGNETIC WAVES

2 MARK - QUESTIONS AND ANSWERS:

1. What are electromagnetic waves?

- Electromagnetic waves are non-mechanical waves which move with speed equals to the speed of light in vacuum.

2. What are Fraunhoffer lines? Give its application.

- The dark lines in the solar spectrum are known as Fraunhofer lines.
- It helps to identify elements in Sun’s atmosphere.

3. What is displacement current?

- The current present in the region in which the electric field or the electric flux are changing with time.

4. Write down the integral form of modified Ampere’s circuital law.

- Maxwell modified Ampere’s circuital law as . $\oint_l \vec{B}.\vec{dl} = \mu_0 (i_c + i_d)$ Here $\mathbf{i = i_c + i_d}$
- Where, **i** - Total current **;** $\mathbf{i_c}$ – Conduction current ; $\mathbf{i_d}$ –Displacement current.

5. Write notes on Ampere-hrough that path.Maxwell law.

- $\oint_l \vec{B}.\vec{dl} = \mu_0 (i_c + i_d) = \mu_0 i_c + \mu_0 \mathcal{E}_0 \frac{d}{dt} \oint_S \vec{E}.\vec{dA}$
- This law relates the magnetic field around any closed path to the conduction current and displacement current through that path.

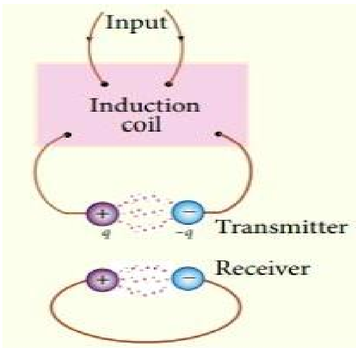
6. Write short notes on [i) microwaves (ii) X-ray (iii) radio waves (iv) visible spectrum

- **Microwaves:**
  - It is produced by special vacuum tubes (magnetron, gun diode)
  - It undergoes reflection and polarization.
- **X-ray:**
  - It is produced when there is a sudden stopping of high speed electrons by high-atomic number target and also by electronic transitions among innermost orbits of atoms.
  - X-rays have more penetrating power than ultraviolet radiation.
- **Radio waves:**
  - It is produced by accelerating charges in conducting wire.
  - It undergoes reflection and diffraction.
  - It is used in radio and television communication systems.
- **Visible light:**
  - It is produced by incandescent bodies and also it is radiated by excited atoms in gases.
  - It obeys the laws of reflection and refraction.
  - It undergoes interference, diffraction, polarization and photo-electric effect .

3 & 5 Mark Questions And Answers:

1. Describe production of electromagnetic waves by Hertz experiment.

- Construction:
  - Two small spherical metals as electrodes
  - These are connected to larger spheres
  - Ends are connected to induction coil to produce Emf.
  - Air between electrodes gets ionized to produce spark
  - This discharge of electricity affects another set of ring shaped electrodes at far distance
  - If receiver is rotated 90^0, no spark is seen.
  - This confirms EM waves are transverse
  - Speed of EM Wave = **$3 \times 10^8 ms^{-1}$** in vacuum.



2. Write down Maxwell equations in integral form.

Maxwell's 1^{st} equation	**(Gauss's law in electrostatics)** It relates the net electric flux to net electric charge enclosed in a surface. $\oint_S \vec{E} \cdot \vec{dA} = \frac{Q_{enclosed}}{\varepsilon_0}$ $\vec{E}$ is the electric field Q is the net charge
Maxwell's 2^{nd} equation	**(Gauss's law in magnetism)** The surface integral of magnetic field over a closed surface is zero. $\oint_S \vec{B} \cdot \vec{dA} = 0$ $\vec{B}$ is the magnetic field.
Maxwell's 3^{rd} equation	**(Faraday's law of electro - magnetic induction)** This law relates electric field with the changing magnetic flux. $\oint_l \vec{E} \cdot \vec{dl} = -\frac{d\Phi_B}{dt}$ Φ_B changing magnetic flux.
Maxwell's 4^{th} equation	**(Ampere - Maxwell's law)** This law relates the magnetic field around any closed path to the conduction current and displacement current through that path. $\oint_l \vec{B}.\vec{dl} = \mu_0 i_c + \mu_0 \varepsilon_0 \frac{d}{dt}\oint_S \vec{E}.\vec{dA}$

3. What is emission spectrum? Classify with example.

- When the spectrum of self luminous source.
- **Types of emission spectrum:** Continuous emission spectrum, Line emission spectrum, Band emission spectrum

Types of emission spectrum	Explanation	Examples
Continuous emission spectrum	✧ If the light from incandescent lamp is allowed to pass through prism. ✧ It splits into seven colours. ✧ Its contain all the visible colour ranging from violet to red.	✧ spectrum obtained from carbon arc and incandescent solids
Line emission spectrum	✧ Light from hot gas is allowed to pass through prism, line spectrum is observed. ✧ sharp lines of definite wavelengths ✧ Due to excited atoms of elements. ✧ These lines are the characteristics of the element.	✧ spectra of atomic hydrogen, helium.
Band emission spectrum	✧ several number of very closely spaced spectral lines which overlapped to form bands with dark spaces. ✧ sharp edge at one end and fades out at the other end. ✧ Due to excited of molecules. ✧ These lines are the characteristics of molecules.	✧ spectra of Ammonia gas ✧ **Use:** Study structure of molecules.

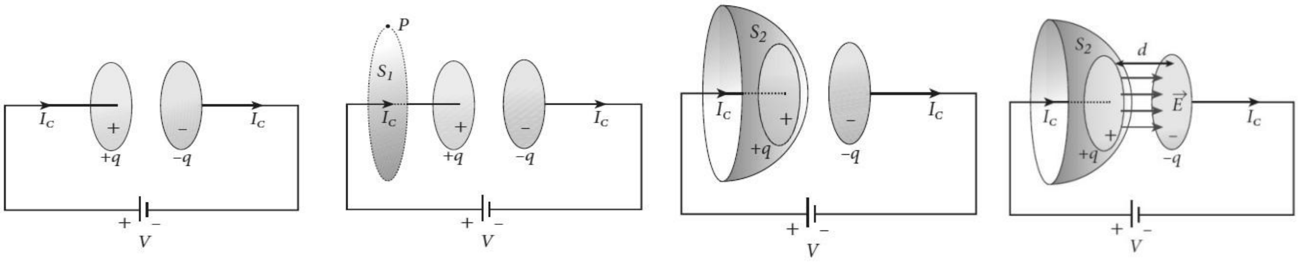
4. What is absorption spectra? Classify with example.

- When light is allowed to pass through a medium or an absorbing substance then the spectrum obtained is known as absorption spectrum

- **Types of absorption spectrum:** Continuous absorption spectrum, Line absorption spectrum, Band absorption spectrum.

Types of absorption spectrum	Explanation	Examples
Continuous absorption spectrum	✧ White light through a blue glass plate, it absorbs all the colours except blue	✧ This is an example for continuous absorption spectrum.
Line absorption spectrum	✧ White Light is passed through cold gas, it is obtained	✧ Light is passed through sodium vapour, a continuous spectrum of carbon arc with two dark lines in the yellow region are obtained.
Band absorption spectrum	✧ White Light is passed through the iodine vapour,	✧ white light is passed through diluted solution of blood or chlorophyll band absorption spectrum is obtained.

5. **Explain the Maxwell's modification of Ampere's circuital law.**
- Let the current which is passed through the wire called as conduction current I_c.
- A magnetic field produced around the current carrying wire.
- To calculate the magnetic field at a point *P* near the wire and outside the capacitor, let us draw a circular Amperian loop which encloses surface S_1.
- Using Ampere's circuital law ,we get



- $\oint \vec{B}.\vec{dl} = \mu_0 I$
- $\oint \vec{B}.\vec{dl} = 0$
- $\phi_E = \oint \vec{E}.\vec{dA} = EA = \frac{q}{\varepsilon_0}$
- The current present in the region in which the electric field or the electric flux are changing with time. $i_d = \varepsilon_0 \frac{d\phi_E}{dt}$
- $\oint \vec{B}.\vec{dl} = \mu_0(i_c + i_d) = \mu_0 i_c + \mu_0 \varepsilon_0 \frac{d\phi_E}{dt}$

UNIT 6. RAY OPTICS

2-MARK QUESTIONS AND ANSWERS:

1. **State the laws of refraction.(Snell's law)**
   - ➢ The incident ray, refracted ray and normal to the refracting surface are all coplanar.

$$\frac{\sin i}{\sin r} = \frac{n_2}{n_1}$$

2. **State the laws of reflection.**
   - ➢ The incident ray, reflected ray and the normal to the surface all are coplanar.
   - ➢ The angle of incidence (*i*) is equal to angle of reflection (*r*). That is $i = r$
3. **What is optical path?**
   - ➢ Optical path of a medium is defined as the distance d' light travels in vacuum in the same time it travels a distance **d** in the medium. $d' = n\,d$
4. **What is principle of reversibility?**
   - ➢ The principle of reversibility states that, light will be following exactly the same path if its direction of travel is reversed.
5. **Why do stars twinkle?**
   - ➢ Actually stars do not twinkle.
   - ➢ They appear twinkling because of the movement of the atmospheric layers with varying refractive index which is clearly seen in the sky.
6. **Define critical angle and total internal reflection.**
   - ➢ The angle of incidence in the denser medium for which the refracted ray graces the boundary is called ***critical angle (i_c)***
   - ➢ If the angle of incidence in the denser medium is greater than the critical angle, there is no refraction possible in the rarer medium. The entire light is reflected back in to the denser medium itself. This phenomenon is called ***total internal reflection.***
7. **Write the two conditions for total internal reflection.**
   - ➢ light must travel from denser to rarer medium.
   - ➢ angle of incidence in the denser medium must be greater than critical angle **($i > i_c$).**

8. What is power of a lens?

- The power of a lens P is defined as the reciprocal of its focal length. $P = \frac{1}{f}$ **Unit : dioptre (D)**

9. How are rainbows formed?

- Dispersion of sunlight through droplets of water during rainy days.
- When sunlight falls on the water drop suspended in air, it splits into its constituent seven colours.
- Thus water drop suspended in air behaves as a glass prism.

10. State Rayleigh's scattering law.

- The intensity (I) of Rayleigh's scattering is inversely proportional to fourth power of wavelength (λ) $I \propto \frac{1}{\lambda^4}$

11. Explain the reason for the glittering of diamond.

- Total Internal reflection.
- Refractive index of diamond is 2.417.
- Critical angle of diamond is about 24.4^o.
- Diamond has large number of cut plane faces.

12. Why does sky appear blue?

- Shortest wavelength gets much scattered during day time.
- As our eyes are more sensitive to blue colour than violet colour, sky appears blue during day time.

13. What are paraxial rays and marginal rays?

- The rays travelling very close to the principal axis and make small angles with it are called **paraxial rays.**
- The rays travelling far away from the principal axis and make large angles with it are called as **marginal rays**

14. What is the reason for reddish appearance of sky during sunset and sunrise?

- During sunrise and sun set, the light from sun travels a greater distance. So blue light which has shorter wavelength scattered away and red light of longer wavelength manages to reach our eyes.

15. What is dispersion?

- Splitting of white light into its constituent colours is called dispersion.
- The coloured band obtained due to dispersion is called spectrum.

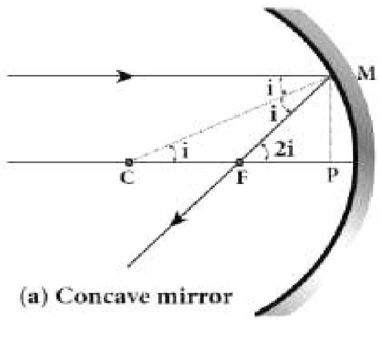
16. Define dispersive power.

- Dispersive power **(ω)** is the ability of the material of the prism to cause prism.
- It is defined as the ratio of the angular dispersion for the extreme colours to the deviation for any mean colour.
- It has no units and dimension. It is a positive number.

3-MARK QUESTIONS AND ANSWERS:

1. Derive the relation between f and R for a spherical mirror.

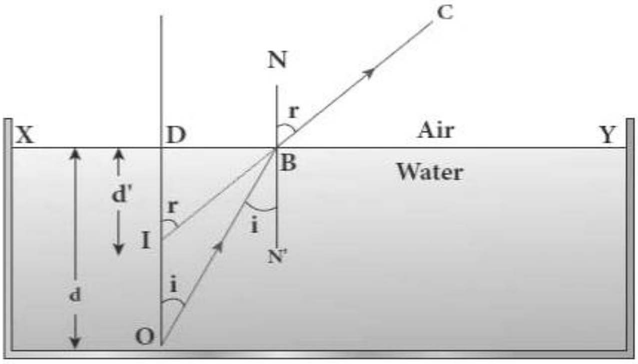
- C – centre of curvature of mirror, i – angle of incidence and F – principal focus.
- From figure, $\tan i = \frac{PM}{PC} = i$
- ΔMFP, $\tan 2i = \frac{PM}{PF} = 2i$
- $\frac{PM}{PF} = 2\frac{PM}{PC}$
- $\frac{1}{PF} = \frac{2}{PC}$
- Substitute, **PF = f, PC = R** $\boxed{f = \frac{R}{2}}$



(a) Concave mirror

2. Obtain the equation for apparent depth.

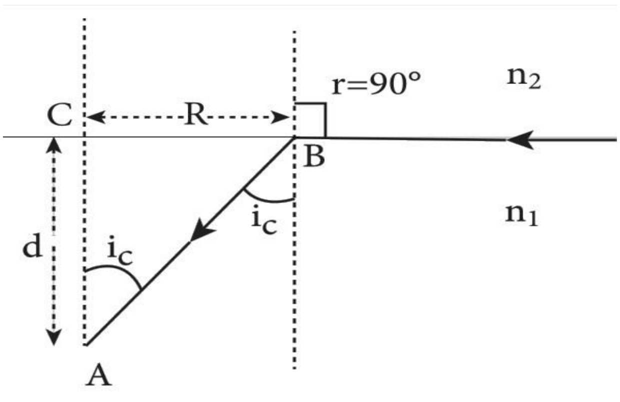
- We observe that the bottom of a tank filled with water with water appears raised as shown
- Light OB from the object 'O' passes through water get refracted in air
- Refractive index of water = **n1**
- Refractive index of air = **n2**
- Angle of incidence in water = i
- Here $n1 > n2$ Hence, $i < r$
- Angle of refraction in air = r
- Original depth of tank = **DO = d**
- Apparent depth of tank = **DI =** d'



- By Snell's law in product form, $n1 \sin i = n2 \sin r$
- As the angles are small, $\sin i = \tan i$; $\sin r = \tan r$
- Hence, $n1 \tan i = n2 \tan r$ ––––––(1)
- $\frac{d'}{d} = \frac{n_2}{n_1}$ $d' = \frac{n_2}{n_1} d$ **For air ;** $n_1 = n$, $n_2 = 1$,
- Then apparent depth
- $d' = \frac{d}{n}$ (or) $d - d' = d\left(1 - \frac{1}{n}\right)$

3. Obtain the equation for radius of illumination (or) Snell's window.

- Light is seem from a point 'A' at a depth 'd'
- Applying Snell's law in product form at point 'B,
- $n_1 \sin i_c = n_2 \sin 90^0$: $\sin 90^0 = 1$
- $n_1 \sin i_c = n_2$ -----------(1)
- From **ΔABC**
- $\sin i_c = \frac{CB}{AB} = \frac{R}{\sqrt{d^2 + R^2}}$ ----- (2)
- Compare equations (1) and (2)
- $\frac{R}{\sqrt{d^2 + R^2}} = \frac{n_2}{n_1}$
- **radius of illumination**
- $\mathbf{R} = \mathbf{d}\sqrt{\frac{n_2^2}{n_1^2 - n_2^2}}$
- If the rarer medium outside is air, then $\mathbf{n_2 = 1}$ and let $\mathbf{n_1 = n}$, then
- $\mathbf{R = d\left(\frac{1}{\sqrt{n^2 - 1}}\right)}$



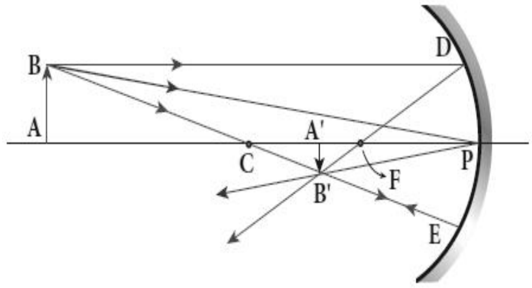
5-MARK QUESTIONS AND ANSWERS:

1. Derive the mirror equation and the equation for lateral magnification

- Let an object AB is placed on the principle axis of a concave mirror beyond the centre of curvature 'C'
- The real and inverted image A'B' is formed between C and F
- From figure, ΔABP & $\Delta A'B'P$ are similar triangles

$$\frac{A'B'}{AB} = \frac{PA'}{PA} \text{ ------------- (1)}$$

- Similarly ΔDPF & $\Delta A'B'F$ are similar triangles.



$$\frac{A'B'}{PD} = \frac{A'F}{PF} \text{ -------------- (2)}$$

$$PD = AB \qquad \frac{A'B'}{AB} = \frac{A'F}{PF} \text{ ---- (3)}$$

- Compare (1) & (3) We can write,

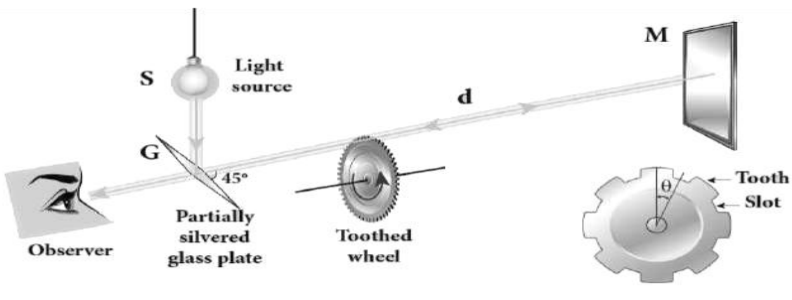
$$\frac{PA'}{PA} = \frac{PA' - PF}{PF} \text{ ----------- (4)} \quad (A'F = PA' - PF)$$

- $PA = -u$; $PA' = -v$; $PF = -f$ Substitute in (4)
- we can arrive $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$
- Lateral magnification

$$m = -\frac{v}{u} = \frac{f}{f-u}$$

2. Describe the Fizeau's method to determine speed of light.

- The light from the source **'S'** was first allowed to fall on a partially silvered glass plate **G** kept at an angle of **45°** to the vertical.
- The light then allowed passing through a rotating toothed-wheel with **N** -teeth and **N** -cuts.



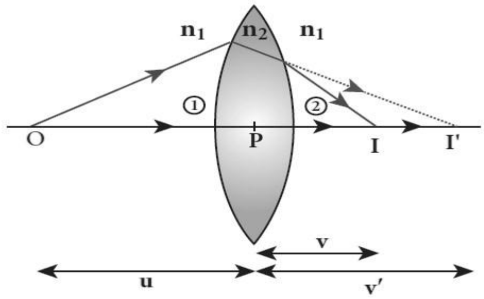
- The light passing through one cut in the wheel get reflected by a mirror M kept at a long distance 'd' (about 8 km) from the toothed wheel.
- If the toothed wheel was not rotating, the reflected light from the mirror would again pass through the same cut and reach the observer through G.
- Angular speed of wheel is

$$\omega = \frac{\theta}{t} = \frac{\pi}{Nt} \qquad \left[\because \theta = \frac{\pi}{N}\right]$$

- Time taken for the angular displacement θ is t. $\quad t = \frac{\pi}{N\omega}$
- The speed of light in air, $v = \frac{2d}{t} = \frac{2dN\omega}{\pi}$
- The speed of light in air was determined as, $v = 2.99792 \times 10^{8}\ m\ s^{-1}$

3. Obtain Lens maker formula.

- Thin lens of refractive index n_2 is placed in a medium of refractive index n_1
- Let R_1 and R_2 be radii of curvature of two spherical surfaces ① and ② respectively
- For refracting surface ①, the light goes from n_1 to n_2
- We know that, equation for single spherical surface



$$\frac{n_2}{v} - \frac{n_1}{u} = \frac{(n_2 - n_1)}{R}$$

- For refracting surface ①, the light goes from n_1 to n_2.

$$\frac{n_2}{v'} - \frac{n_1}{u} = \frac{(n_2 - n_1)}{R_1} \quad \text{------ (1)}$$

- For refracting surface ②, the light goes from n_2 to n_1

$$\frac{n_1}{v} - \frac{n_2}{v'} = \frac{(n_1 - n_2)}{R_2} \quad \text{------ (2)}$$

- Adding equation (1) and (2), we get,

$$\frac{n_1}{v} - \frac{n_1}{u} = (n_2 - n_1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right] \text{------ (3)}$$

- If the object is at infinity, image is formed at the focus of the lens. Then substitute **u = ∞ ,** **v = f** $n_2 = n$ and $n_1 = 1$(air) using eq; 3 we get

$$\frac{1}{f} = (n - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

- The above equation is called lens maker's formula. By comparing equation (2) and (3)

.

$$\boxed{\frac{1}{v} - \frac{1}{u} = \frac{1}{f}}$$

4. Obtain the equation for dispersive power of a medium.

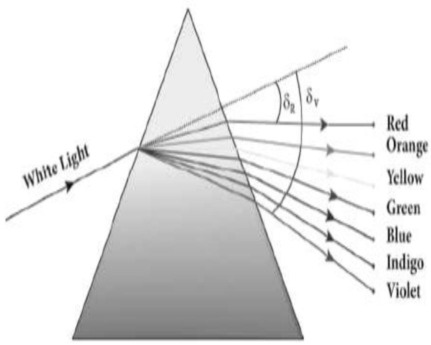
❖ **Dispersion :**

- Splitting of white light into its constituent colours is called dispersion. The coloured band obtained due to dispersion is called spectrum.
- Let A be the angle of prism and D be the angle minimum deviation
- The refractive index of the material of the prism is

$$\mathbf{n} = \frac{\sin\left(\frac{A+\delta}{2}\right)}{\sin\left(\frac{A}{2}\right)} \quad \text{---------(1)} \quad \sin\left(\frac{A}{2}\right) \approx \frac{A}{2}$$

$$\mathbf{n} = \frac{\left(\frac{A+\delta}{2}\right)}{\left(\frac{A}{2}\right)} = \frac{A+\delta}{A}$$

$$\delta = (n-1)A \quad \text{-------------- (2)}$$



- Thus, angle of deviation for violet and red light,

$$\delta_v = (n_v - 1)A \quad \text{-------(3)}$$

$$\delta_r = (n_r - 1)A \quad \text{-------(4)}$$

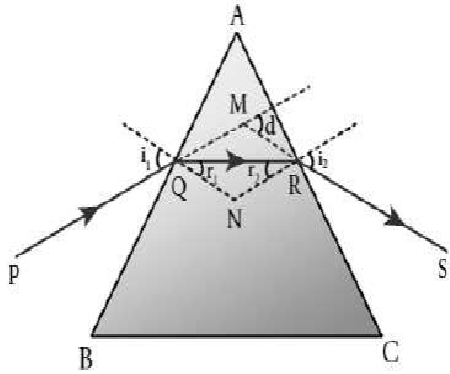
- The angular dispersion is given by,

$$\delta_v - \delta_r = (n_v - n_r)A \quad \text{-- (5)}$$

Definition, dispersive power

$$\omega = \frac{\text{angular dispersion}}{\text{mean deviation}} = \frac{\delta_v - \delta_r}{\delta} = \frac{n_v - n_r}{n - 1}$$

5. **Derive the equation for angle of deviation produced by a prism and thus obtain the equation for refractive index of material of the prism.**
   - Here, 'PQ' be incident ray, 'QR' be refracted ray and 'RS' be emergent ray.
   - From figure, $\angle\ MQR = d_1 = i_1 - r_1$ **and** $\angle\ MRQ = d_2 = i_2 - r_2$
   - Then total angle of deviation,



$$d = d_1 + d_2$$

$$d = (i_1 - r_1) + (i_2 - r_2)$$

$$d = (i_1 + i_2) - (r_1 + r \quad - - -(1)$$

ΔQNR,

$$A = r_1 + r_2 \qquad - - -(2)$$

   - Put equation (2) in equation (1),

$$d = (i_1 + i_2) - A \qquad - - -(3)$$

   - At angle of minimum deviation,

$$i_1 = i_2 = i \text{ and } r_1 = r_2 = r \text{ also } d = D.$$

   - Put this value in equation **(2)** and **(3)**

$$r = \frac{A}{2} \qquad\qquad i = \frac{A + D}{2}$$

   - **From Snell's law we get,**

$$n = \frac{\sin i}{\sin r} = \frac{\sin\left(\frac{A + D}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

UNIT 7. WAVE OPTICS

2 - MARK QUESTIONS AND ANSWERS:

1. **State Huygen's principle ?**
   - Each point on the wavefront behaves as the source of secondary wavelets spreading out in all directions with the speed of the wave. These are called as secondary wavelets.
   - The envelope to all these wavelets gives the position and shape of the new wavefront at a later time.

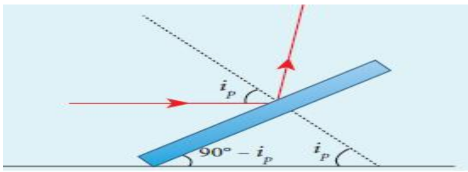
2. **What are coherent sources?**
   - Two light sources are said to be coherent if they produce waves which have same phase or constant phase difference, same frequency or wavelength, same waveform and same amplitude.

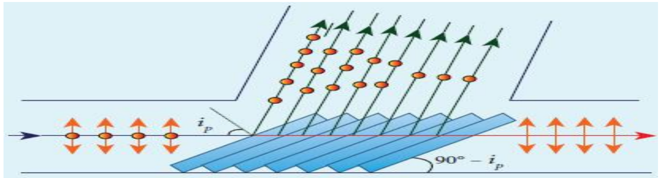
3. **What are the conditions for obtaining clear and broad interference fringes**
   - The distance between the screen and slits should be as large as possible.
   - The wavelength of the light used must be large.
   - The distance between the two slits must be small.

4. **What is double refraction?**
   - When a ray of unpolarised light is incident on a calcite crystal, two refracted rays are produced. Hence two images of an object are formed.

3 - MARK QUESTIONS AND ANSWERS:

1. Explain the pile of plates.

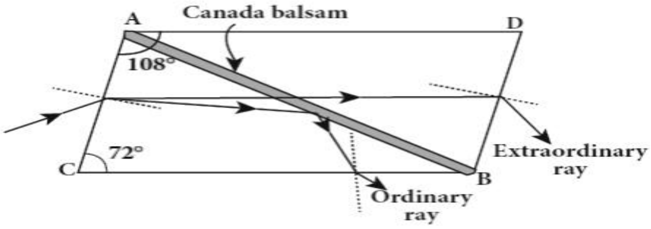




- It works on the principle of polarization by reflection.
- It makes use of Brewster's law.
- It consists of a number of glass plates placed one over the other in a tube.
- Several plates are kept one behind the other at an angle $\mathbf{90^o - i_p}$ with the horizontal surface.
- Parallel light falls on the plate at i_P, the refracted light get a chance for further reflections at the succeeding plates.
- Both refracted and reflected lights are found to be plane polarised.

2. Discuss about Nicol prism.

- Based on the principle of double refraction.
- It is a calcite crystal which has a length three times its breadth and angles **72^0 and 108^0.**



- It is cut into two halves along the diagonal and pasted together with a layer of canada balsam, a transparent cement.When unpolarised light is passed through Nicol prism , it splits into ordinary and extraordinary rays. For this calcite crystal.
- The refractive index for ordinary ray = **1.658**
- The refractive index for the extraordinary ray **= 1.486**
- The refractive index of canada balsam = **1.523**
- Extraordinary ray is transmitted and serves as a plane polarised ray.
- Its act as a polariser and analyser.

5 - MARK QUESTIONS AND ANSWERS:

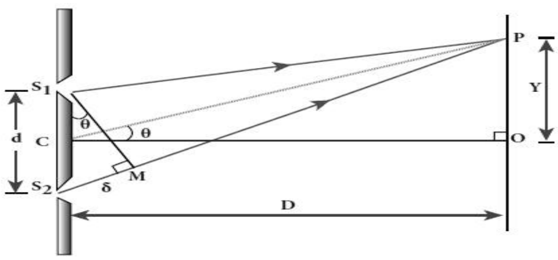
1. Obtain the equation for Path difference and band width in Young's double slit Experiment.

- Let distance between S_1 and S_2 **is d**
- Distance of the screen from double slit D
- Wavelength of coherent light wave = λ
- Hence path difference between the light waves from S_1 and S_1 to the point 'P'

$$\delta = \theta . d \text{ ------(1)}$$

$$\theta = \frac{y}{D}$$

$$\delta = \frac{y}{D}.d \text{ ------ (2)}$$



❖ **Condition for bright fringes:**

The path difference $\delta = n\lambda$

$$\frac{y}{D}.\text{d} = \text{n}\lambda \text{ - - - -(3)}$$

(n = 0,1,2,3……..)

- **The distance of n^{th} bright fringe:** $y_n = \frac{D}{d} n\lambda$

❖ **Condition for dark fringes:**

The path difference, $\delta = (2n-1)\frac{\lambda}{2}$

$$\frac{y}{D}.d = (2n-1)\frac{\lambda}{2} \quad ----(4) \qquad (n = 1,2,3\ldots\ldots)$$

- **The distance of n^{th} dark fringe:** $y_n = \frac{D}{d}(2n-1)\frac{\lambda}{2}$

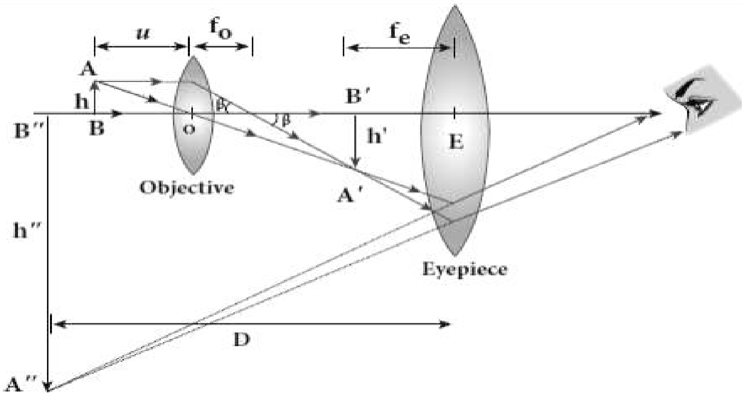
❖ **Band width:**

The distance between any two consecutive bright (or) dark fringes $\beta = y_{n+1} - y_n$

$$\beta = \frac{\lambda D}{d}$$

2. Explain about compound microscope and obtain the equation for Magnification.

- The lens near the object is called the objective, forms a real, inverted, magnified image of the object.
- Image produced by objective lens act as an object to the eyepiece.
- Eyepiece produces an enlarged and virtual image.



- Magnification of objective lens,

$$m_0 = \frac{h'}{h} = \frac{L}{f_0}$$

- The magnification of the eyepiece,

$$m_e = 1 + \frac{D}{f_e}$$

- The total magnification 'm' in near point focusing,

$$m = m_0 m_e = \left(\frac{L}{f_0}\right)\left(1 + \frac{D}{f_e}\right)$$

- If the final image is formed at infinity (normal focusing), the magnification if eye piece is,

$$m_e = \frac{D}{f_e}$$

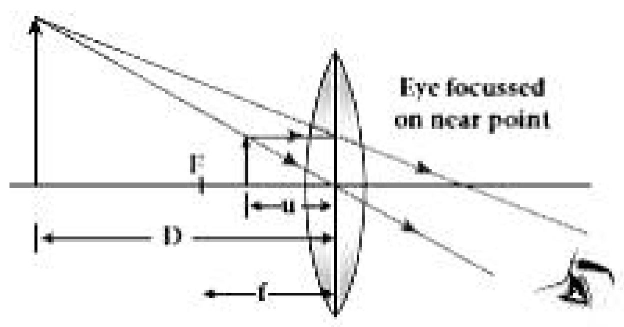
- The total magnification 'm' in normal focusing is,

$$m = m_0 m_e = \left(\frac{L}{f_0}\right)\left(\frac{D}{f_e}\right)$$

3. Discuss about simple microscope and obtain equation for magnification.

❖ **Simple microscope - Near point focussing** :

- A simple microscope is a single magnifying lens of small focal length.
- In near point focusing, object distance **u** is less than **f.** The image is formed at near point **or** least distance **D** of distinct vision.



- The Magnification m is given by,

$$m = \frac{v}{u} = \frac{-D}{-u}$$

- Lens equation,

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

- Magnification,

$$m = \frac{v}{u} = 1 + \frac{D}{f}$$

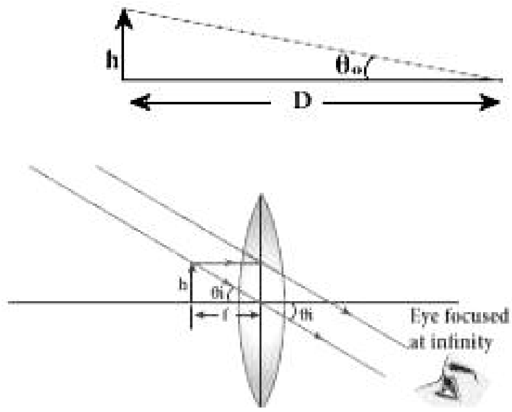
❖ **<u>Simple microscope - Normal focussing</u>** :

- Here the image is formed at infinity,
- Angular magnification is

$$\mathbf{m} = \frac{\theta_i}{\theta_0} \quad \text{- - - - (1)}$$

$$\tan\theta_0 \approx \theta_0 = \frac{h}{D}$$

$$\tan\theta_i \approx \theta_i = \frac{h}{f}$$



- Using equation (1) we get,
- The angular magnification is

$$\boxed{\mathbf{m} = \frac{D}{f}}$$

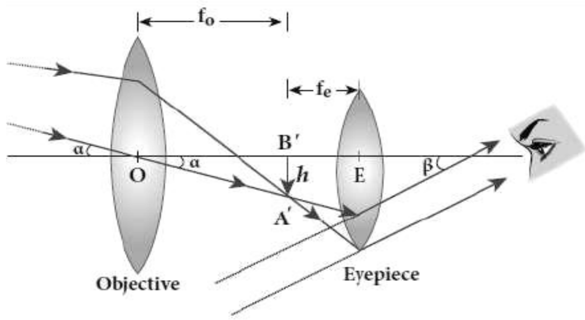
4. Discuss about astronomical telescope.

- An astronomical telescope is used to get the magnification of distant astronomical objects like stars, planets.
- The image formed by this will be inverted.
- It has an objective of long focal length and a much larger aperture than eye piece.
- Light from a distant object enters the objective and a real image is formed in the tube at its second focal point.

❖ **Magnification (m) :**

- The magnification 'm' is the ratio of the angle ***(β)*** subtended at the eye by the final image to the angle ***(α)*** which the object subtends at the lens or the eye.

$$\mathbf{m} = \frac{\beta}{\alpha}$$



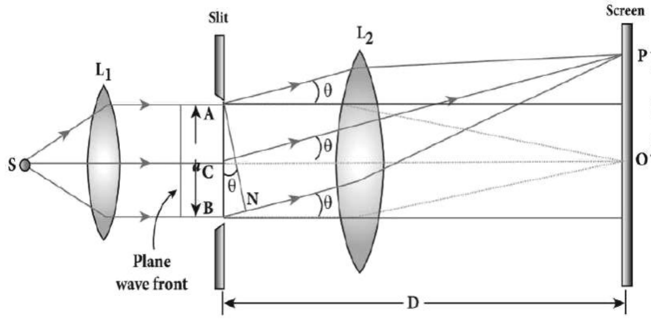
- From figure,

$$\mathbf{m} = \frac{\left(\frac{h}{f_e}\right)}{\left(\frac{h}{f_0}\right)} = \frac{f_0}{f_e}$$

- The length of the telescope is approximately

$$\boxed{L = f_o + f_e}$$

5. Discuss about diffraction in single slit.



- Let a parallel beam of light fall normally on a single slit AB.
- The centre of the slit is C,
- D – distance between screen and slit

- Path difference between the corresponding points $\boldsymbol{\delta} = \frac{a}{2}\sin\theta$
- Condition for first minimum, $\mathbf{a}\sin\theta = \lambda$
- Condition for second minimum, $\mathbf{a}\sin\theta = 2\lambda$
- Condition for nth minimum, $\mathbf{a}\sin\theta = n\lambda$ **Where n = 1,2,3……**

- Condition for first maximum, $\mathbf{a}\sin\theta = \frac{3\lambda}{2}$
- Condition for second maximum, $\mathbf{a}\sin\theta = \frac{5\lambda}{2}$
- Condition for n^{th} maximum, $\mathbf{a}\sin\theta = (2n+1)\frac{\lambda}{2}$ **Where n = 0,1,2,3,…..**

UNIT 8. DUAL NATURE OF RADIATION AND MATTER

2 - MARK QUESTIONS AND ANSWERS:

1. What is photoelectric effect?

- The ejection of electrons from a metal plate when illuminated by light or any other electromagnetic radiation of suitable wavelength is called Photoelectric effect.

2. Define work function of a metal. Give its unit.

- The minimum energy needed for an electron to escape from the metal surface is called work function of that metal. Its unit is electron volt.**(eV**).

3. Define surface barrier.

- The potential barrier which prevents free electrons from leaving the metallic surface is called Surface Barrier.

4. Define electron volt (eV).

- It is the kinetic energy gained by an electron when it is accelerated through a potential difference of 1 Volt.**1eV = 1.6×10^{-19} J**

5. Define stopping potential.

- The negative or retarding potential given to collecting electrode which is just sufficient to stop the most energetic photo electrons emitted and make the photo current zero is called stopping potential or cut-off potential.

6. Define threshold frequency.

- For a given metallic surface, the emission of photo electrons takes place only if the frequency of incident light is greater than a certain minimum frequency called **Threshold frequency**.

7. What is photo electric cell? Give its types.

- The device which converts light energy into electrical energy is called Photo electric cell.
- It works on the principle of photo electric effect.
- They are of three types : Photo emissive cell, Photo voltaic cell, Photo conductive cell .

8. A proton and an electron have same kinetic energy. Which one has greater de Broglie wavelength. Justify.

- De – Broglie wavelength $\lambda \ \alpha \ \frac{1}{\sqrt{m}}$ $\quad \lambda \frac{h}{\sqrt{2meV}}$
- mass of the electron < mass of the proton $[m_e < m_p]$
- wavelength of the electron > wavelength of the proton $[\lambda_e > \lambda_p]$

9. Why we do not see the wave properties of a baseball?

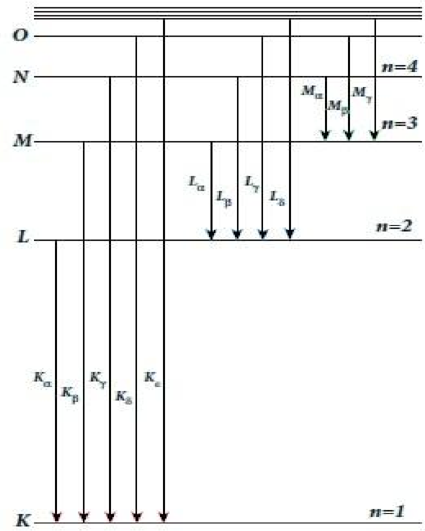
- De – Broglie wavelength of matter is $\lambda = \frac{h}{mv}$ So the de Broglie wavelength is inversely proportional to the mass.Since the mass of baseball is too large as compared with the electron, the de Broglie wavelength of baseball is negligibly small.
- So we do not see the wave property of the baseball.

3 - MARK QUESTIONS AND ANSWERS :

1. Derive an expression for de Broglie wavelength of electron.

- The kinetic energy of the electron is given by $\frac{1}{2}mv^2 = eV$
- The speed of the electron is $v = \sqrt{\frac{2eV}{m}}$
- Hence, the de Broglie wavelength of the electron is $\lambda = \frac{h}{mv} = \frac{h}{\sqrt{2meV}}$
- Kinetic energy **k=eV** then $\lambda = \frac{h}{\sqrt{2mk}}$
- Substituting the known values $\lambda = \frac{12.27\ A^0}{\sqrt{V}}$

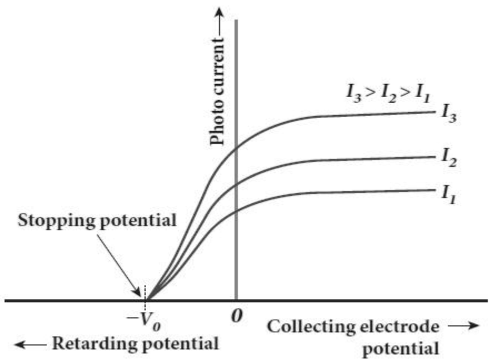
2. Write a note on characteristic X-ray spectra.



- When the target is hit by fast electrons,the obtained X-ray spectra shows some narrow peaks at some well defined wave-length.
- The line spectrum showing these peaks is called characteristic X-ray spectrum. This X-ray spectrum is due to the ***electronic transitions*** Within the atoms.
- **For example,** when an energetic electron penetrates into the target atom and removes the electrons in **K-shell** and create a vacancy in it.
- So the electrons from outer orbits **(L,M,N,O.)** jump to fill up the vacancy in **K-shell.**
- The energy difference between the levels is given out in the form of X-ray photon. **K-series (K_α, K_β, K_γ…)** originates due to Electronic transition from **L,M,N,O….** shells to **K-shell. L-series (L_α, L_β, L_γ…)** originates due to electronic transition from **M,N,O….**shells to **L-shell.**

FIVE MARK QUESTIONS AND ANSWERS:

1. Explain the effect of Potential difference on photoelectric current.



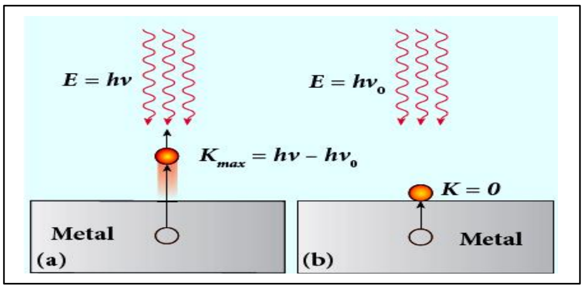
- Frequency, Intensity – Constant.
- Positive Anode potential increases,
- Photo current increases.Finally Photo current reaches saturation.
- When a negative potential is applied to A photocurrent becomes zero V_0 called **stopping potential (or) cut off potential**.
- The negative potential when given to the collecting electrode, photo electrons emitted make the photo current zero, is called stopping potential.
- The initial kinetic energy of the fastest electron **(K_{max})** is equal to the work done by the stopping potential to stop it. (eV_o).
- $K_{max} = \frac{1}{2} mv^2_{max} = eV_o$; $v_{max} = \sqrt{\frac{2ev_0}{m}}$
- Stopping potential and the maximum kinetic energy of the photoelectrons is independent of intensity of the incident light.

2. Obtain Einstein's photoelectric equation with necessary explanation.

- When a photon of energy $h\nu$ is incident on a metal surface, it is completely absorbed by a single electron is utilized in two ways.
- Part of the photon energy is used for the ejection of the electrons from the metal surface and it is called *work function* (ϕ_0).

- Remaining energy as the kinetic energy $\frac{1}{2}mv^2$ of the ejected electron
- From the law of conservation of energy,

$$h\nu = \phi_0 + \frac{1}{2}mv^2 \text{ --------(1)}$$



- At threshold frequency,

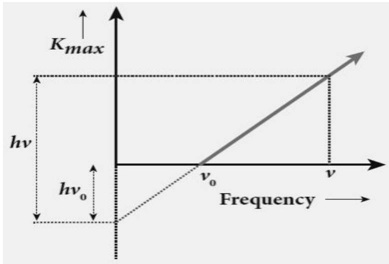
$$h\nu_0 = \phi_0 \text{ ---------------(2)}$$

- Substitute (2) in (1)

$$h\nu = h\nu_0 + \frac{1}{2}mv^2 \text{ --------(3)}$$

- **The equation (3) is known as Einstein's photoelectric equation.**
- If the electron does not lose energy by internal collisions, then it is emitted with maximum kinetic energy

$$h\nu = h\nu_0 + \frac{1}{2}mv_{max}^2 \text{ -----(4)}$$

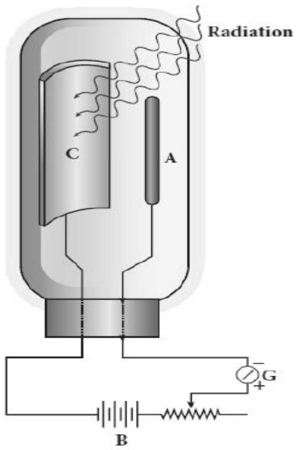


- Maximum kinetic energy of photoelectron; $K_{max} = \frac{1}{2}mv_{max}^2$

$$h\nu = h\nu_0 + K_{max} \text{ ----------(5)}$$

$$\boxed{K_{max} = h\nu - h\nu_0}$$

3. Give the construction and working of photo emissive cell.



- **Principle:** Photoelectric effect
- **Construction:**
  - It consists of an evacuated glass or quartz bulb.
  - The cathode *C* is semi-cylindrical in shape and is coated with a Photo sensitive material.
  - The anode *A* is a thin rod or wire.
  - A potential difference is applied between the anode and the cathode through a galvanometer *G*.
- **Working:**
  - When cathode is irradiated with suitable radiation, electrons are emitted from it.
  - These electrons are attracted by anode and hence a current is produced which is measured by the galvanometer.
  - The magnitude of the current depends on i) the intensity of incident radiation and ii) the potential difference between anode and cathode.

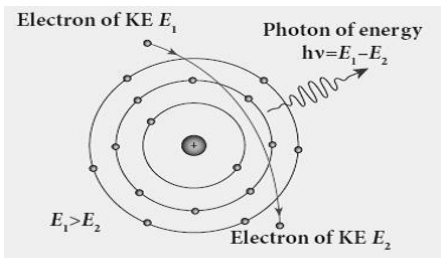
4. Write a note on continuous X-ray spectrum.

(1) When a fast moving electron penetrates and approaches a target nucleus, the electron either accelerates or decelerates.It results in a change of path of the electron.

(2) The radiation produced from such decelerating electron is called **Bremsstrahlung (or) braking radiation.**

(3) The energy of the photon emitted = The loss of kinetic energy of the electron.

$$h\nu = \frac{hc}{\lambda_0} = eV$$

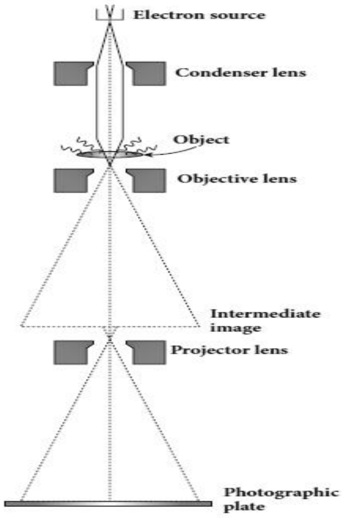


Substitute the known values,

Minimum wavelength $\lambda_0 = \frac{12400}{V}$ Å

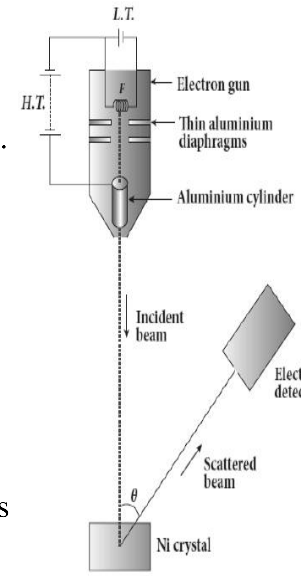
This relation is known as **Duane-Hunt** formula.

5. Explain the principle and working of electron microscope.



- **Principle:** The wave nature of the moving electron
- **Construction:**
  - In electron microscope focusing of electron beam is done. By the electrostatic or magnetic lenses.
- **Working:**
  - The electrons emitted from the source are accelerated by high potentials.
  - The beam is made parallel by magnetic condenser lens.
  - When the beam passes through the sample whose magnified image is needed, the beam carries the image of the sample.
  - With the help of magnetic objective lens and Magnetic Projector lens system, the magnified image is obtained on the screen.

6. Describe briefly Davisson – Germer experiment which demonstrated the wave nature of electrons.



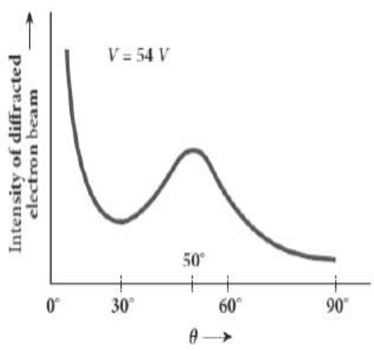
- **Construction :**
  - The filament F is heated by a low tension **(L.T.)** battery.
  - Electrons are emitted from the hot filament by **thermionic emission**.
  - They are then accelerated due to the potential difference between the filament and the anode aluminium cylinder by a high tension **(H.T.)** battery.
  - Electron beam is collimated by using two thin aluminium diaphragms and is allowed to strike a single crystal of **Nickel.**
- **Working :**
  - The intensity of electron scattered by **Ni** atoms in different directions are measured by the electron detector which is capable of rotation.
  - For a given accelerating voltage **(54 V)**, the scattered wave shows a maximum intensity at an angle of $\mathbf{50^0}$
- **Conclusion:**

  The wavelength of electron

  i) By experiment **(angle = 50^0)** $\boldsymbol{\lambda = 1.65Å}$

  ii) The wavelength can also be calculated from de Broglie relation For V = **54 V**

$$\boldsymbol{\lambda = \frac{12.27\,A^0}{\sqrt{V}} = \frac{12.27\,A^0}{\sqrt{54}} = 1.67Å}$$



  - This experiment directly verifies de-Broglie's hypothesis of the wave nature of moving particles.

UNIT 9. ATOMIC AND NUCLEAR PHYSICS

2 - MARK QUESTIONS AND ANSWERS:

1. Define atomic mass unit (u).

- ✧ **1amu =** $\frac{1}{12^{th}}$ of the mass of the isotope of carbon $^{12}C_6$. **1 amu = 1.660 x10^{-27} Kg**

2. Define Impact parameter.

- ✧ Perpendicular distance between Centre of gold nucleus and velocity vector of alpha particle at large distance.

3. Define excitation energy.

- ✧ The energy required to excite an electron from lower energy state to any higher energy state is known as excitation energy.

4. Define a) Isotope b) Isobar c) Isotone with an example for each Elements.

	Elements	Atomic No.	Mass No.	Example
Isotope	Same	Same	Different	$_1H^1$, $_1H^2$
Isobar	Different	Different	Same	$_{16}Si^{40}$, $_{17}cl^{40}$
Isotone	Different	Different	Different	**Same no. of neutron** $_5B^{12}$, $_6C^{13}$

5. Define Ionization energy (or) Binding energy.

- ✧ The minimum energy required to remove an electron from an atom in the ground state is known as ionization energy.

6. What is mass defect.

- ✧ Mass defect = Total mass of nucleons – mass of nucleus.

7. What is meant by radioactivity?

- ✧ Spontaneous emission of highly penetrating radiations such as α, β and ϒ rays by an element **(Z** > **82**) is called radioactivity

8. Define one Curie.

- ✧ Number of decays per second in One gram of radium; **1 curie = 3.7 x 10^{10} decays / second**

9. What is meant by activity or decay rate? Give its unit.

- ✧ Number of nuclei decayed per second **R =** $\frac{dN}{dt}$ **;** Unit is Becquerel.

10. Define Half-life.

- ✧ Time required for number of atoms initially present to reduce one half of initial amount.

$$T_{\frac{1}{2}} = \frac{0.6931}{\lambda}$$

11. Define mean life.

- ✧ Ratio of sum of life time of all nuclei to total number of nuclei present initialty. $\tau = \frac{1}{\lambda}$

12. What are the constituent particles of neutron and proton?

- ✧ Proton is made up of two up quarks and one down quark
- ✧ Neutron is made up of one up quark and two down quarks

13. Explain Proton – Proton cycle

$_1H^1 + {_1H^1} \rightarrow {_1H^2} + e^+ + \nu$

$_1H^1 + {_1H^2} \rightarrow {_2He^3} + \gamma$

$_2He^3 + {_2He^3} \rightarrow {_2He^4} + {_1H^1} + {_1H^1}$ Over all Energy produced = 27 MeV.

14. What is radio carbon dating?

- ✧ Radioactive dating or carbon dating is the technique to estimate the age of ancient object by using radio carbon isotope ($_6C^{14}$)

15. What is binding energy of a nucleus? Give its expression.

- ✧ When Z protons and N neutrons are combine form a nucleus, the mass disappear equivalent to mass defect (Δm) is converted in to energy which is used to bind the nucleons in the nucleus. This is known as binding energy (BE) of a nucleus.
- ✧ $BE = \Delta mc^2 = [(Zm_p + Nm_n) - M]c^2$

3 -MARK QUESTIONS AND ANSWERS :

1. State the postulates of Bohr atom model

- ✧ The centripetal force for the electron is given by coulomb force.
- ✧ The angular momentum of electron $\mathbf{L = \frac{nh}{2\pi}}$
- ✧ Electron jumps from one orbit to another emitting a photon of energy, $\mathbf{\Delta E = E_f - E_i = h\nu}$.

2. Give the limitations of Bohr atom model.

- ✧ Valid only for H_2
- ✧ Cannot explain fine structure
- ✧ Cannot explain intensity variation of spectral lines
- ✧ Cannot explain distribution of electrons

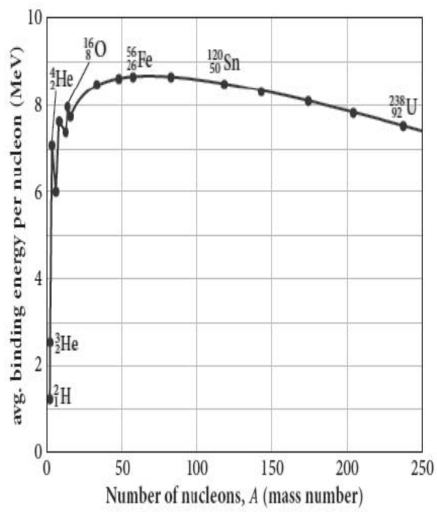
3. Give the results of Rutherford alpha particle scattering experiment.

- ✧ Most of the alpha particles goes without any deviation.
- ✧ Some of the alpha particles are deflected with small angle.
- ✧ A few of alpha particles are deflected above 90^0.
- ✧ Very few numbers of alpha particles retrace their path with 180^o.

4. Explain Alpha decay, beta decay and gamma emission.

Decay	Atomic No.	Mass No.	Examples
α - decay	Decreases by **2**	Decreases by **4**	$\mathbf{_{92}U^{238} \rightarrow {}_{90}Th^{234} + {}_{2}He^{4}}$
+ β - decay	Decreases by **1**	Remain the same	$\mathbf{_{11}Na^{22} \rightarrow {}_{10}Ne^{22} + e^{+} + \nu}$
- β - decay	Increases by **1**	Remain the same	$\mathbf{_{6}C^{14} \rightarrow {}_{7}N^{14} + e^{-} + \bar{\nu}}$
γ - decay	Remain the same	Remain the same	$\mathbf{_{5}B^{12} \rightarrow {}_{6}C^{12*} + e^{-} + \bar{\nu}}$

5. Explain the variation of average binding energy with the mass number using graph and discuss about its features.



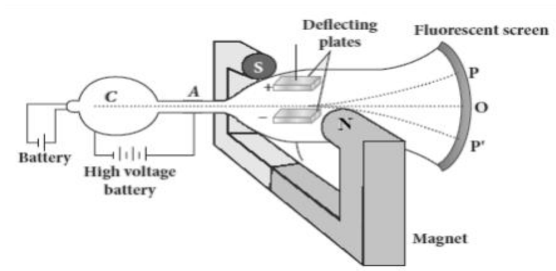
- ✧ **BE** is taken along y axis, mass number **A** is taken along x axis.
- ✧ **A < 40** Mass no A increases, average binding energy per nucleon *BE* increases.
- ✧ **A = 56** BE becomes maximum for Fe, which is **8.8 MeV**
- ✧ **A = 40 to 12** Average **BE/A = 8.5 MeV**
  These elements are more stable and non radioactive
- ✧ **A > 120,** Average BE is decreases, BE for **Uranium** is **7.6 MeV.** They are unstable and radioactive.
- ✧ **A < 28,** elements combine to form **A < 56** This the basis of **Nuclear fusion** and its principle of **Hydrogen bomb**.
- ✧ Heavy element split to form medium value A nuclei. This the basis of **Nuclear fission** and its principle of **Atom bomb.**

5 - MARK QUESTIONS AND ANSWERS:

1. Explain the J.J. Thomson experiment to determine the specific charge of electron.

- ❖ **Principle:** Deflection of electron in electric and magnetic field.

- ❖ **Construction:**



1) Cathode rays are produced in discharge tube
2) It is made into narrow beam by anode disc.
3) **E** is provide by parallel plates.
4) ***B*** is provided by magnets.
5) Cathode rays fall on screen at O to produce fluorescence.

- ❖ **Determination of velocity of Cathode rays:**
  - ✧ Let 'e' be the charge of cathode ray particle.
  - ✧ The upward force acting on cathode rays due to electric field 'E' is $F_E = eE$
  - ✧ The downward force acting on cathode rays due to magnetic field is $F_B = eBv$
  - ✧ In undeflected equilibrium position, $\mathbf{Bev = eE}$

$$v = \frac{E}{B} \text{ - - - - (1)}$$

- ❖ **Determination Specific charge:**
  - ✧ Potential energy = Kinetic energy

$$eV = \frac{1}{2} mv^2$$

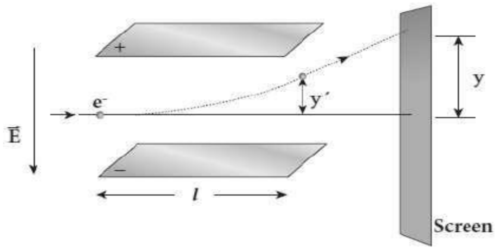
$$\frac{e}{m} = \frac{1}{2}\frac{v^2}{V}$$

  - ✧ **Using eqn. (1) we get** $\frac{e}{m} = \frac{E^2}{2VB^2} = 1.7 \times 10^{11}\ \mathrm{C\,kg^{-1}}$

- ❖ **Deflection of charge only due to uniform electric field:**
  - ✧ When the magnetic field is turned off **(B = 0)**, the deflection is only due to electric field.

$$a_e = \frac{eE}{m} \quad ; \quad t = \frac{l}{v}$$

$$y' = \frac{1}{2}\left(\frac{e}{m}\right)\frac{l^2B^2}{E}$$

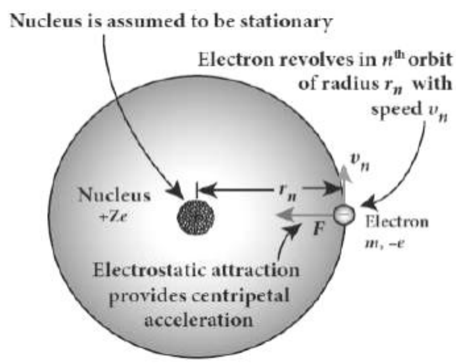


$$y = C\ y'$$

$$\frac{e}{m} = \frac{2yE}{C\,l^2B^2} = 1.7 \times 10^{11}\ \mathrm{C\,kg^{-1}}$$

2. Derive the expression for the radius of n^th^ orbit of an electron and its velocity

- ✧ Atomic number = Z
- ✧ Total charge of the nucleus = $+Ze$
- ✧ Charge of an electron = $-e$
- ✧ Mass of the electron = m
- ✧ From Coulomb's law,



$$\vec{F}_{\text{Coulomb}} = -\frac{1}{4\pi\varepsilon_0}\frac{Ze^2}{r_n^2}\hat{r}$$

- ✧ Centripetal force given by,

$$\vec{F}_{\text{Centripetal}} = -\frac{mv_n^2}{r_n}\hat{r}$$

- At equilibrium, $|F_{\text{Coulomb}}| = |F_{Centripetal}|$

$$r_n = \frac{4\pi\mathcal{E}_0(mv_nr_n)^2}{Zme^2} \text{ - - -(1)}$$

- From Bohr's assumption ; $mv_nr_n = \frac{nh}{2\pi}$ - - - - - (2)
  Substitute **(2)** in **(1)**

$$r_n = \frac{4\pi\mathcal{E}_0}{Zme^2}\ \frac{n^2h^2}{4\pi^2}$$ So radius, $$r_n = a_0\,\frac{n^2}{Z}$$

- Here $a_0 = \frac{\mathcal{E}_0\, h^2}{\pi\, m\, e^2} = 0.529$ **Å** This is known as Bohr radius
- For hydrogen **(Z = 1)**, $r_n = a_0 n^2$ **(i.e)** $r_n \propto n^2$
- The velocity of the electron decreases as the principal quantum number increases **(i.e)** $v_n\ \alpha\ \frac{1}{n}$

3. Explain the spectral series of an hydrogen atom.

n- lower energy orbit, **m-** higher energy orbit and **R-** Rydberg's constant

n	m	Series	Wave number $\frac{1}{\lambda} = R\left(\frac{1}{n^2} - \frac{1}{m^2}\right) = \bar{v}$	Region
1	2,3,4…	**Lyman**	$\bar{v} = R\left(\frac{1}{1^2} - \frac{1}{m^2}\right)$	**UV**
2	3,4,5…	**Balmer**	$\bar{v} = R\left(\frac{1}{2^2} - \frac{1}{m^2}\right)$	**Visible**
3	4,5,6…	**Paschen**	$\bar{v} = R\left(\frac{1}{3^2} - \frac{1}{m^2}\right)$	**Near IR**
4	5,6,7…	**Brackett**	$\bar{v} = R\left(\frac{1}{4^2} - \frac{1}{m^2}\right)$	**Middle IR**
5	6,7,8…	**P Fund**	$\bar{v} = R\left(\frac{1}{5^2} - \frac{1}{m^2}\right)$	**Far IR**

4. Derive the energy expression for hydrogen atom using Bohr model.

- The Potential energy for the n[th] orbit is $$U_n = -\frac{Z^2me^4}{4\mathcal{E}_0^2\, h^2n^2}$$
- The Kinetic energy for the n[th] orbit is $$KE_n = \frac{Z^2me^4}{8\mathcal{E}_0^2\, h^2n^2}$$
- This implies that $U_n = -2KE$ - - -(1)
- Total energy in the n[th] orbit $E_n = KEn + Un$:

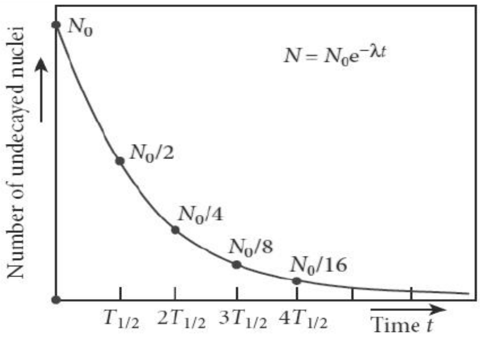
  Using eqn (1) $$E_n = KEn - 2\ KEn = -KEn = -\frac{Z^2me^4}{8\mathcal{E}_0^2\, h^2n^2}$$

- For hydrogen atom (Z =1) and substitute the known value $E_n = -\frac{13.6}{n^2}$ eV
- Negative sign indicate that electron is bound to the nucleus.

5. Obtain the expression for number of atoms present at any instant and also derive the equation for half-life period.

- **Law of Radioactivity :**
- At any instant t, the number of decays per unit time, called rate of decay **(dN/dt)** is proportional to the number of nuclei **(N)** at the same instant. This is called law of radioactive decay.
- N_o be the number of nuclei at initial time (t = 0)
- Let 'N' be the number of undecayed nuclei at any time 't'
- If 'dN' be the number of nuclei decayed in time 'dt' then, rate of decay = $\frac{dN}{dt}$
- From law of radioactivity,

$$\frac{dN}{dt} \propto N \quad \text{(or)} \quad \frac{dN}{dt} = -\lambda N \qquad \text{---(1)}$$



- Integrating on both sides,

$$\int_{N_0}^{N} \frac{dN}{dt} = -\lambda \int_0^t dt$$

$$\ln\left[\frac{N}{N_0}\right] = -\lambda t$$

- Taking exponential on both sides, $\frac{N}{N_0} = e^{-\lambda t}$: $N = N_0\, e^{-\lambda t}$ ---(2)
- Equation **(2)** is called the law of radioactive decay. Here the number of atoms is decreasing exponentially over the time. This implies that the time taken for all the radioactive nuclei to decay will be infinite.

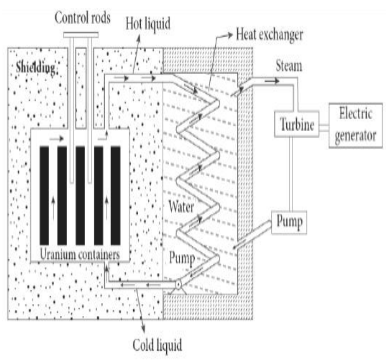
- **Half life :** The time required for the number of atoms to reduce one half of the initial amount.

$$N = \frac{N_0}{2} \text{ and } \quad t = T_{\frac{1}{2}}$$

$$\frac{N_0}{2} = N_0 e^{-\lambda T_{\frac{1}{2}}} \qquad \therefore \quad T_{\frac{1}{2}} = \frac{0.6391}{\lambda}$$

7. What is nuclear reactor? Explain its essential parts.

- Nuclear reactor is a system in which the nuclear fission takes place in a self-sustained controlled manner.

Parts	Function of the part	Material used	Diagram
Fuel	Fissionable material	Uranium-235, Plutonium	
Moderator	To slow down the neutron	Heavy water, Graphite	
Control rod	Controls the reaction rate by absorbing neutrons	Cadmium, Boron	
Cooling system	Removes the heat generated in the reactor core	Water, Heavy water ,Liquid sodium	
Shielding	Protects from harmful Radiations	concrete wall of thickness 2 to 2.5 m	

8. Discuss the Millikan's oil drop experiment for the determination of charge of an electron.

- **<u>Principle</u>:**

- By adjusting the electric field, motion of the oil drop can be controlled, can be made to move up or down.

❖ **Construction:**

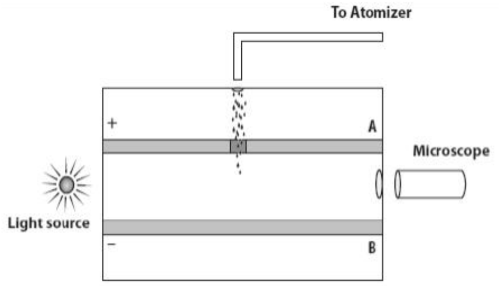
✧ A and B each with diameter around 20cm are separated by a distance of 1.5cm

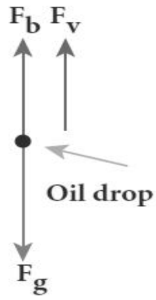
✧ Parallel plates are enclosed in an evacuated glass chamber

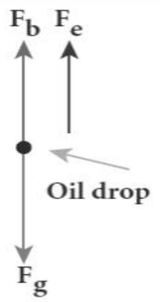
✧ 10KV potential difference is applied between the plates.

✧ A small hole is made at the centre of the plate A

✧ An atomizer is kept exactly above the hole to spray the liquid.Chamber is illuminated by light and oil drops can be seen clearly using microscope.







❖ **Forces on drop**

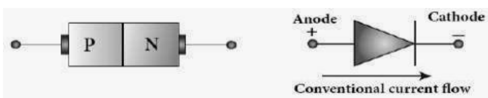
- **Downward gravitational force** F_g = mg = $\frac{4}{3}\pi r^3 \rho g$
- **Electric force** F_e = q E
- **Upward Buoyant force** $F_b = \frac{4}{3}\pi r^3 \sigma g$
- **Viscous force** F_v = 6πηv

Under gravity force	Under Electric force
Determination of radius of the oil drop	**Determination of electric charge:**
$F_g = F_b + F_v$	$F_e + F_b = F_g$
$\frac{4}{3}\pi r^3(\rho - \sigma)g = 6\pi\eta v$	$qE = \frac{4}{3}\pi r^3(\rho - \sigma)g$
$r = \left[\frac{9}{2(\rho - \sigma)}\frac{\eta}{g}\right]^{\frac{1}{2}}$	$q = \frac{4}{3E}\pi r^3(\rho - \sigma)g$
● **Charge of the electron is calculated** $q = -1.6 \times 10^{-19}$ **C**	

UNIT 10. ELECTRONICS AND COMMUNICATION

2 & 3 MARK QUESTIONS AND ANSWERS:

1. **Define doping.**
   - The process of adding impurities to the intrinsic semiconductor is called ***doping.***
2. **Define junction potential or barrier potential.**
   - The potential difference across the depletion region is called as potential barrier
   - At 25^0C, the value of potential barrier is **0.3 V** for Germanium and **0.7 V** for Silicon
3. **What is an intrinsic semiconductor.**
   - Pure form of semiconductor without impurity. Example: **Si** and Pure **Ge.**
4. **What is P-N junction diode? Give its symbol.**
   - PN junction diode is formed when a P is fused with a N-type semiconductor.

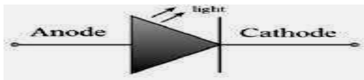


5. **What is meant by rectification?**
   - The process of converting alternating current into direct current is called rectification.

6. What is called Zener diode?

- Zener diode is a reverse based heavily doped Silicon diode which is specially designed to be operated in the breakdown region.

7. What is light emitting diode (LED)?



- **LED** is a **P-N** junction diode which emits visible or invisible light with is forward biased.
- Here electrical energy is converted into light energy, this process is also called electroluminescence.

8. What are called solar cells?

- A solar cell, also known as photovoltaic cell, converts light energy directly into electricity **or** electric potential difference by photovoltaic effect.

9. Define input resistance of transistor.

- The ratio of the change in base-emitter voltage **(ΔV_{BE})** to the change in base current **(ΔI_B)** at aconstant collector-emitter voltage **(V_{CE})** is called the input resistance **(r_i).**

$$r_I = \left(\frac{\Delta V_{BE}}{\Delta I_B}\right)_{V_{CE}}$$

10. Define output resistance of transistor.

- The ratio of the change in collector-emitter voltage **(ΔV_{CE})** to the change in collector current **(ΔI_C)** at a constant base current **(I_B)** is called the output - resistance **(r_o)**

$$r_0 = \left(\frac{\Delta V_{CE}}{\Delta I_C}\right)_{I_B}$$

11. Give the Barkhausen conditions for sustained oscillations.

- The loop phase shift must be **0°** or integral multiples of **2π.**
- The loop gain must be unity. **|Aβ| = 1**
- Here, **A** → Voltage gain of the amplifier, **β** → Feedback ratio

12. What is called modulation? Give its types.

- For long distance transmission, the low frequency base band signal (input signal) is superimposed on to a high frequency carrier signal (radio signal) by a process called modulation.
- **1.** Amplitude **(AM)** **2.** Frequeny Modulation **(FM)** **3.** Phase Modulation **(PM)**

13. Define amplitude modulation (AM)

- If the amplitude of the carrier signal is modified according to the instantaneous amplitude of the baseband signal, then it is called amplitude modulation (AM).

14. Define frequency modulation (FM)

- If the frequency of the carrier signal is modified according to the instantaneous amplitude of the baseband signal then it is called frequency modulation (FM)
- Here amplitude and phase does not modified for carrier wave.

15. Define phase modulation (PM)

- The instantaneous amplitude of the baseband signal modifies the phase of the carrier signal keeping the amplitude and frequency constant is called phase modulation

16. Define skip distance.

- The shortest distance between the transmitter and the point of reception of the sky wave along the surface is called as the skip distance

17. Define skip zone.

- There is a zone in between where there is no reception of electromagnetic waves neither ground nor sky, called as skip zone or skip area.

18. What is called biasing? Give its types.

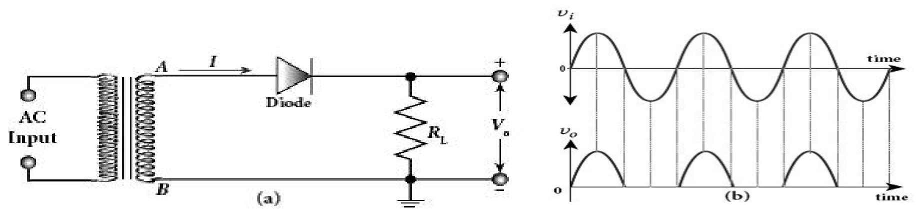
- Biasing is the process of giving external energy to charge carriers to overcome the barrier potential and make them move in a particular direction.
- P-N junction we have two types of biasing 1) Forward bias 2) Reverse bias

19. **Compare FM and PM ?**
- PM wave is similar to FM wave.
- PM generally uses a smaller bandwidth than FM.
- In other words, in PM, more information can be sent in a given bandwidth.
- Hence, phase modulation provides high transmission speed on a given bandwidth.

20. **What is called transistor amplifier?**
- A transistor operating in the active region has the capability to amplify weak signals.
- Amplification is the process of increasing the signal strength (increase in the amplitude).

<u>5. MARK QUESTIONS AND ANSWERS:</u>

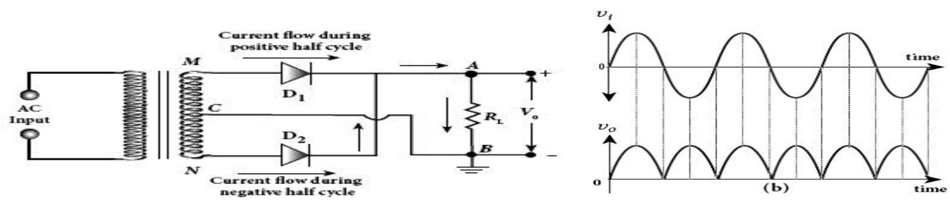
1. **Draw the circuit diagram of a half wave rectifier and explain its working.**



- This circuit consists of a step down transformer, a P-N junction diode and a resistor **(R_L)** Here, a P-N junction diode acts as a rectifying diode.

- **<u>During positive half cycle of input AC:</u>**
  - Terminal **A** becomes positive with respect to terminal **B.**
  - The diode is forward biased and hence it conducts
  - The current flows through load resistor **R_L** and the **AC** voltage developed across **R_L** constitutes the output voltage **V_o**
- **<u>During negative half cycle of input AC:</u>**
  - Terminal B becomes positive with respect to terminal **A.**
  - The diode is reverse biased and hence it does not conduct.
  - No current passes through **R_L** and there is no voltage drop across **R_L**
  - Efficiency **(η)** of half wave rectifier is ***η = 40.6 %***

2. **Explain the construction and working of a full wave rectifier.**



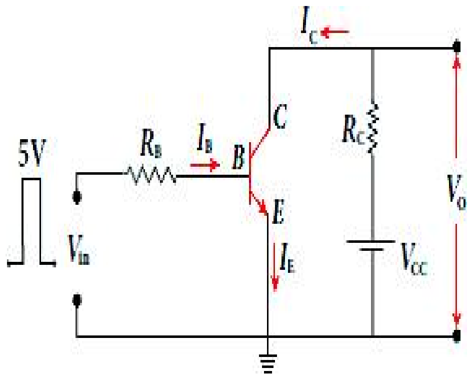
- It consists of two P-N junction diodes, a center tapped transformer, and a load resistor **(R_L).** The centre **(C)** is usually taken as the ground or zero voltage reference point.

During positive half cycle of input AC	During positive half cycle of input AC:
Terminal **M** is positive, **C** at zero potential and N is at negative potential	Terminal **M** is negative, **G** is at zero potential and N is at positive potential
Diode **D_1** is forward biased Diode **D_2** is reverse biased	Diode **D_1** is forward biased Diode **D_2** is reverse biased
D_1 conducts and current flows along the path **MD_1ABC**	**D_2** conducts and current flows along the path **ND_2ABC**
Efficiency **(η)** of full wave rectifier is ***η = 81.2 %***.	

3. Explain how transistor acts as a switch .

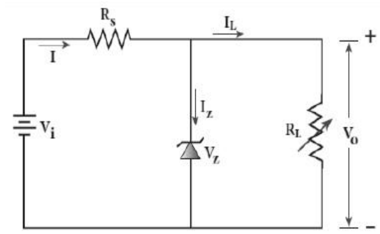
- A transistor in saturation and cut-off region functions like an electronic switch by a small control switch.

	Input Voltage (V_{in})	
	0 V	**5 V**
Collector Current (I_c)	Zero	Increases
P.D. across R_c (I_cR_c)	Zero	Increases
Output Voltage $\mathbf{V_0 = V_{CC} - I_CR_C}$	High	Low
Region	Cut off region	Saturation region
Action of the transistor	Open (Switch Off)	Close (Switch ON)



4. Explain the working of Zener diode as a voltage regulator.

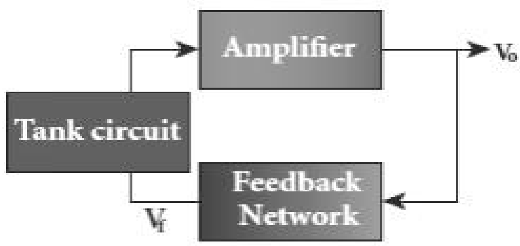
- A Zener diode working in the breakdown region can serve as a voltage regulator. It maintains a constant output voltage even when input voltage **(V_i)** or load current **(I_L)** varies.
- The output voltage is maintained constant as long as the input voltage does not fall below $\mathbf{V_Z}$.
- When the potential developed across the diode is greater than $\mathbf{V_Z}$, the diode moves into the Zener breakdown region.
- It conducts and draws relatively large current through the series resistance $\mathbf{R_S}$.



- The total current I passing through R_S equals the sum of diode current $\mathbf{I_Z}$ and load current $\mathbf{I_L}$ (i.e.) $\mathbf{I = I_Z + I_L}$
- It is to be noted that the total current is always less than the maximum Zener diode current. under all conditions $\mathbf{V_O = V_Z}$ .Thus, output voltage is regulated.

5. Explain the action transistor as an oscillator.

- An electronic oscillator basically converts dc energy into ac energy of high frequency ranging from a few **Hz** to several **MHz.**
- An oscillator circuit consists of
  - ❖ Amplifier Circuit
  - ❖ Feedback Circuit
  - ❖ Tank circuit



- **<u>Amplifier Circuit:</u>**
  - ❖ Amplifier amplifies the input ac signal.
- **<u>Feedback Circuit:</u>**
  - ❖ The circuit used to feedback a portion of the output to the input is called the feedback network.
  - ❖ If the portion of the output fed to the input is in phase with the input, then the magnitude of the input signal increases.
- **<u>Tank Circuit:</u>**
  - ❖ The LC tank circuit consists of an inductance and a capacitor connected in parallel.
  - ❖ This produces electrical oscillations of definite frequency.

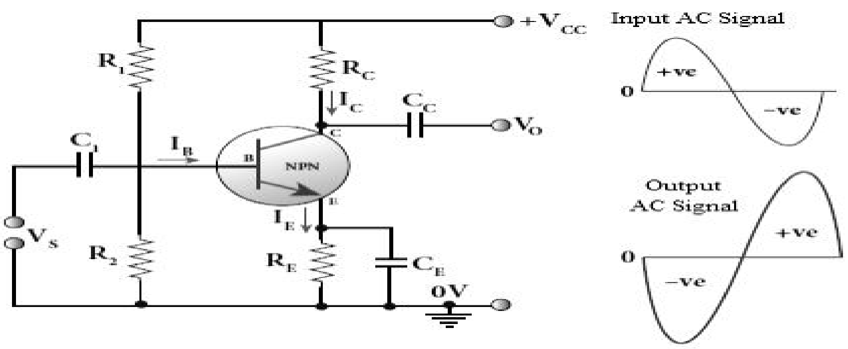
- **Working:**

    - Whenever energy is supplied to the tank circuit from a DC source, the energy is stored in inductor and capacitor alternatively. But in practical oscillator circuits there will be loss of energy across resistors, inductor coils and capacitors.
    - Due to this, the amplitude of the oscillations decreases gradually.
    - Hence, the tank circuit produces damped electrical oscillations.
    - Therefore, in order to produce un damped oscillations, a positive feedback is provided from the output circuit to the input circuit.
    - The frequency of oscillations is determined by the values of L and C using the equation.

$$\mathbf{f} = \frac{\mathbf{1}}{\mathbf{2\pi\sqrt{LC}}}$$

6. Describe the function of a transistor as an amplifier with the neat circuit diagram. Sketch the input and output wave form.

- Amplification is the process of increasing the signal strength (increase in the amplitude).
- Single stage indicates that the circuit consists of one transistor with the allied components.
- An NPN transistor is connected in the common emitter configuration



- The capacitor $\mathbf{C_1}$ allows only the ac signal to pass through.
- The emitter bypass capacitor $\mathbf{C_E}$ provides a low reactance path to the amplified ac signal.
- The coupling capacitor $\mathbf{C_C}$ is used to couple on stage of the amplifier with the next stage while constructing multistage amplifiers.
- V_S is the sinusoidal input signal source applied across the base-emitter. The output is taken across the collector-emitter.
- The phase relationship between the AC input and output voltages in a common emitter amplifier is 180°.
- **Collector Current is** $I_C = \beta I_B$ $\left[\because\ \beta = \frac{I_C}{I_B}\right]$
- Applying Kirchhoff 's voltage law, the collector-emitter voltage is $V_{CE} = V_{CC} - I_C R_C$
- **Working of the amplifier:**

(1) During the positive half cycle:

- Input signal $(\mathbf{V_S})$ increases the forward voltage across the emitter-base.
- As a result, the base current $(\mathbf{I_B})$ increases.
- Consequently, the collector current (I_C) increases β times.
- This increases the voltage drop across $\mathbf{R_C}$ which in turn decreases the collector-emitter voltage $(\mathbf{V_{CE}})$.
- Therefore, the input signal in the positive direction produces an amplified signal in negative direction at the output. Hence, the output signal is reversed by **180°.**

(2) During the negative half cycle:

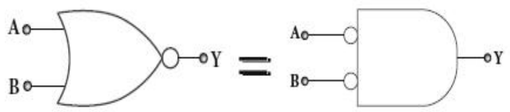
- ❖ Input signal **(V_s)** decreases the forward voltage across the emitter-base.
- ❖ As a result, base current **(I_B)** decreases and in turn increases the collector current **(I_C).**
- ❖ The increase in collector current **(I_C)** decreases the potential drop across **R_C** and increases the collector-emitter voltage **(V_{CE}).**
- ❖ Thus, the input signal in the negative direction produces an amplified signal in the positive direction at the output.
- ❖ Therefore, **180°** phase reversal is observed during the negative half cycle of the input signal.

7. State and prove De Morgan's theorem.

❖ **First theorem :**

➢ The complement of the sum of two logical inputs is equal to the product of complements.

$$\overline{\boldsymbol{A+B}} = \overline{\boldsymbol{A}}.\overline{\boldsymbol{B}}$$

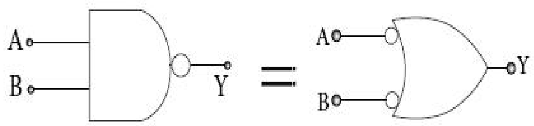


A	B	A+B	$\overline{A+B}$	$\overline{A}$	$\overline{B}$	$\overline{A}.\overline{B}$
0	0	0	1	1	1	1
0	1	1	0	1	0	0
1	0	1	0	0	1	0
1	1	1	0	0	0	0

❖ **Second theorem:**

➢ The complement of the product of two inputs is equal to the sum of its complements.

$$\overline{\boldsymbol{A}.\boldsymbol{B}} = \overline{\boldsymbol{A}} + \overline{\boldsymbol{B}}$$



A	B	A.B	$\overline{A.B}$	$\overline{A}$	$\overline{B}$	$\overline{A}+\overline{B}$
0	0	0	1	1	1	1
0	1	0	1	1	0	1
1	0	0	1	0	1	1
1	1	1	0	0	0	0

8. Elaborate on the basic elements of communication system with the necessary block diagram.

❖ <u>**Communication system :**</u>

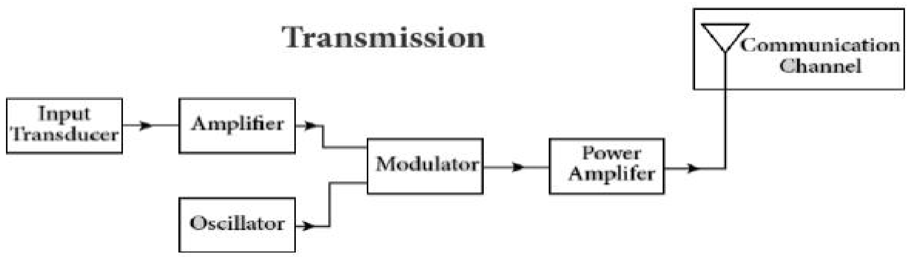
- ➢ Electronic communication is nothing but the transmission of sound, text, pictures, or data through a medium.

1. Input transducer :

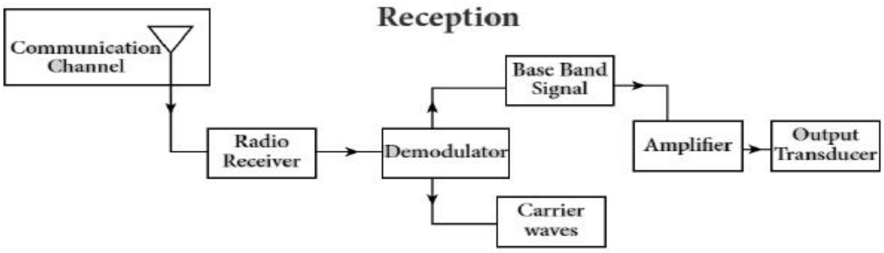
- ➢ A transducer is a device that converts variations in a physical quantity (pressure, temperature, sound) into an equivalent electrical signal or vice versa.

2. Transmitter :

- ➢ It feeds the electrical signal from the transducer to the communication channel. The transmitter located in local at the broad casting station.
- ➢ Transmitter consist of Amplifier, Oscillator, Modulator, Power Amplifier



3. **Transmitting antenna :**
   - It radiates the radio signal into space in all directions.
   - It travels in the form of electromagnetic waves with the velocity of light ***(3×10^8 m s^{-1})***
4. **Communication channel :**
   - Communication channel is used to carry the electrical signal from transmitter to receiver with less noise or distortion.
   - The communication medium is basically of two types:
   - wireline communication
   - wireless communication



5. **Receiver :**
   - The signals that are transmitted through communication medium are received with help of a receiving antenna and are fed into the receiver.
   - The receiver consists of electronic circuits like demodulator, amplifier, detector etc
   - **Demodulator:**
   - The demodulator extracts the baseband signal from the carrier signal.
   - **Amplifier:**
   - Then the baseband signal is detected and amplified using amplifiers. Finally, it is fed to the output transducer.
6. **Output transducer :**
   - It converts the electrical signal back to its original form such as sound, music, pictures or data. **(e.g.)** loudspeakers, picture tubes, computer monitor, etc.,

UNIT 11. RECENT DEVELOPMENTS IN PHYSICS

TWO, THREE & FIVE MARK QUESTIONS AND ANSWERS:

1. Why steels are preferred to make robots?
- For robots, aluminum and steel are the most common metals.
- Aluminum is a softer metal and is therefore easier to work with it.

2. Give two examples for Nano structure in nature.

i) Single strand DNA
- It is the basic building block of all living things.
- It is about 3 nm wide

ii) **Morpho butterfly**
- The scales of the wings of this butterfly contain nano structures.

3. Write a note on black holes.
- Black holes are end stage of stars which are highly dense massive object.
- Its mass ranges 20 times mass of the sun to 1 million times mass of the sun.
- Every galaxy has black hole at its centre.

4. What are called gravitational waves?
- The disturbances in the curvature of space-time are called gravitational waves. Its travels with speed of light.
- Any accelerated charge emits electromagnetic waves. Similarly any accelerated mass emits gravitational waves.
- The strongest sources of gravitational waves are black holes.

5. What is robotics?

- Robotics is an integrated study of mechanical, electronic engineering, computer engineering and science.
- Robot is a mechanical device designed with electronic circuitry and programmed to perform a specific task.

6. What are the possible harmful effects of usage of Nanoparticles? Why?

- The major concern here is that the nanoparticles have the dimensions same as that of the biological molecules such as proteins.
- The interaction with living systems is also affected by the dimensions of the nanoparticles.
- Nanoparticles can also cross cell membranes. It is also possible for the inhaled nanoparticles to reach the blood, to reach other sites such as the liver, heart or blood cells.

7. Explain the various components of robotics.

- Most robots are composed of 3 main parts: Controller, Mechanical parts, Sensor
  - **Controller :**
- It is also known as the "brain" which is run by a computer program.
- It gives commands for the moving parts to perform the job.
  - **Mechanical parts :**
- It consist motors, pistons, grippers, wheels gears that make the robot move, grab, turn, and lift.
  - **Sensors :**
- It tells the robot about its surroundings. It helps to determine the sizes and shapes of the objects around, distance between the objects, and directions as well.

❖ <u>Some important three marks questions:</u> (Distinguish between based questions:)

1. Distinguish between Coulomb force and Gravitational force.

S.N	Coulomb force	Gravitational force
1	It acts between two charges.	It acts between two masses .
2	It can be attractive or repulsive .	It is always attractive .
3	It is always greater in magnitude .	It is always lesser in magnitude.
4	It depends on the nature of the medium .	It is independent of the medium.

2. Distinguish between drift velocity and mobility.

S.N	Drift Velocity	Mobility
1	The average velocity acquired by the electrons inside the conductor when it is subjected to an electric field.	The magnitude of the drift velocity per unit electric field.
2	Its unit is ms^{-1}.	Its unit is $m^2\ v^{-1}s^{-1}$.

3. Distinguish electric energy and electric power.

S.N	Electric energy	Electric power
1	Work has to be done by a cell to move the charge from one end to the other end of the conductor and this work done is called electric energy.	The rate at which the electrical potential energy is delivered is called electric power.
2	Its SI unit is joule (J)	It SI unit is watt(W)
3	Its practical unit is kilowatt hour (kWh) **1 kWh=3.6× 10^6J.**	Its practical unit is horse power(H.P). **1 H.P = 746W.**

4. What are the differences between Soft and Hard ferro magnetic material.

S.N	Soft ferromagnetic materials	Hard ferro magnetic materials
1	When external field is removes, its magnetization will disappear.	When external field is removes, its magnetization will persists.
2	Area of the loop is small	Area of the loop is large
3	Low retentivity	High retentivity
4	Low coercivity	High coercivity
5	(e.g.) Soft iron, Mumetal, Stalloy	(e.g.) Steel, Alnico, Lodestone

5. Distinguish between Fresnel and Fraunhofer diffraction.

	Fresnel diffraction	Fraunhofer diffraction
1	Spherical or cylindrical wave front undergoes diffraction.	Plane wavefront undergoes diffraction
2	The source of light is finite distance from the obstacle.	The source of light is infinite distance from the obstac
3	Convex lenses need not be used	Convex lenses are to be used
4	Difficult to observe and analyze	Difficult to observe and analyze

6. Differentiate interference and diffraction.

S. N	Interference	Diffraction
1	Equally spaced bright and dark fringes.	Central bright is double the size of other fringes.
2	Equal intensity for all bright fringes.	Intensity falls rapidly.
3	Large number of fringes are obtained.	Less number of fringes are obtained.

7. Distinguish between near point focusing and normal focusing.

S.N	Near point focusing	Normal focusing
1	The image is formed at near point	The image is formed at infinity
2	In this position, the eye is feel little strain	In this position, the eye is most relaxed to view the image
3	Magnification is high $m = 1 + D/f$	Magnification is low $m = D/f$

8. Distinguish intrinsic semiconductor and extrinsic semiconductor.

S.N	INTRINSIC SEMICONDUCTOR	EXTRINSIC SEMICONDUCTOR
1	Pure form of semiconductor without impurity. e.g: Pure Si and Pure Ge	Impurity added semiconductor
2	The number of electrons in the conduction band is equal to the number of holes in the valence band.	The number of electrons in the conduction band is not equal to the number of holes in the valence band.
3	Electrical conductivity is less.	Electrical conductivity is high.

9. Differentiate - donor and acceptor impurities.

S.N	DONAR IMPURITIES	ACCEPTOR IMPURITIES
1	Pentavalent (Group V) impurity atoms.	Trivalent (Group III)impurity atoms.
2	Donate electrons to the conduction band.	Accept electrons from the neighbouring atoms.
3	Eg: Phosphorous, Arsenic, Antimony.	Eg: Boron, Aluminium, Gallium.

10. Differentiate Zener breakdown, Avalanche breakdown.

S.N	Zener breakdown	Avalanche breakdown
1	Heavily doped p – n junction.	Lightly doped p -n junction.
2	Narrow depletion region.	Wide depletion region.
3	It occurs due to strong electric field	It occurs due to thermally generated minority charge carriers.

APPLICATIONS / USES BASED QUESTIONS:

1. Give the applications and disadvantage of capacitors

i. Flash capacitors are used in digital camera .

ii. It is used in heart defibrillator to retrieve the normal heart function during cardiac arrest .

iii. Capacitors are used in the ignition system of automobile engines to eliminate sparking.

iv. Capacitors are used to reduce power fluctuations in power supplies and to increase the efficiency of power transmission.

2. State the applications of seeback effect.

i. Seeback effect is used in thermo electric generators .These generators are used in power plants to convert waste heat into electricity.

ii. It is used in automobiles as automotive thermoelectric generators for increasing fuel efficiency.

iii. It is used in thermocouples and thermopiles to measure the temperature difference between the two objects.

3. Give any two uses of (i) IR radiation, (ii) Microwaves and (iii) UV radiation

❖ **IR radiation**

i. It is used to provide electrical energy to satellites .

ii. It is used to produce dehydrated fruits.

❖ **Microwaves**

i. It is used in microwave oven for cooking.

ii. It is used in very long distance wireless communication through satellites

❖ **UV radiation**

i. It is used in burglar alarm.

ii. It is used to destroy bacteria and sterilizing the surgical instruments.

4. Write uses of polaroids.

i. Used to take 3D pictures. Example: Holography.

ii. Used in goggles and cameras to avoid glare of light.

iii. Used as window glasses to control the intensity of incoming light.

iv. Used to improve contrast in old oil painting.

v. Used in LCD (liquid crystal display).

vi. Used in optical stress analysis.

5. Give the application of photo cells.

i. It is used as switches and sensors.

ii. Automatic lights that turn on when it gets dark use photocells.

iii. Street lights that switch onand off according to whether it is night or day.

iv. They are used for reproduction of sound in motion pictures.

v. They are used as timers to measure the speeds of athletes during a race.

vi. They are used to measure the intensity of the given light in photography.

6. Explain the applications of X-rays.

i. It is used to detect fractures, foreign bodies in Medical diagnosis.

ii. It is used to cure malignant tumours.

iii. It is used to check for flaws in welded joints, tennis balls.

iv. It is used for detection of contraband goods in custom

v. It is used to study the structure of the crystalline materials.

7. Give the uses of Zener diode.

Zener diode can be used

i. As voltage regulators.

ii. In calibrating voltages.

iii. In providing fixed reference voltage for biasing.

iv. In protecting any gadget against damage from excessive voltage.

8. Give the applications of Light Emitting Diode (LED).

i. Indicator lamps on the front panel of the scientific and laboratory equipments.

ii. Seven-segment displays

iii. Traffic signals, exit signs, emergency vehicle lighting etc.

iv. Industrial process control, position encoders, bar graph readers.

9. Give the applications of photo diode.

i. Alaram System

ii. Count items on a conveyer belt

iii. Photoconductors

iv. Compact Disc players, Smoke detectors

v. Medical applications such as detectors for computed to mography etc.

10. Give the applications of solar cells.

i. Solar cells are widely used in calculators, watches, toys, portable power supplies.

ii. Solar cells are used in satellites and space application

iii. Solar panels are used to generate electricity.

11. Give applications of RADAR.

i. In military, it is used for locating and detecting the targets.

ii. It is used in navigation systems.

iii. In Meteorological observation, Radars are used.

iv. It is employed to locate and rescue people in emergency situations.

12. Write the application of Satellite communication.

❖ **Weather Satellites:**

i. They are used to monitor the weather and climate of Earth.

ii. By measuring cloud mass, these satellite enable us to predict rain and dangerous storms like hurricanes, cyclones etc.

❖ **Communication satellites:**

i. They are used to transmit television, radio, internet signals etc. Multiple satellites are used for long distances.

❖ **Navigation satellites:**

i. These are employed to determine the geographic location of ships, aircrafts or any other object.

PROPERTIES BASED QUESTIONS:

1. List the properties of electric field lines.

- They starts from positive charge and end at negative charge or at infinity.
- The electric field vector at a point in space is tangential to the electric field line at that point.
- The electric field lines are denser in a region where the electric field has larger magnitude and less dense in region where the electric field is of smaller magnitude.
- No two electric fid lines intersect each other
- The number of electric field lines that eminent from the positive charge or end at a negative charge is directly proportional to the magnitude of the charges.

2. Write down the properties of electromagnetic waves.

- Electromagnetic waves are produced by any accelerated charge.
- Electromagnetic waves do not require any medium for propagation. So electromagnetic wave is a non-mechanical wave.
- Electromagnetic waves travel with the speed of light in vacuum or free space.
- Electromagnetic waves are not deflected by electric field or magnetic field.
- Electromagnetic waves can exhibit interference, diffraction and polarization.
- Electromagnetic waves carry energy, linear momentum and angular momentum.

3. List the properties of Dia, Para, Ferro magnetic materials.

Magnetic materials properties	Dia magnetic	Para magetic	Ferro magnetic
Magnetic Susceptibility (χ_m)	$(\chi_m = -ve)$	$\chi_m = +ve$ [small]	$\chi_m = +ve$ [large]
Relative permeability (μ_r)	$(\mu_r < 1)$	$(\mu_r > 1)$	$(\mu_r >> 1)$
Susceptibility (χ_m) **in temperature**	Independent of temperature	Inversely proportional to temperature	Inversely proportional to temperature
Examples	Bi, Cu, H_2O	Al, pt, Cr	Fe, Ni, Co

4. **What are the properties of Cathode rays.**
   - Possess energy and momentum.
   - Travel in a straight line .
   - Can be deflected by both electric and magnetic fields.
   - They affect photographic plates.
   - They produce fluorescence.
   - Ionize the gas through which they pass.
   - They produce heat when they fall on matter.

5. **What are the properties of neutrino?**
   - It has zero charge.
   - It has an antiparticle called anti neutrino.
   - It hasvery small mass.
   - It interacts weakly with matter.

6. **What are the properties of Nuclear Force?**
   - The Strongest force in nature.
   - Very short range of force.
   - It is an attractive force.
   - Nuclear force is same for (n-n), (p-p), (p-n).
   - It doesn't act on electrons.

7. **Write down the properties of neutron.**
   - They are stable inside the nucleus.
   - Outside the nucleus it decays with a half life of **13** minutes.
   - They are neutral in charge.

Types	Kinetic energy
Slow neutron	0 to 1000eV
Fast neutron	0.5 MeV to 10 MeV
Thermal neutron	0.025 eV (in thermal equilibrium).

<u>LAWS BASED QUESTIONS:</u>

1. **State Kirchhoff's first and second rules.**

❖ **<u>Kirchhoff's first rule (current rule or junction rule).</u>**

➢ It states that the algebraic sum of the currents at any junction of a circuit is zero.(i.e) $\mathbf{\Sigma I = 0}$.

➢ It is based on law of conservation of electric charge.

❖ **<u>Kirchhoff's second rule (voltage rule or loop rule).</u>**

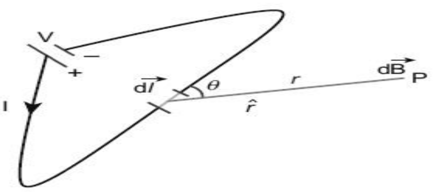
➢ It states that in a closed circuit the algebraic sum of the products of the current and resistance of each part of the circuit is equal to the algebraic sum of emf included in the circuit.

(i.e) $\mathbf{\Sigma IR = \Sigma \varepsilon}$.

➢ It is based on law of conservation of electric energy.

2. State and explain Biot savart law.

- According to Biot savart law, the magnitude of magnetic field dB is



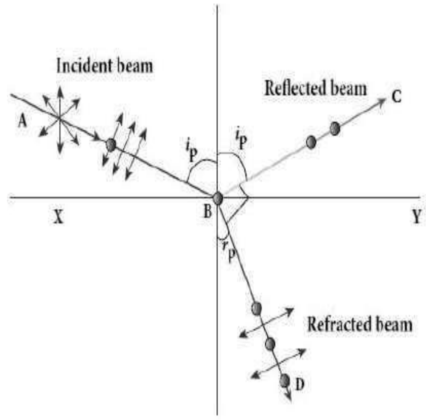
- $dB \propto I$
- $dB \propto dl$
- $dB \propto \sin\theta$
- $dB \propto \frac{1}{r^2}$
- $dB \propto \frac{I\,dl\,\sin\theta}{r^2}$ **(OR)** $dB = \frac{\mu_0}{4\pi}\frac{I\,dl\,\sin\theta}{r^2}$
- **In vector notation**

  $\vec{dB} = \frac{\mu_0}{4\pi}\frac{I\,\vec{dl} \times \hat{r}}{r^2}$

3. State Faraday's laws of electromagnetic induction.

- **<u>Faraday's first law:</u>**
- Whenever magnetic flux linked with a closed circuit changes, an emf is induced in the circuit.
- **<u>Faraday's second law:</u>**
- The magnitude of induced emf in a closed circuit is equal to e time rate of change of magnetic flux linked with the circuit. $\mathcal{E} = \frac{d\Phi_B}{dt}$

4. State and explain Brewster's law.



- $i_p + 90^0 + r_p = 180^0$ (or) $r = 90^0 - i_p$
- Snell's law,
- $n = \frac{\sin i_p}{\sin r_p}$
- $n = \frac{\sin i_p}{\sin(90^0 - i_p)} = \frac{\sin i_p}{\cos i_p} = \tan i_p$
- $n = \tan i_p$
- The tangent of the polarising angle for a transparent medium is equal to its refractive index.

5. State Malus's law.

- When a beam of plane polarised light of intensity I_o is incident on an analyser, the intensity of light transmitted from the analyser varies directly as the square of the cosine of the angle θ between the transmission axes of polariser and analyser. $I = I_o \cos^2\theta$

6. List out the laws of photoelectric effect.

- For a given metallic surface, the emission of photoelectrons takes place only if the frequency of incident light is greater than certain minimum frequency called the threshold frequency.
- For a given frequency of incident light (above threshold frequency) , the number of photoelectrons emitted is directly proportional to the intensity of the incident light.
- Maximum kinetic energy of the photoelectrons is independent of intensity of the incident light.
- Maximum kinetic energy of the photoelectrons is directly proportional to the frequency of incident light.
- There is no time lag between incidence of light and ejection of photoelectrons

CHARACTERISTICS BASED QUESTIONS:

1. **Write the Characteristics of Lorentz force.**
   - **$F = Bqv \sin\theta$**
   - When v = 0, Lorentz force F = 0
   - When q moves in parallel or anti parallel F = 0
   - $F \propto B$
   - $F \propto q$
   - $F \propto v$
   - **In vector notation** $\overrightarrow{F_m} = q\left(\vec{v} \times \vec{B}\right)$
2. **Write the characteristics of photons.**
   - Each photon will have energy ***E= hν.***
   - The energy of a photon is determined by the frequency of the radiation.
   - The photons travel with the speed of light.
   - They are unaffected by electric and magnetic fields.
   - When a photon interacts with matter, the total energy and angular momentum are conserved.

ADVANTAGE AND DISADVANTAGES BASED QUESTIONS:

1. **What are Advantages and disadvantages of AC over DC?**
   - **Advantages:**
     i. The generation of AC is cheaper than that of DC.
     ii. The transmission losses are small compared to DC transmission.
     iii. AC can easily be converted into DC with the help of rectifiers.
   - **Disadvantages:**
     i. Alternating voltages cannot be used for certain applications.
     ii. At high voltages, it is more dangerous to work with AC than DC.

2. **Write Merits and Demerits of Fibre Optic Communication.**
   - **Merits**
     i. Fibre cabbles are very thin and weight lesser than copper cables.
     ii. This system has much larger band width.
     iii. Fibre optic system is immune to electrical interferences.
     iv. Fibre optic cables are cheaper.
   - **Demerits**
     i. Fibre optic cables are more fragile when compared to copper wires.
     ii. Its an expensive technology.
3. **Write the advantages and limitations of amplitude modulation (AM).**
   - **Advantages of AM :**
     i. Easy transmission and reception.
     ii. Lesser bandwidth requirements.
     iii. Low cost.
   - **Limitations of AM**
     i. Noise level is high .
     ii. Low efficiency.
     iii. Small operating range.

4. Write the advantages and limitations of frequency modulation (FM).

❖ **Advantages of FM:**

i. There is a large decrease in noise.

ii. The operating range is quite large.

iii. The transmission efficiency is very high.

iv. FM radio has better quality compared to AM radio.

❖ **Limitations of FM:**

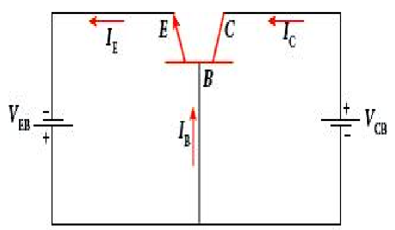
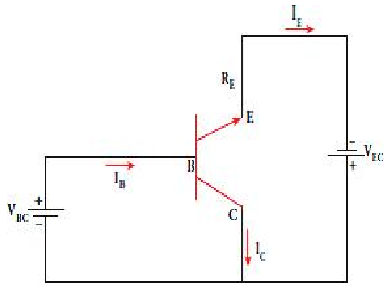
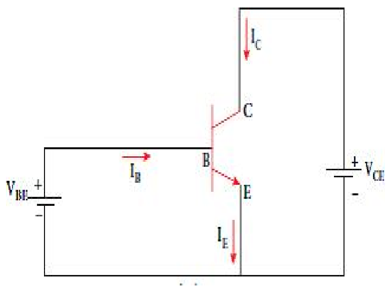
i. FM requires a much wider channel.

ii. FM transmitters and receivers are more complex and costly.

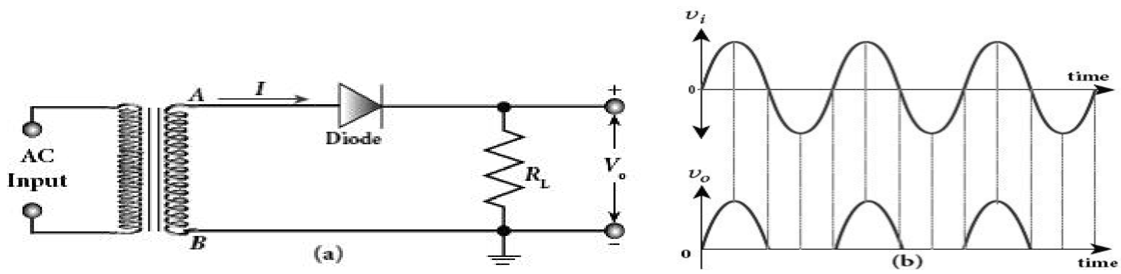
iii. In FM reception, less area is covered compared to AM.

<u>CIRCUIT - DIAGRAM BASED QUESTIONS:</u>

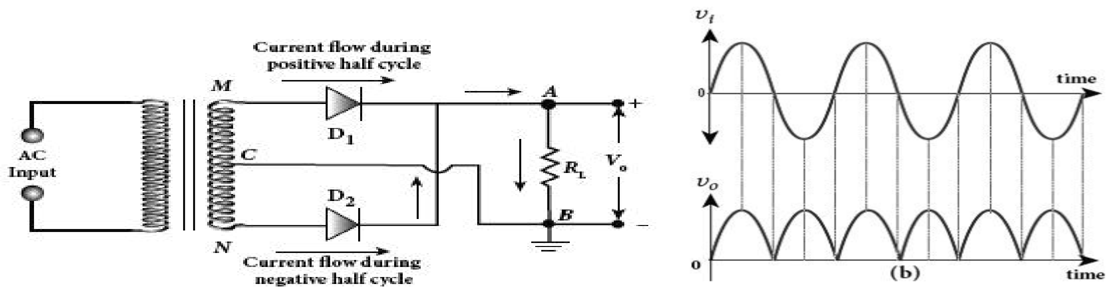
1. Draw the circuit diagram for CB / CE / CC configuration

CB configuration	CE configuration.	CC configuration
		

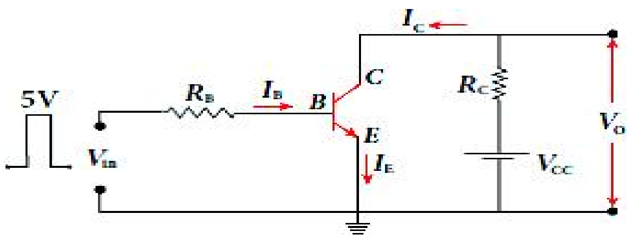
2. Draw the circuit diagram of a half wave rectifier and draw its input and output waveform.



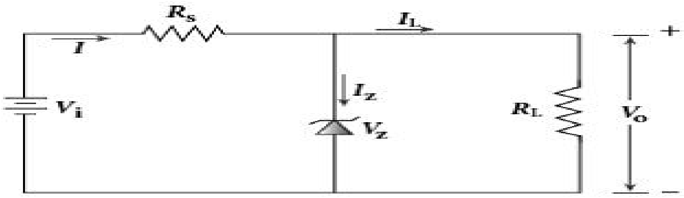
3. Draw the circuit diagram of a Full wave rectifier and draw its input and output waveform.



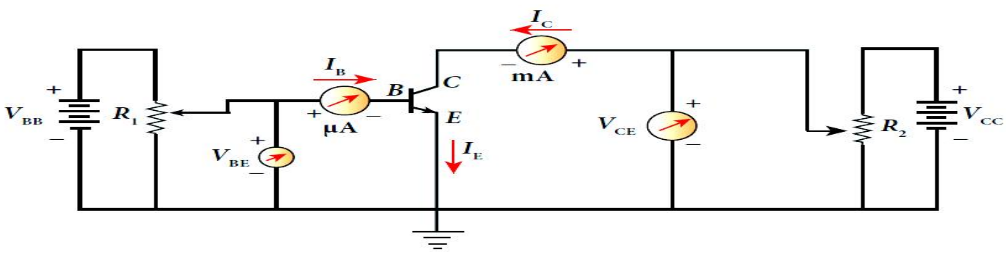
4. Draw the circuit diagram of transistor acts as a switch.



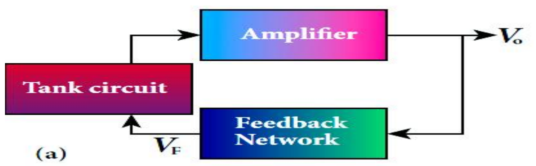
5. Draw the circuit diagram of Zener diode acts as a voltage regulator.



6. Draw the Circuit diagram of Static characteristics of NPN transistor in CE mode.



7. Draw the block diagram of Transistor of an oscillator.

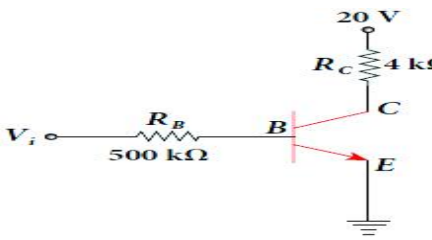


8. In the circuit shown in the figure, the input voltage V_i is 20 V, V_{BE} = 0 V and V_{CE} = 0 V. What are the values of I_B, I_C, β ?

$$I_B = \frac{V_i}{R_B} = \frac{20\,V}{500\,k\Omega} = 40\,\mu A$$

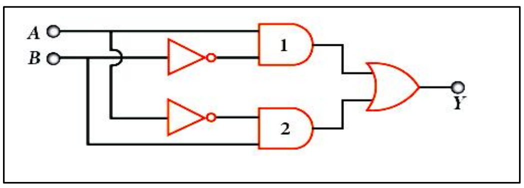
$$I_C = \frac{V_{CC}}{R_C} = \frac{20\,V}{4\,k\Omega} = 5\ mA$$

$$\beta = \frac{I_C}{I_B} = \frac{50\,mA}{40\,\mu A} = 125$$



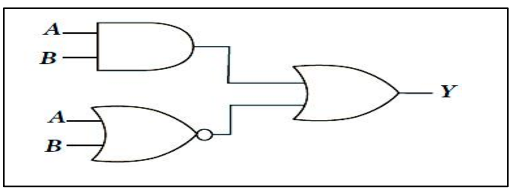
9. In the combination of the following gates, write the Boolean equation for output *Y* in terms of inputs *A* and *B*.

- **The output at the 1st AND gate : $A\overline{B}$**
- **The output at the 2nd AND gate : $\overline{A}B$**
- **The output at the OR gate: Y = $A.\overline{B} + \overline{A}.B$**

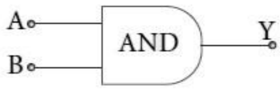


10. Write down Boolean equation for the output Y of the given circuit.

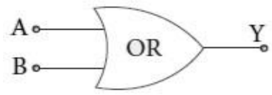
- **Output of AND gate : A . B**
- **Output of NOR gate : $\overline{A + B}$**
- **The final output of OR gate : Y = (A . B) + ($\overline{A + B}$)**



11. Give Circuit symbol, logical operation, truth table, and Boolean expression of
i) AND gate ii) OR gate iii) NOT gate iv) NAND gate v) NOR gate and vi) EX-OR gate.

<table>
<tr><th>Logic gate</th><th>Logic Symbol, Operation and Boolean expression</th><th>Truth Table</th></tr>
<tr><td>AND gate</td><td>


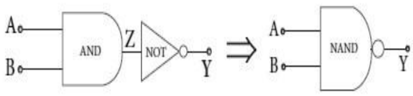
$Y = A \cdot B$

➢ The output of AND gate is high **(1)** only when all the inputs are high **(1).**
➢ The rest of the cases the output is low **(0)**
</td><td>
<table>
<tr><th colspan="2">Inputs</th><th>Output</th></tr>
<tr><td>A</td><td>B</td><td>$Y = A \cdot B$</td></tr>
<tr><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>1</td><td>0</td></tr>
<tr><td>1</td><td>0</td><td>0</td></tr>
<tr><td>1</td><td>1</td><td>1</td></tr>
</table>
</td></tr>
<tr><td>OR gate</td><td>


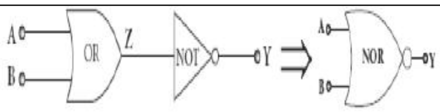
$Y = A + B$

➢ The output of OR gate is high **(1)** when either of the inputs or both are high **(1)**
➢ The rest of the cases the output is low **(0)**
</td><td>
<table>
<tr><th colspan="2">Inputs</th><th>Output</th></tr>
<tr><td>A</td><td>B</td><td>$Y = A + B$</td></tr>
<tr><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>1</td><td>1</td></tr>
<tr><td>1</td><td>0</td><td>1</td></tr>
<tr><td>1</td><td>1</td><td>1</td></tr>
</table>
</td></tr>
<tr><td>NOT gate</td><td>

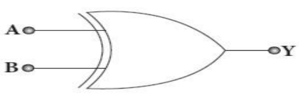

$Y = \overline{A}$

➢ The output is the complement of the input.
➢ The output Y is high **(1),** when input is low **(0)** and vice versa.
</td><td>
<table>
<tr><th>Inputs</th><th>Output</th></tr>
<tr><td>A</td><td>$Y = \overline{A}$</td></tr>
<tr><td>0</td><td>1</td></tr>
<tr><td>1</td><td>0</td></tr>
</table>
</td></tr>
<tr><td>NAND gate</td><td>


$Y = \overline{A \cdot B}$

➢ The circuit is an **AND** gate followed by a **NOT** gate. Therefore, it is summarized as **NAND**.
➢ The output is at low **(0)** only when all the inputs are high **(1).**The rest of the cases, the output is high **(1)**
</td><td>
<table>
<tr><th colspan="2">Inputs</th><th>Output</th></tr>
<tr><td>A</td><td>B</td><td>$Y = \overline{A \cdot B}$</td></tr>
<tr><td>0</td><td>0</td><td>1</td></tr>
<tr><td>0</td><td>1</td><td>1</td></tr>
<tr><td>1</td><td>0</td><td>1</td></tr>
<tr><td>1</td><td>1</td><td>0</td></tr>
</table>
</td></tr>
<tr><td>NOR gate</td><td>


$Y = \overline{A + B}$

➢ The circuit is an **OR** gate followed by a **NOT** gate and is summarized as **NOR.**
➢ The output is high **(1)** when all the inputs are low **(0)**
➢ The rest of the cases, the output is low **(0)**
</td><td>
<table>
<tr><th colspan="2">Inputs</th><th>Output</th></tr>
<tr><td>A</td><td>B</td><td>$Y = \overline{A + B}$</td></tr>
<tr><td>0</td><td>0</td><td>1</td></tr>
<tr><td>0</td><td>1</td><td>0</td></tr>
<tr><td>1</td><td>0</td><td>0</td></tr>
<tr><td>1</td><td>1</td><td>0</td></tr>
</table>
</td></tr>
<tr><td>EXOR gate</td><td>


$Y = A \oplus B$

➢ The output Y is high **(1)** only when either of the two inputs is high **(1)**.
➢ In the case of an **Ex-OR** gate with more than two inputs, the output will be high **(1)** when odd number of inputs are high **(1)**
</td><td>
<table>
<tr><th colspan="2">Inputs</th><th>Output</th></tr>
<tr><td>A</td><td>B</td><td>$Y = A \oplus B$</td></tr>
<tr><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>1</td><td>1</td></tr>
<tr><td>1</td><td>0</td><td>1</td></tr>
<tr><td>1</td><td>1</td><td>0</td></tr>
</table>
</td></tr>
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