1 . ELECTROSTATICS

2 MARK - QUESTIONS AND ANSWERS :

1. Write down Coulomb's law in vector form and mention what each term represents.

- Coulomb's law in vector form $\vec{F} = k \frac{q_1 q_2}{r^2}\hat{r}$
- Here, $\vec{F}$ - the force between point charges

  q_1, q_2 - magnitude of point charges

  r - distance between the two charges

  $\hat{r}$ - the unit vector pointing along the line joining q_1, and q_2

State coulomb's law in electrostatics.

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 $F \alpha \frac{q_1 q_2}{r^2}$

2. **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 .

3. 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.

4. What is the general definition of electric dipole moment?

- 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) $|\vec{p}|$ = q 2a.
- Its unit is ***coulomb meter*** **(C m).**

5. 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).**

6. Define potential difference. Give its unit.

- The electric potential difference is defined as the work done by an external force to bring unit positive charge from one point to another point against the electric field.
- Its unit is ***volt*** (V)

7. 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).**

8. What is an Equipotential Surface?

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

9. What is an electrostatic induction?

- The phenomenon of charging without actual contact of charged body is called electrostatic induction.

10. What is dielectric (or) insulator?

- A dielectric is a non-conducting material and has no free electrons.
- The electrons in a dielectric are bound within the atoms. **Examples:** Ebonite, glass and mica.

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 even in the absence of an electric field.
- They have a permanent dipole moment. **Examples :** N_2O, H_2O, HCl, NH_3.

13. Define (electric) polarisation?

- (Electric) Polarisation is defined as the total dipole moment per unit volume of the dielectric.

14. Define electric susceptibility. Give its unit.

- Electric susceptibility is defined as polarization per unit external electric field. (i.e) $\vec{P} = \chi_e \vec{E}_{ext}$.
- Its unit is $C^2 N^{-1} m^{-2}$.

15. What is dielectric breakdown.?

- When the external electric field applied to a dielectric is very large, it tears the atoms apart so that the bound charges become free charges.
- Then the dielectric starts to conduct electricity. This is called dielectric breakdown.

16. What is dielectric strength?

- The maximum electric field ,the dielectric can withstand before it breakdowns is called dielectric strength.
- E.g. dielectric field strength of air is 3×10^6 V m^{-1}.

17. 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.

18. The electric field lines never intersect. Justify.

- If two lines cross at a point, then there will be two different electric field vectors at that point.
- If a charge is placed in 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.

19. 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.

20. What is meant by quantisation of charges?

- The charge in an object $q = ne$.
- Here n = 0, ±1, ±2, ±3, ±4….. and e is electron charge.

21. Write short notes on superposition principle

- The total force acting on a given charge is equal to the vector sum of forces exerted on it by all the other charges.
- $\vec{F}_1^{tot} = \vec{F}_{12} + \vec{F}_{13} + \vec{F}_{14} + \cdots \ldots\ldots + \vec{F}_{1n}$

22. 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) $C=Q/V$
- Its unit is ***farad*** **(F)** or **$C\,V^{-1}$.**

23. Define electrostatic energy density.

- The energy stored per unit volume of space is defined as energy density.

24. 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.
- Its unit is NC^{-1} (or) Vm^{-1}.

25. 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.
- Its unit is Nm^2C^{-1}

26. What are the properties of an equipotential surface?

- The work done to move a charge between any two points on the equipotential surface is zero.
- The electric field must always be normal to an equipotential surface.

27. Give the relation between electric field and electric potential.

- Electric field is the negative gradient of the electric potential. (i. e) $E = -\frac{dV}{dx}$.

28. Write a note on electrostatic shielding .

- The electric field inside the charged spherical shell is zero.
- A sensitive electrical instrument which is to be protected from external electrical disturbance is kept inside the cavity of a charged conductor . This is called electrostatic shielding. (e.g) Faraday cage .

29. What is meant by 'electric field lines'.

- A set of continuous lines which are the visual representation of the electric field in some region of space is called electric field lines.

30. State conservation of electric charges.

- The total electric charge in the universe is constant and charge can neither be created nor be destroyed
- In any physical process, the net change in charge will be zero.

3 MARK - QUESTIONS AND ANSWERS :

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. List the properties of electric field lines.

i) They start from positive charge and end at negative charge.

ii) The electric field vector at a point in space is tangential to the electric field line at that point.

iii) 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.

iv) No two electric field lines intersect each other.

v) The number of electric field line is directly proportional to the magnitude of the charge.

3. Give the applications and disadvantage of capacitors

Applications of capacitor:

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.

Disadvantage:

- Even after the battery or power supply is removed, the capacitor stores charges and energy for some time. It causes unwanted electric shock.

4. 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 at an angle θ.

➢ The force on '+q' = q $\vec{E}$; The force on '-q' = $-$ q$\vec{E}$.

➢ Then the total force acting on the dipole is zero.

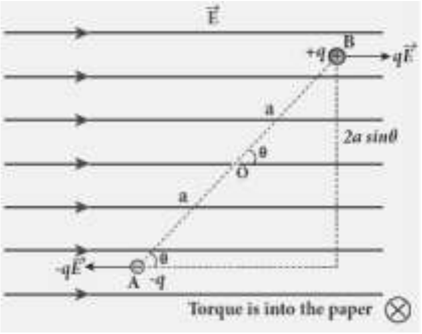
➢ Due to these two forces the dipole experience a torque which tends to rotate the dipole.

➢ The magnitude of the torque

τ = magnitude of one of the force x perpendicular distance between forces

τ = qE x 2a sinθ (p = q x 2a)

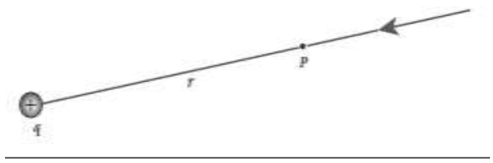
τ = pE sinθ.



➢ In vector notation, $\vec{\tau} = \vec{p} \times \vec{E}$

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

- Consider a point charge +$\boldsymbol{q}$ at origin. ‘P’ be a point at a distance ‘r’ from origin.
- Electric potential at ‘P’ , $V = -\int_{\infty}^{r} \vec{E}.d\vec{r}$
- By definition, the electric field at ‘P’ , $\vec{E} = \frac{1}{4\pi\epsilon_0}\frac{q}{r^2}\hat{r}$
- $V = -\int_{\infty}^{r} \frac{1}{4\pi\epsilon_0}\frac{q}{r^2}\,\hat{r}\,d\vec{r}$
- $V = \frac{q}{4\pi\epsilon_0 r}$



6. **Derive an expression for energy stored in capacitor** .

- The work done to transfer charge from one plate to other plate is stored as electrostatic energy in the capacitor.
- The work done to transfer $'dQ'$ amount of charge

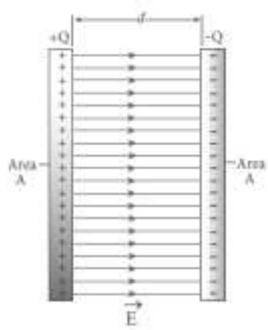
  dW = V dQ $= \frac{Q}{C}dQ \left(\because V = \frac{Q}{C}\right)$
- The total work done to charge a capacitor,
- $W = \int_0^Q \frac{Q}{C}dQ = \frac{Q^2}{2C}$
- This work done is stored as electrostatic energy of the capacitor,

  $U = \frac{Q^2}{2C}$ (or) U = $\frac{1}{2}C\,V^2$.

7. 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 ‘$\boldsymbol{\sigma}$’ be the surface charge density of the plates. (i.e) $\sigma = \frac{Q}{A}$
- The electric field between the plates $E = \frac{\sigma}{\epsilon_0} = \frac{Q}{A\epsilon_0}$
- The potential difference between the plates $V = Ed = \frac{Q}{A\epsilon_0}d$
- The capacitance of the capacitor $C = \frac{Q}{V} = \frac{Q}{\frac{Qd}{A\epsilon_0}}$

  $C = \frac{\epsilon_0 A}{d}$.



8. Obtain Gauss’s law from Coulomb’s law.

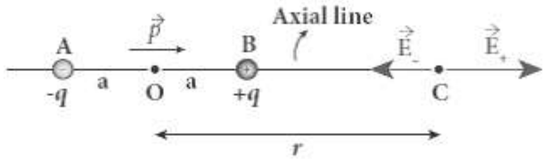
- Consider a point charge ‘+q’. C - is a point at a distance of ‘r’ from the charge.
- The electric field at this point, $E = \frac{F}{q_0}$. q_0 is the test charge and $q_0 = 1$ C
- Force between the charges, $F = \frac{1}{4\pi\epsilon_0}\frac{q\,q_0}{r^2}\,\hat{r}$. This is Coulomb’s law.
- Therefore, Electric field at C , $E = \frac{F}{q_0} = \frac{1}{4\pi\epsilon_0}\frac{q}{r^2}\,\hat{r}$ - - - - - - - (1)
- From the definition, the electric flux $\Phi_E = \oint \vec{E}\,.d\vec{A} = \vec{E}\oint d\vec{A}$ - - - - -(2)

  Substitute (1) in (2), $\Phi_E = \frac{1}{4\pi\epsilon_0}\frac{q}{r^2}\,\hat{r}\oint d\vec{A}$ - - - - - - - (3)
- Put $\hat{r} = 1$ and $\oint d\vec{A} = 4\,\pi r^2$ in (3)
- $\Phi_E = \frac{q}{\epsilon_0}$. This is Gauss’s law. So we can able to derive Gauss’s law from Coulomb’s law.

5 MARK - QUESTIONS AND ANSWERS :

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

- Consider an electric dipole AB along X - axis. Let 'C' be the point at a distance 'r' from the mid point 'O' on its axial line.
- Electric field at C due to +q, $\vec{E}_{+} = \frac{1}{4\pi\epsilon_0}\frac{q}{(r-a)^2}\hat{p}$
- Electric field at C due to $-\boldsymbol{q}$, $\vec{E}_{-} = -\frac{1}{4\pi\epsilon_0}\frac{q}{(r+a)^2}\hat{p}$



- The total electric field at 'C' due to dipole is

$$\vec{E}_{tot} = \vec{E}_{+} + \vec{E}_{-}$$
$$= \frac{1}{4\pi\epsilon_0}\frac{q}{(r-a)^2}\hat{p} - \frac{1}{4\pi\epsilon_0}\frac{q}{(r+a)^2}\hat{p}$$
$$= \frac{q}{4\pi\epsilon_0}\left[\frac{1}{(r-a)^2} - \frac{1}{(r+a)^2}\right]\hat{p}$$
$$= \frac{q}{4\pi\epsilon_0}\left[\frac{(r+a)^2-(r-a)^2}{(r^2-a^2)^2}\right]\hat{p}$$
$$= \frac{q}{4\pi\epsilon_0}\left[\frac{4ra}{(r^2-a^2)^2}\right]\hat{p}$$

- If r >> a, $(r^2 - a^2)^2 \approx r^4$

$$\vec{E}_{tot} = \frac{2\,\vec{p}}{4\pi\epsilon_0 r^3}\;(\vec{p} = 2aq\hat{p})$$

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

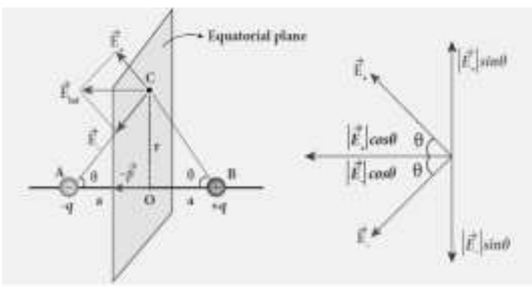
2. Calculate the electric field due to a dipole on its equatorial line.

- Consider an electric dipole AB along X - axis. Let 'C' be the point at a distance 'r' from the mid point 'O' on its equatorial plane.
- The magnitude of electric field at C due to $+\boldsymbol{q}$, $|\vec{E}_{+}| = \frac{1}{4\pi\epsilon_0}\frac{q}{(r^2+a^2)}$ ------(1)
- The magnitude of electric field at C due to $-\boldsymbol{q}$, $|\vec{E}_{-}| = \frac{1}{4\pi\epsilon_0}\frac{q}{(r^2+a^2)}$ ------(2)
- Moreover,

i) $|\vec{E}_{+}| = |\vec{E}_{-}|$

ii) The perpendicular components $(|\vec{E}_{+}|\sin\theta, |\vec{E}_{-}|\sin\theta)$ are equal and oppositely directed .So they cancel each other.

iii) The parallel components $(|\vec{E}_{+}|\cos\theta, |\vec{E}_{-}|\cos\theta)$ are equal and same in direction .So they are added together.



- $\vec{E}_{tot} = -2\,|\vec{E}_{+}|\cos\theta\,\hat{p}$ ------(3)

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

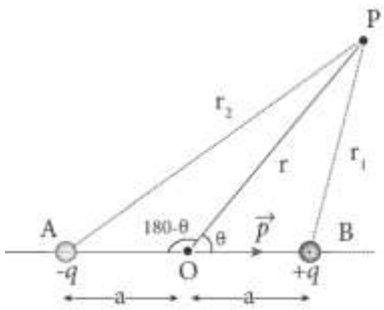
Substitute equation (1) ,(4) in (3)

$$\vec{E}_{tot} = -2\,\frac{1}{4\pi\epsilon_0}\frac{q}{(r^2+a^2)}\frac{a}{(r^2+a^2)^{1/2}}\hat{p}$$
$$= -\frac{2q}{4\pi\epsilon_0}\frac{a}{(r^2+a^2)^{3/2}}\hat{p}$$

- If r >> a then

$\vec{E}_{tot} = -\frac{\vec{p}}{4\pi\epsilon_0 r^3}$ $(\vec{p} = 2qa\hat{p})$. The direction of $\vec{E}_{tot}$ 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 , $V_1 = \frac{1}{4\pi\epsilon_0}\frac{q}{r_1}$ - - - - - -(1)
- Electric potential at P due to −q , $V_2 = \frac{-1}{4\pi\epsilon_0}\frac{q}{r_2}$ - - - - - (2)
- Electric potential at 'P' due to dipole is $V = \frac{1}{4\pi\epsilon_0}\frac{q}{r_1} - \frac{1}{4\pi\epsilon_0}\frac{q}{r_2}$

$$V = \frac{q}{4\pi\epsilon_0}\left(\frac{1}{r_1} - \frac{1}{r_2}\right) \quad \text{- - - - - -(3)}$$

- $\frac{1}{r_1} = \frac{1}{r}\left(1 + \frac{a\cos\theta}{r}\right)$ and $\frac{1}{r_2} = \frac{1}{r}\left(1 - \frac{a\cos\theta}{r}\right)$- - - - -(4)

Substitute equation (4) in (3)

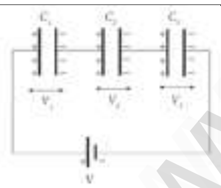
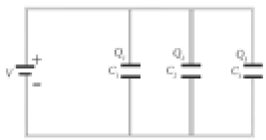
$$V = \frac{q}{4\pi\epsilon_0}\left[\frac{1}{r}\left(1 + \frac{a\cos\theta}{r}\right) - \frac{1}{r}\left(1 - \frac{a\cos\theta}{r}\right)\right]$$

$$V = \frac{q}{4\pi\epsilon_0}\frac{2a\cos\theta}{r^2}$$

$$\boxed{V = \frac{P\cos\theta}{4\pi\epsilon_0 r^2}} \quad (P = 2qa) \quad \text{(or)} \quad \boldsymbol{V = \frac{1}{4\pi\epsilon_0}\frac{\vec{P}.\hat{r}}{r^2}}$$

$\theta = 0^0$	$V = \frac{P}{4\pi\epsilon_0 r^2}$	Point P lies on the axial line of electric dipole, near +q
$\theta = 180^0$	$V = \frac{-P}{4\pi\epsilon_0 r^2}$	Point P lies on the axial line of electric dipole, near - q
$\theta = 90^0$	$V = 0$	Point P lies on the equatorial line of electric dipole.

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

Capacitors in series	**Capacitors in parallel**
Consider three capacitors of capacitance C_1, C_2 and C_3 connected in series . C_S - the equivalent capacitance of capacitor in series connection .	Consider three capacitors of capacitance C_1, C_2 and C_3 connected in parallel . C_P - the equivalent capacitance of capacitor in parallel connection
	
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 . $Q = Q_1 + Q_2 + Q_3$
$V = \frac{Q}{C_S}$; $V_1 = \frac{Q}{C_1}$, $V_2 = \frac{Q}{C_2}$, $V_3 = \frac{Q}{C_3}$	$Q = C_P V$ $Q_1 = C_1 V$; $Q_2 = C_2 V$; $Q_3 = C_3 V$
$\frac{Q}{C_S} = \frac{Q}{C_1} + \frac{Q}{C_2} + \frac{Q}{C_3}$	$C_P V = C_1 V + C_2 V + C_3 V$
$\frac{1}{C_S} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$	$C_P = C_1 + C_2 + C_3$
The inverse of the equivalent capacitance of capacitors connected in series is equal to the sum of the inverses of each capacitance.	The equivalent capacitance of capacitors connected in parallel is equal to the sum of the individual capacitances.

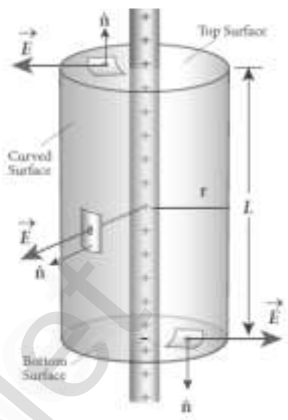
5.Obtain an expression for electric field due to an infinitely long charged wire.

i) Consider an infinitely long straight wire of uniform linear charge density λ. $(i.e)\lambda = \frac{Q_{enclosed}}{L}$

So, total charge enclosed by the closed surface $Q_{encl} = \lambda L$ - - - - (1)

ii) Electric field : Let 'E' be the electric field at the point 'P' which is at a distance 'r' from the wire

iii) Gaussian surface :A cylinder of length 'L' and radius 'r'.



iv) The electric flux for the curved surface:

$$\phi_E = \int_{\text{Curved surface}} E\, dA \cos\theta = E\,(2\pi r L) \quad [\because \theta = 0]$$

v) The electric flux for top and bottom surfaces: $\phi_E = 0$

($\vec{E}$ is perpendicular to $\vec{A}$;. so $\vec{E}.\overrightarrow{dA} = 0$)

vi) Then the total electric flux $\phi_E = E(2\pi rL)$ - - - - - (2)

vii) According to Gauss law, $\phi_E = \frac{Q_{encl}}{\epsilon_0}$ - - - - - (3)

Substitute equation (1) and (2) in (3)

$$E(2\pi r L) = \frac{\lambda L}{\epsilon_0}$$

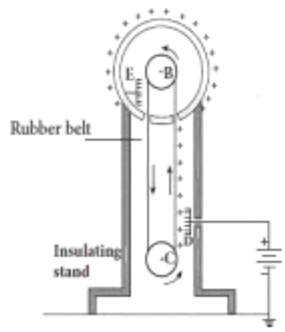
$$E = \frac{\lambda}{2\pi\epsilon_0 r} \quad \text{(OR)} \quad \vec{E} = \frac{1}{2\pi\epsilon_0}\frac{\lambda}{r}\hat{r}$$

- If $\lambda > 0$, then the direction of E is perpendicular to wire and pointing outward.
- If $\lambda < 0$, then the direction of E is perpendicular to wire and pointing inward.

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

Principle : Electrostatic induction and Action at points

Construction :



i) 'A' is a hollow spherical conductor fixed on the insulating stand.

ii) 'B'and 'C' are pulleys and they are connected by a belt made up of silk .

iii) 'D'and 'E' are metallic comb shaped conductors fixed near the pulleys.

iv) The comb 'D' is maintained at a positive potential of $10^4 V$ by a power supply.

v) The upper comb 'E' is connected to the inner side of the hollow metal sphere.

Working of comb 'D':

i) Due to the high electric field near comb 'D', air gets ionized.

ii) The positive charges are pushed towards the belt and negative charges are attracted towards the comb 'D' .

iii) The positive charges stick to the belt and reach comb 'E'.

Working of comb 'E':

i) Due to electrostatic induction ,the comb 'E' get negative charges and the sphere gets positive charges

ii) Due to action at points at 'E' ,descending belt has no charge.

Charge leakage:

i) Beyond the maximum potential difference of $10^7 V$ of the sphere, the charges start leaking to the surroundings due to ionization of air.

ii) It is prevented by enclosing the machine in a gas filled steel chamber at very high pressure.

Application:

- The high voltage ($10^7 V$) produced in the Van de Graff generator is used to accelerate positive ions (protons and deuterons) for nuclear disintegrations.

7. Obtain an expression for electric field due to an charged infinite plane sheet.

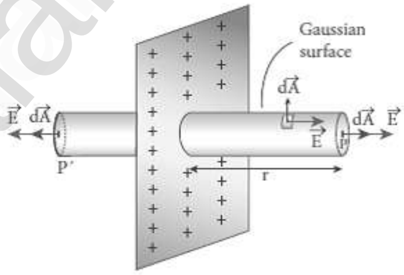
- Consider an infinite plane sheet of uniform surface charge density 'σ' $(i.e)\ \sigma = \frac{Q_{enclosed}}{A}$

  So, total charge enclosed by the plane sheet $Q_{encl} = \sigma A$ ------ (1)
- Electric field : Let 'E' be the electric field at 'P' which is at a distance 'r' from the sheet.
- Gaussian surface : a cylindrical of length '2r' and area of cross section 'A'
- The electric flux through the curved surface, $\phi_1 = \int_{\text{Curved surface}} E\, dA \cos\theta = 0 \quad [\because \theta = 90]$
- The electric flux through end surface P and P '

$$\phi_2 = \int_p E\, dA + \int_{p'} EdA \qquad [\because \theta = 0]$$

$$\phi_2 = EA + EA$$

$$\phi_2 = 2EA \quad \text{------ (2)}$$



- Total electric flux $\phi_E = 0 + 2EA = 2EA$
- According to Gauss law, $\phi_E = \frac{Q_{encl}}{\epsilon_0}$ - - - - - (3)

  Substitute equation (1) and (2) in (3)

$$2EA = \frac{\sigma A}{\epsilon_0}$$

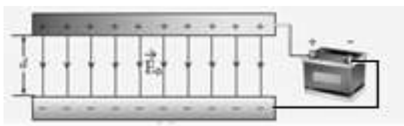
$$E = \frac{\sigma}{2\epsilon_0}$$

8. 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.

- A parallel plate capacitor is charged by a battery of voltage 'V_o'.

  Q_o - is the charge stored in the plates.

  E_o - is the electric field between the plates.



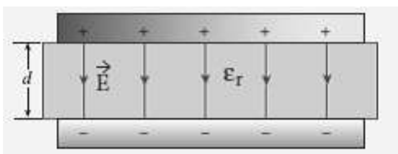
- Capacitance of the capacitor without dielectric medium, $C_o = \frac{Q_0}{V_0}$.
- The battery is then disconnected from the capacitor and the dielectric is inserted between the plates.

  Q_o - is the charge stored in the plates.

  E - is the electric field between the plates.

  V - is the potential difference between the plates.

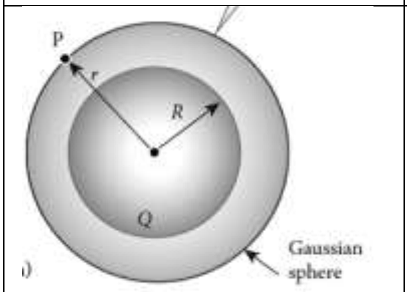
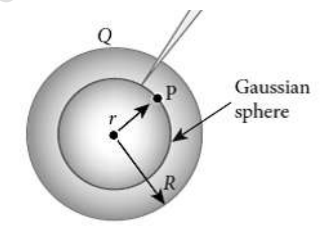
  ϵ_r – dielectric constant of the dielectric medium.



➢ Effect of dielectric medium between the plates

Quantity	Value	Effect of dielectric When $\epsilon_r > 1$	
Electric field	$E = \frac{E_0}{\epsilon_r}$	$E < E_0$	Decreased
Potential difference	$V = \frac{V_0}{\epsilon_r}$	$V < V_0$	Decreased
Capacitance	$C = \epsilon_r C_0$	$C > C_0$	Increased
Energy	$U = \frac{U_0}{\epsilon_r}$	$U < U_0$	Decreased

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

At a point outside the shell	**At a point on the surface of the shell**	**At a point inside the shell**
Gaussian surface : Sphere with radius r	Gaussian surface : Sphere with radius r	Gaussian surface : Sphere with radius r
R -radius of spherical shell	R -radius of spherical shell	R-radius of spherical shell
Here r > R	Here r = R	Here r < R
	Substitute r = R	
According to Gauss's law, $\oint EdA\cos\theta = \frac{Q_{encl}}{\epsilon_0}$		According to Gauss's law, $\oint EdA\cos\theta = \frac{Q_{encl}}{\epsilon_0}$
Substitute $\oint EdA\cos\theta = E\ 4\pi r^2$ $Q_{encl} = Q$		Substitute $\oint EdA\cos\theta = E\ 4\pi r^2$ $Q_{encl} = 0$
$E(4\pi r^2) = \frac{Q}{\epsilon_0}$ $E = \frac{Q}{4\pi\epsilon_0 r^2}$	$E = \frac{Q}{4\pi\ \epsilon_0\ R^2}$	$E(4\pi r^2) = \frac{0}{\epsilon_0}$ $E = 0$

OTHER IMPORTANT QUESTION (3 - MARK):

1. Define - 1 coulomb.
2. Define - 1 volt.
3. Define - 1 farad.
4. Balloon sticks to the wall. Why?
5. What is the role of capacitor in a ceiling fan.

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2. CURRENT ELECTRICITY

2 MARK -QUESTIONS AND ANSWERS:

1. Electric current is a scalar quantity why?

- $I = \vec{J}.\vec{A}$
- Even though current has particular direction and magnitude they will not obey vector laws. So current is a scalar quantity.

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 $m\ s^{-1}$.	Its unit is $m^2\, v^{-1} s^{-1}$.

3. Define current density and give its unit.

- The current density is defined as the current per unit area of cross section of the conductor. J = $\frac{I}{A}$.
- Its unit is A m^{-2}.

4.Give the microscopic form of ohm's law.

- Current density is directly proportional to the applied electric field.
- $\vec{J} = \sigma \vec{E}$. Here $\vec{J}$ - current density. σ- Conductivity $\vec{E}$. - Electric field.

5. Give the macroscopic form of ohm's law.

- The macroscopic form of ohm's law is **V=IR**.
- Here 'V' - Potential difference, '**I**' - Current and '**R**' - Resistance.

6.What are ohmic and non-ohmic materials?

S.N	Ohmic materials	Non-ohmic materials
1	V-I graph is a straight line	V-I graph is non-linear
2	obey Ohm's law	Doesn't obey Ohm's law
3	They have constant resistance	They do not have constant resistance

7.Define electrical resistivity and give its unit.

- Electrical resistivity of a material is defined as the resistance offered to current flow by a conductor of unit length having unit area of cross section.
- Its unit is Ω m (ohm meter).

8. 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 T_o.
- Its unit is per °C.

9. What is known as superconductivity?

- The resistance of certain material becomes zero below certain temperature .
- The materials which exhibit this property are called superconductors.
- The property of conducting current with zero resistance is called superconductivity.

10. What is electric energy and electric power ?

Electric energy

- 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.
- Its SI unit is joule (J). Its practical unit is kilowatt hour (kWh). Moreover 1 kWh=3.6×10^6J.

Electric power

- The rate at which the electrical potential energy is delivered is called electric power.
- It SI unit is watt(W). Its practical unit is horse power(H.P). Moreover 1 H.P = 746W.

11.Derive the expression for power P=VI in electrical circuit.

- The equation for electrical potential energy dU=V dQ
- The rate at which the electrical potential energy is delivered is the electrical power. $P = \frac{dU}{dt} = V\frac{dQ}{dt}$
- Since the electric current $I = \frac{dQ}{dt}$, electrical power P= VI.

12. Write down the various forms of expression for power in electrical circuit.

- Electrical power equation is P = VI.
- According to ohm's law V = IR. So electrical power P = (IR) I = I^2R.
- According to ohms law $I = \frac{V}{R}$, so electrical power $P= V\frac{V}{R} = V^2$ / R.

13. State Kirchhoff's first rule (current rule or junction rule).

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

14. State Kirchhoff's second rule (voltage rule or loop rule).

- 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 total emf included in the circuit. (i.e) $\Sigma \boldsymbol{I R} = \Sigma \varepsilon$.

15. State the principle of potentiometer.

- If I- current, r – resistance per unit length of the wire of potentiometer, l – balancing length, then emf of the cell $\varepsilon = Irl$.
- since I and r constant $\varepsilon \propto l$
- The emf of the cell is directly proportional to the balancing length.

16. Define internal resistance of a battery .

- The resistance offered by the electrolyte to the flow of charges within the battery is called internal resistance (r).
- A freshly prepared cell has low internal resistance and it increases with ageing.

17. State Joule's heating law.

- Heat librated by Joule's heating effect, **$H = I^2 R t$**
- The heat developed in an electrical circuit due to the flow of current varies directly to
  - i) The square of the current ($H \alpha I^2$)
  - ii) The resistance of the circuit ($H \alpha$ R)
  - iii) The time of flow ($H \alpha$ t)

18.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.

19. 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.

20. 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.

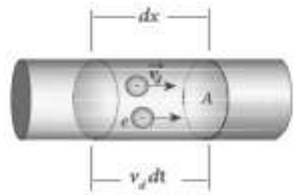
21. State the applications of seeback effect.

- Seeback effect is used in thermo electric generators . These generators are used in power plants to convert waste heat into electricity.
- It is used in automobiles as automotive thermoelectric generators for increasing fuel efficiency.
- It is used in thermocouples and thermopiles to measure the temperature difference between the two objects.

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.
- The number of electrons available in the volume (Adx) = n A v_d dt



- charge of an electron = e.
- Total charge in the volume element

  $dQ = (\text{nA } v_d \text{dt})e$
- current $I = \frac{dQ}{dt}$

  $I = (\text{nA } v_d \text{dt})e / dt$

  $I = nAv_d e.$
- current density $\vec{J} = \frac{I}{A}$

  $\vec{J} = \frac{nA\vec{V_d}\, e}{A} = ne\vec{v_d}$

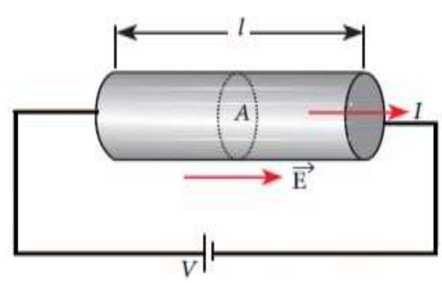
  Substitute $\vec{V_d} = -\frac{e\tau}{m}\vec{E}$

  $\vec{J} = -ne\left(\frac{e\tau}{m}\vec{E}\right)$

  $\vec{J} = -n\left(\frac{e^2\tau}{m}\right)\vec{E}$ or

  $\vec{J} = -\sigma\vec{E}$, Here $\sigma = \frac{n\, e^2\tau}{m}$ is conductivity.
- But conventionally we take the direction of current density as the direction of electric field. So, This is called macroscopic form of ohm's law.

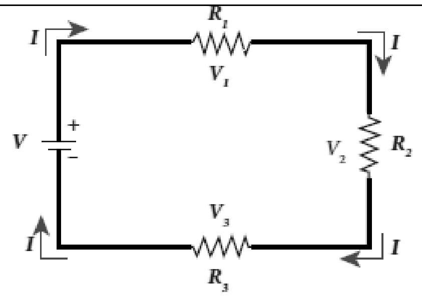
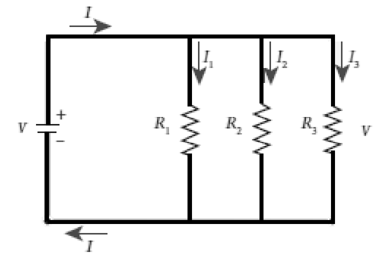
2.Obtain the macroscopic form of ohm's law from its microscopic form.



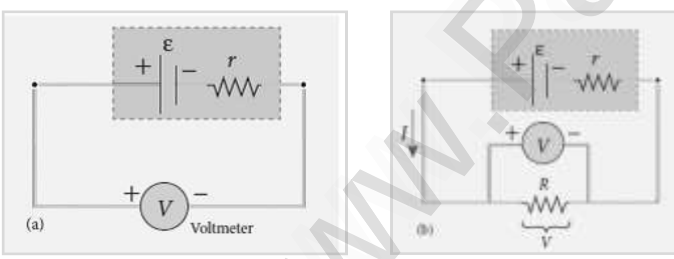
- Microscopic form of ohm's law **J=σ E**
- Substitute current density **J=$\frac{I}{A}$** and electric field **E = $\frac{V}{l}$**
- $\frac{I}{A} = \sigma \frac{V}{l}$ or
- $V = I \frac{l}{\sigma A}$,

  Let $\frac{l}{\sigma A}$ is the resistance -R of a conductor then
- **V= IR .** This is the macroscopic form of ohm's law.

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

S.no	Series circuit	Parallel circuit
1		
2	Let R_1, R_2,R_3 be the resistance of three resistors connected in series	Let R_1, R_2, R_3 be resistance of three resistors connected in parallel
3	The current flowing through all the resistors are equal	The potential difference between all the resistors are equal
4	Potential difference varies	current varies
5	$V = V_1+V_2+V_3$	$I = I_1 + I_2 + I_3$
6	$V = IR_s$ V_1=I R_1; V=I R_2;V_3=I R_3	$I = V/ R_P$ $I_1 = V / R_1$; $I_2 = V / R_2$; $I_3 = V / R_3$
7	I R_S= I R_1+ I R_2+ I R_3	$\frac{V}{R_P} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$
8	$R_S=R_1+R_2+R_3$	$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

4. 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 (ε)

$$\mathbf{V = \varepsilon \quad ------ (1)}$$

- The external resistance R is included in the circuit. Current I is established in the circuit.
- Potential drop across R is V = I R

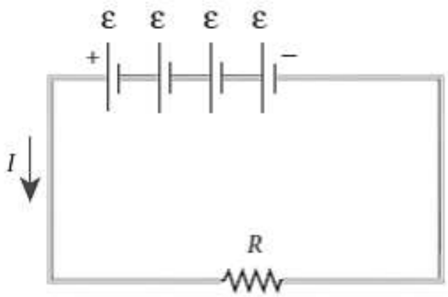
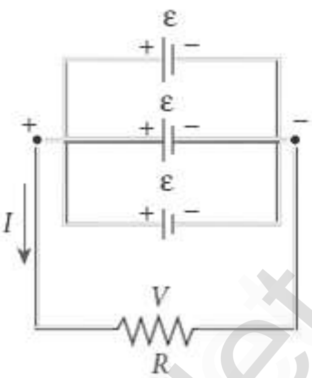
Or **I R = V - - - - - - (2)**

- Due to internal resistance 'r' of the cell, the voltmeter reads a value 'v', which is less than the emf of cell $\boldsymbol{\varepsilon}$.

$$\mathbf{Ir = \varepsilon - V \quad -------- (3)}$$

(3) ÷ (2) Internal resistance $r = \left(\frac{\varepsilon - V}{v}\right) R$.

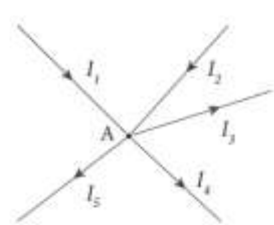
5. **Explain series and parallel connections in cell**.

S.no	cells in series	cells in parallel
1		
2	'n ' Batteries having internal resistance 'r' and emf 'ε' are connected in series	'n' batteries having internal resistance 'r' and emf 'ε' are connected in parallel.
3	Total emf = n ε	Total emf = ε
4	Total resistance = nr + R	Total resistance = $\frac{r}{n}$ + R
5	Current in the circuit $I = \frac{n\varepsilon}{nr+R}$	Current in the circuit $I = \frac{n\varepsilon}{r+nR}$
6	If $r << R,\ I = \frac{n\varepsilon}{R}$	If $r << R,\ I = \frac{\varepsilon}{R}$
7	If $r >> R,\ I = \frac{\varepsilon}{r}$	If $r >> R,\ I = \frac{n\varepsilon}{r}$

6. **State and explain Kirchoff's rules**

Kirchoff's first rule

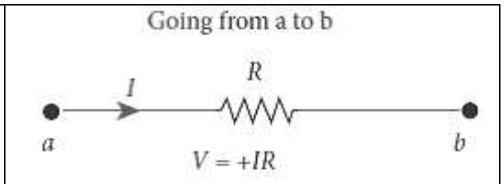
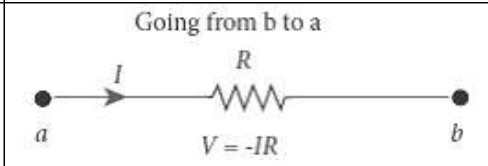
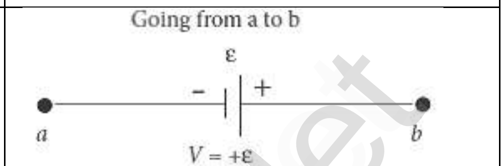
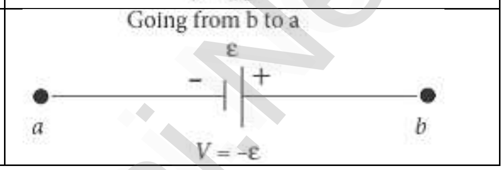
- The algebraic sum of the current at any junction of a circuit is zero. (i.e) $\Sigma I = 0$.
- It is a statement of law of conservation of electric charges.
- Current entering the junction is taken as positive and leaving the junction is taken as negative.



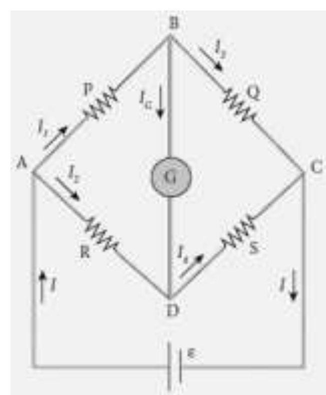
$$I_1 + I_2 - I_3 - I_4 - I_5 = 0$$

Kirchoff's second rule:

- 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 total emf included in the circuit. (i.e) $\Sigma IR = \Sigma \varepsilon$
- This rule follows from the law of conservation of energy for an isolated system.

1	The product of current and resistance is taken as positive when the direction of the current is followed.	
2	Suppose if the direction of current is opposite to the direction of the loop,then product of current and voltage across the resistor is negative.	
3	The emf is considered positive when proceeding from the negative to the positive terminal.	
4	The emf is considered negative when proceeding from the positive to the negative terminal.	

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



- The bridge consists of four resistances P,Q,R and S connected as shown in figure.
- A galvanometer 'G' is connected between the points B and D.
- The battery is connected between the points A and C.
- The current through the galvanometer is I_G and its resistance is G.
- 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,

  $I_1P + I_GG - I_2R = 0$ ------ (3)
- Applying Kirchhoff's voltage rule to loop BCDB.

  $I_3Q - I_GG - I_4S = 0$ ------ (4)
- Substitute $I_G = 0$ in equation (1) (2) (3) &(4)

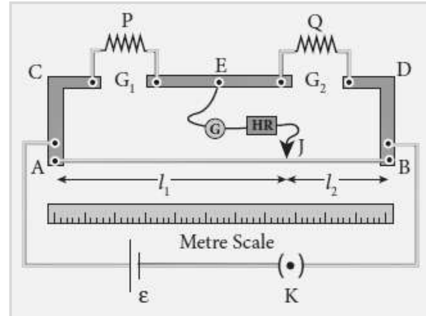
  $I_1 = I_3$ ------(5)

  $I_2 = I_4$ ------(6)

  $I_1P = I_2R$ ------(7)

  $I_3Q = I_4S$ ------(8)
- (7) ÷ (8) $\frac{I_1P}{I_3Q} = \frac{I_2R}{I_4S}$
- Using equations (5) and (6) $\boxed{\frac{P}{Q} = \frac{R}{S}}$

8.**Explain the determination of unknown resistance using metre bridge.**



Construction:

- A uniform wire of manganin AB of one meter length is stretched along a metre scale on a wooden board between two copper strips.
- In the gap G_1, unknown resistance 'P' and in the gap 'G_2' standard resistance Q are connected.
- A jockey is connected to the terminal 'E' on the central strip through a galvanometer (G) and a high resistance (HR).
- A Lechlanche cell and a key are connected between the ends of the bridge wire.

Working:

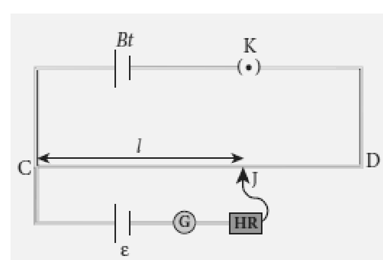
- The position of the jockey on the wire is adjusted so that the galvanometer shows zero deflection.
- The resistances corresponding to AJ(l_1) and JB(l_2) of the bridge wire form the resistances 'R' and 'S' of the wheatstone's bridge

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

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

- Unknown resistance P= $Q\,\frac{l_1}{l_2}$
- The end resistance due to the bridge wire soldered at the ends of the strips can be eliminated if another set of reading is taken with P and Q interchanged and average value of 'P' is found.
- Specific resistance of the material of the wire $\rho = \frac{P\pi r^2}{l}$

9.**Explain the principle of a potentiometer**



- **Primary circuit** : The battery, key and the potentiometer wire are connected in series to form primary circuit.
- **Secondary circuit**: The positive terminal of a primary cell of emf ε is connected to the point C and negative terminal is connected to the jockey through a galvanometer G and a high resistance HR. This forms the secondary circuit.
- Contact is made at any point J on the wire.
- If the potential difference across (J) is equal to the emf of the cell ε, then no current will flow through the galvanometer and it will show zero deflection.
- CJ is the balancing length.

- potential difference across CJ is equal to Irl, whereas

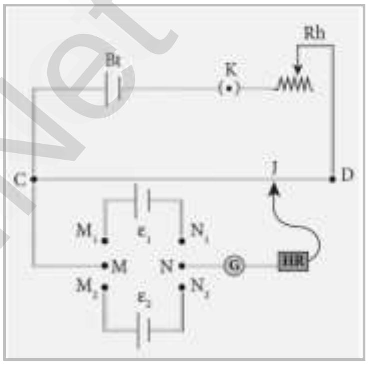
  I – The current flowing through the conductor

  r – the resistance per unit length of wire.
- emf of the cell = potential difference across CJ

$$\varepsilon = Irl$$

- If I and r constant, $\varepsilon \alpha\ l$
- The emf of a cell is directly proportional to the balancing length.

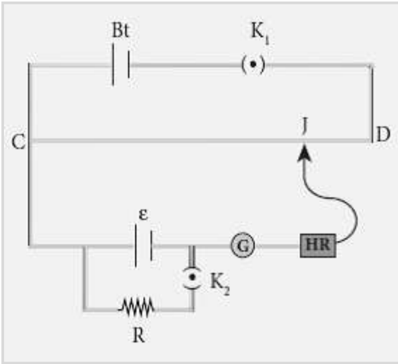
10. How the emf of two cells are compared using potentiometer?



- Primary circuit: Potentiometer wire (CD) is connected in series with battery (Bt), key(K) and rheostat (Rh).
- Secondary circuit: The end C of potentiometer wire is connected to the terminal M of a DPDT switch and the other terminal N is connected to a jockey through a galvanometer G , a high resistance HR.
- The cells whose emf $\boldsymbol{\varepsilon_1}$ and $\boldsymbol{\varepsilon_2}$ to be compared are connected to the terminals $M_1\ N_1$ and $M_2\ N_2$ of the DPDT switch.
- I – Steady current passing through the potentiometer wire.

  r – Resistance per unit length of the potentiometer wire.
- **Procedure 1:**
  - i) Initially the cell of emf $\boldsymbol{\varepsilon_1}$ is included in the secondary circuit and the balancing length l_1 is found by adjusting jockey for zero deflection.
  - ii) According to the principle of potentiometer , $\boldsymbol{\varepsilon_1 = Irl_1}$ - - - - - - **(1)**
- **Procedure 2:**
  - i) Similarly the cell of emf $\boldsymbol{\varepsilon_2}$ is included in the secondary circuit and the balancing length l_2 is found.
  - ii) According to the principle of potentiometer , $\boldsymbol{\varepsilon_2 = Irl_2}$ - - - - - - **(2)**
- (1) ÷(2) $\quad \frac{\varepsilon_1}{\varepsilon_2} = \frac{l_1}{l_2}$ - - - - - - **(3)**

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



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

- Balancing length l_1 is determined when key K_2 is open. According to principle of potentiometer.

$$\varepsilon \, \alpha \, l_1 \text{ ------ } (1)$$

- When Key K_2 is closed, the balancing length l_2 is determined.

$$\frac{\varepsilon R}{R+r} \, \alpha \, l_2 \text{ ------ } (2)$$

- (1) ÷(2) $r = \left[\frac{l_1 - l_2}{l_2}\right] R$ ----- **(3)**

Substituting R, l_1, l_2 in equation (3) the internal resistance of a cell can be calculated.

Annexure

2 - MARK QUESTIONS AND ANSWERS:

1.Why nichrome is used as heating element in electric heaters?

i) It has a high specific resistance.

ii) It has high melting point.

iii) It can be heated to very high temperature without Oxidation.

2. Differentiate Joule heating effect and peltier effect.

S.no	Joule heating effect	Peltier effect
1	It is irreversible	It is reversible
2	Heat energy developed is directly proportional to the square of current (H α I^2)	Rate of heat energy developed is directly proportional to the current. ($\frac{dH}{dt} \alpha I$)
3	It does not depend on the direction of current.	It depends on the direction of current.

3. Define electric current and give its unit.

- The electric current in a conductor is defined as the rate of flow of charges through a given cross sectional area.
- The SI unit of current is ampere (A).

4. What is called mean free time?

- The average time between two successive collisions is called the mean free time.

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3 .MAGNETISM AND MAGNETIC EFFECTS OF ELECTRIC CURRENT

2 MARK - QUESTIONS AND ANSWERS :

1. What are the elements of the Earth's Magnetic field?

i) Magnetic declination (D)

ii) Magnetic dip or inclination (I)

iii) The horizontal component of the Earth's magnetic field (B_H)

2. Define Magnetic Dipole Moment. Give its unit.

- The product of its pole strength (q_m) and magnetic length.$(2l)$.
- **The magnitude of magnetic dipole moment $p_m = 2lq_m$.**
- SI unit is A m ^{2}.

3. Define Magnetic flux. Give its unit.

- Magnetic flux is defined as the number of magnetic field lines crossing any area normally .
- $\phi_B = \vec{B}.\vec{A}$
- SI unit is **weber**. Dimension is **M L ^{2} T^{-2} A^{-1}**

4. 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
- inversely proportional to the square of the distance between them.
- $\vec{F} = k\frac{q_{m_A} q_{m_B}}{r^2}\hat{r}$

5. 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.
- $B = B_H \tan\theta$

6. Define Intensity of Magnetisation. Give its unit.

- The net magnetic moment per unit volume of the material. $\vec{M} = \frac{\vec{p}_m}{V}$.
- SI unit is **Am^{-1}.** It is a vector quantity.

7. Define Magnetic susceptibility.

- The ratio of the intensity of magnetisation (M) induced in the material to the magnetising field (H)
- $\chi_m = \frac{|\vec{M}|}{|\vec{H}|}$

8. What is Meissner effect?

- The expulsion of magnetic flux from a dia magnetic material during its transition to the super conducting state .

9. Define Curie's law.

- Magnetic susceptibility of paramagnetic materials decreases with increase in temperature.
- $\chi_m \; \alpha \frac{1}{T}$. This relation is called Curie's law.

10. What is curie temperature?

- At a particular temperature, ferromagnetic material becomes paramagnetic material.
- This temperature is known as Curie temperature.

11. What is Hysteresis?

- The phenomenon of lagging of magnetic induction behind the magnetising field is called hysteresis.

12. What are the Soft and Hard Ferromagnetic materials?

- Soft Ferromagnetic materials: Area of the Hysteresis loop is small. Example: Soft iron , Mumetal.
- Hard Ferromagnetic materials: Area of the Hysteresis loop is Large. Example: Steel, Alnico.

13. State right hand thumb rule.

If we hold the current carrying conductor in our right hand,

- The thumb points the direction of current flow
- The fingers encircling the conductor point the direction of the magnetic field lines produced.

14. State Maxwell's right hand cork screw rule.

If we rotate a right-handed screw using a screw driver,

- The direction of current is same as the direction in which screw advances
- The direction of rotation of the screw gives the direction of the magnetic field.

15. Define Magnetic dipole moment of current loop.

- Magnetic dipole moment (p_m) of any current loop is equal to the product of the current (I) and area of the loop (A).
- $\vec{p}_m = I\vec{A}$

16. What are the limitations of cyclotron?

i) The speed of the ion is limited.
ii) Electron cannot be accelerated.
iii) Uncharged particles cannot be accelerated.

17. 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.

18. Define current sensitivity of a galvanometer.

- The deflection produced by per unit current flowing through galvanometer. (i.e) $\frac{\theta}{I} = \frac{NBA}{K}$

19. 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 .

20. Why Phosphor-Bronze is used as suspension wire in galvanometer?

- Phosphor-Bronze wire has very small couple per unit twist.

21.Define Voltage sensitivity of the galvanometer.

- Deflection produced per unit voltage applied across the galvanometer. (i.e) $\frac{\theta}{V} = \frac{NBA}{KR_g}$

22. Define magnetic declination and inclination.

- The angle between magnetic meridian at a point and geographical meridian is called the declination.
- The angle subtended by the Earth's total magnetic field $\vec{B}$ with the horizontal direction in the magnetic meridian is called dip or magnetic inclination at that point.

23. Explain the concept of velocity selector.

- By the proper choice of electric and magnetic fields, the particle with particular speed can be selected. Such an arrangement of field is called a velocity selector.
- For a given magnitude of Electric field $(\vec{E})$ and magnetic field $(\vec{B})$ the forces act only on the particle moving with particular speed $v_0 = \frac{E}{B}$.

24. **Define - 1 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.

<u>3 - MARK QUESTIONS AND ANSWERS :</u>

1. Give properties of magnetic field lines.

i) Magnetic field lines are continuous closed curves.

ii) The direction of magnetic field lines is from North pole to South pole outside the magnet and South pole to North pole inside the magnet.

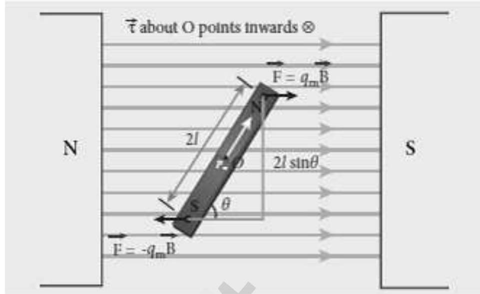
iii) The direction of magnetic field at any point on the curve is known by drawing tangent to the magnetic field lines at that point.

iv) Magnetic field lines never intersect each other.

v) The magnetic field is strong where magnetic field lines are crowded and weak where magnetic field lines are separated.

2. Calculate the torque acting on a bar magnet in uniform magnetic field.

i) Consider a magnet of length 2*l* of pole strength q_m kept in a uniform magnetic field .



ii) The force experienced by north pole , $\vec{F_N} = q_m\vec{B}$

The force experienced by south pole, $\vec{F_S} = -q_m\vec{B}$

iii) The net force acting on the dipole becomes zero.

iv) The moment of force or torque , $\tau = q_m\ B \times 2l sin\,\theta$

$$\tau = p_m\ B \sin\theta \quad (\ p_m = 2lq_m\ )$$

v) In vector form $\vec{\tau} = \vec{p}_m \times \vec{B}$.

3. List the properties of Diamagnetic materials.

i) Magnetic susceptibility is negative.

ii) Relative permeability is slightly less than unity.

iii) The magnetic field lines are repelled or expelled by it when placed in a magnetic field.

iv) Susceptibility is temperature independent

v) Examples: Bismuth, Copper and Water.

4. List the properties of paramagnetic materials.

i) Magnetic susceptibility is positive and small.

ii) Relative permeability is greater than unity.

iii) The magnetic field lines are attracted into the paramagnetic materials when placed in a magnetic field.

iv) Susceptibility is inversely proportional to temperature.

v) Example: Aluminium, Platinum, Chromium and Oxygen.

5. List the properties of Ferro magnetic materials.

i) Magnetic susceptibility is positive and large.

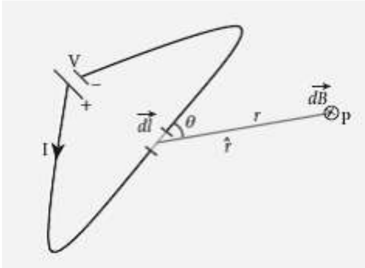
ii) Relative permeability is very large.

iii) The magnetic field lines are strongly attracted into the ferromagnetic materials when placed in a magnetic field.

iv) Susceptibility is inversely proportional to temperature.

v) Example: Iron, Cobalt and Nikel.

6. State and explain Biot savart law.



According to Biot savart law, the magnitude of magnetic field $d\vec{B}$ is

i) directly as the strength of the current (I)

ii) directly as the magnitude of the length of the element ($d\vec{l}$)

iii) directly as the sine of the angle (θ) between $d\vec{l}$ and $\hat{r}$

iv) inversely as the square of the distance r between the point P and length element $d\vec{l}$.

$$(i.e)\ dB = \frac{\mu_0}{4\pi}\frac{Idl\sin\theta}{r^2}$$

v) In a vector form , $d\vec{B} = \frac{\mu_0}{4\pi}\frac{I\,d\vec{l}\times\hat{r}}{r^2}$

7. How is a galvanometer converted into an ammeter?

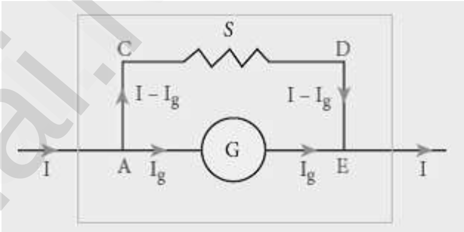
i) A galvanometer is converted into an ammeter by connecting a low resistance in parallel with it.

ii) (I - I_G) - current flowing through the shunt resistance.

S - shunt resistance.

I_G - current flows through the galvanometer.

R_G - galvanometer resistance.



Ammeter

iii) $V_{galvanometer} = V_{shunt}$

$$(I - I_G)\,S = I_G\,R_G$$

$$S = \frac{I_G\,R_G}{(I-I_G)}$$

R_a − Resistance of Ammeter $\frac{1}{R_a} = \frac{1}{R_G} + \frac{1}{S}$

iv) An ammeter is a low resistance instrument and it is always connected in series to the circuit.

v) An ideal ammeter has zero resistance.

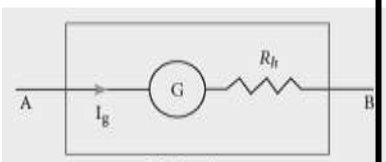
8. How is galvanometer converted into a voltmeter ?

i) A galvanometer is converted into a voltmeter by connecting high resistance (R_h) in series with it.

ii) V - Voltage to be measured.

I_G - current flowing through the galvanometer.

(R_G + R_h) - Total resistance.



Voltmeter

iii) $V = I_G(R_h + R_G)$

$$R_h = \frac{V}{I_G} - R_G$$

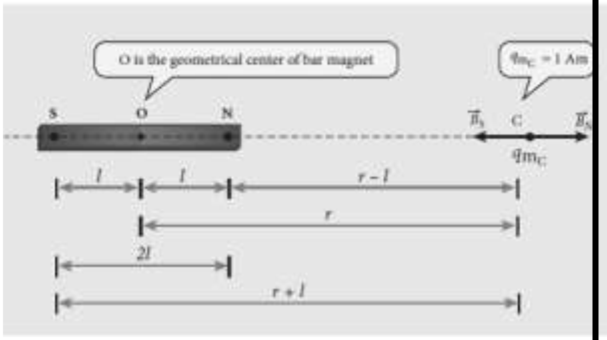
- Total resistance of the voltmeter $R_v = (R_G + R_h)$

iv) Voltmeter is a high resistance instrument and it is always connected in parallel with the circuit.

v) An ideal voltmeter has infinite resistance.

5 - MARK QUESTIONS AND ANSWERS :

1.Calculate the magnetic field at a point on the axial line of a bar magnet.



- Let N be the north pole and S be the south pole of the bar magnet, each of pole strength q_m and are separated by a distance of $2l$. C be the point on the axial line at a distance r from the centre of magnet.
- The magnetic field at C due to the north pole, $\vec{B}_N = \frac{\mu_0}{4\pi}\frac{q_m}{(r-l)^2}\hat{\imath}$
- The magnetic field at C due to the south pole, $\vec{B}_S = -\frac{\mu_0}{4\pi}\frac{q_m}{(r+l)^2}\hat{\imath}$
- The net magnetic field due to the magnetic dipole at point C ,

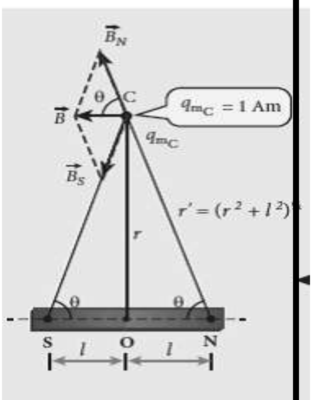
$$\vec{B} = \vec{B}_N + \vec{B}_S$$

$$\vec{B} = \frac{\mu_0}{4\pi}\frac{q_m}{(r-l)^2}\hat{\imath} - \frac{\mu_0}{4\pi}\frac{q_m}{(r+l)^2}\hat{\imath}$$

$$\vec{B} = \frac{\mu_0 q_m}{4\pi}\left(\frac{4rl}{(r^2-l^2)^2}\right)\hat{\imath}$$

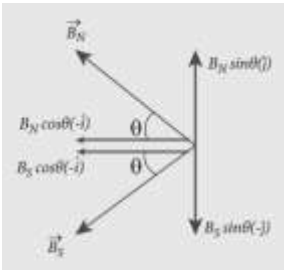
- If $r \gg l$, $\vec{B} = \frac{\mu_0}{4\pi}\left(\frac{2\,\vec{P}_m}{r^3}\right)$ $(\because\ P_m = q_m \times 2l \quad and \quad P_m\hat{\imath} = \vec{P}_m\ )$

2. **Obtain the magnetic field at a point on the equatorial line of a bar magnet.**



- Let N be the north pole and S be the south pole of the bar magnet, each of pole strength q_m and are separated by a distance of $2l$. C be the point on the axial line at a distance r from the centre of magnet.
- Each pole of the bar magnet is in equal distance from a point C. Therefore magnitude of magnetic field due to each pole of the bar magnet are equal.
- $|\vec{B}_N| = |\vec{B}_S| = \frac{\mu_0}{4\pi}\ \frac{q_m}{(r^2+l^2)}$ ------ (1)
- Vertical component cancel each other. The horizontal components are add up.
- Total magnetic field at C , $\vec{B} = \vec{B}_N + \vec{B}_S = -2\,B_N\cos\theta\ \hat{\imath}$ ------ (2) $(\because |\vec{B}_N| = |\vec{B}_S|)$

Sub (1) in (2) $\vec{B} = -2\frac{\mu_0}{4\pi}\frac{q_m}{(r^2+l^2)}\cos\theta\,\hat{\imath}$ ------ (3)



- From the right angle triangle NOC , $\cos\theta = \frac{l}{(r^2+l^2)^{1/2}}$ ------ (4)

Sub (4) in (3) $\vec{B} = -\frac{\mu_0}{4\pi}\frac{q_m\times(2l)}{(r^2+l^2)^{3/2}}\hat{\imath}$

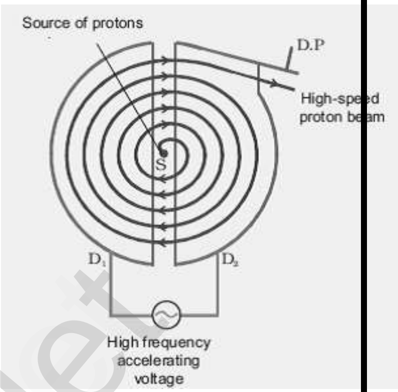
- If $r \gg l$, $\vec{B} = -\frac{\mu_0}{4\pi}\left(\frac{\vec{P}_m}{r^3}\right)$ $(\because\ P_m = q_m \times 2l \quad and \quad P_m\hat{\imath} = \vec{P}_m\ )$

3. Describe the principle, Construction and working of cyclotron.

Principle :

- When a charged particle moves normal to the magnetic field, it experiences magnetic Lorentz force.

Construction:



- D_1 and D_2 are two semi-circular metal containers called Dees. The two Dees are separated with a gap.
- The source S is placed at the center in the gap between the Dees.
- The direction of magnetic field is normal to the plane of the Dees.
- Dees are connected to high frequency alternating potential difference.

Working

- The ion ejected from source S is positively charged is accelerated towards a Dee (D_1)which has negative potential at that time.
- Since the magnetic field is normal to the plane of the Dees, the ion moves in a circular path.
- After one semi-circular path inside 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.

Calculation:

- For this circular motion, the centripetal force on the charged particle is provided by Lorentz force.

Magnetic force = Centripetal force

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

$$r = \frac{m}{qB} v$$

$r \alpha v$ (The increase in velocity increases the radius of circular path.)

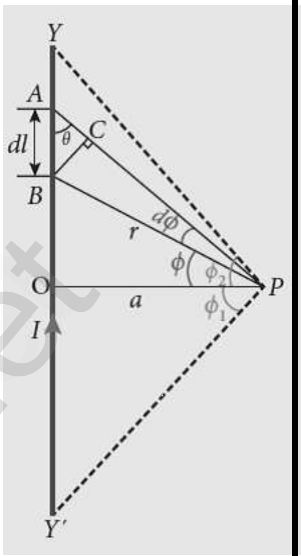
- When the ion reaches near the edge ,it is taken out with help of deflector plate and allowed to hit the target T.

Resonance Condition of cyclotron operation:

- The frequency of the positive ion circulates in the magnetic field , $f = \frac{qB}{2\pi m}$.
- It must be equal to the constant frequency of the electrical oscillator , $f_{osc} = \frac{qB}{2\pi m}$.
- Time period of oscillation, $T = \frac{2\pi m}{qB}$

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

- I be the steady current flowing through an infinitely long straight conductor of YY^1 .
- Point P is at a distance of '*a*' from the centre of a wire O.
- Consider a small line element *dl* of the wire at a distance *l* from point O .
- The magnetic field at a point P due to current element *I dl*



$$d\vec{B} = \frac{\mu_0}{4\pi}\frac{I\,dl\,\sin\theta}{r^2}\hat{n} \text{ -------- } (1)$$

- Substitute $dl\sin\theta = r\,d\phi$ and $r = \frac{a}{\cos\phi}$ in eqn (1)

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

- The total magnetic field at P due to the conductor YY^1

$$\vec{B} = \int_{-\phi_1}^{\phi_2} d\vec{B} = \int_{-\phi_1}^{\phi_2}\frac{\mu_0 I}{4\pi a}\cos\phi\, d\phi\,\hat{n}$$

$$\vec{B} = \frac{\mu_0 I}{4\pi a}[\sin\phi]_{-\phi_1}^{\phi_2}\hat{n} = \frac{\mu_0 I}{4\pi a}(\sin\phi_1 + \sin\phi_2)\hat{n}$$

- If $\phi_1 = \phi_2 = 90°$ then $(\sin\phi_1 + \sin\phi_2) = 2$

$$\vec{B} = \frac{\mu_0 I}{4\pi a}\times 2\ \hat{n}$$

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

5. 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.
- The magnetic field at a point P on the axis of the circular coil at a distance *z* from its center of the coil O.
- Magnetic field B is computed by taking two diametrically opposite line elements $d\vec{l}$ of the coil each of length at C and D.
- Let $\vec{r}$ be the vector joining the current element ($Id\vec{l}$) at C and the point P.
- According to Biot-Savart's law, the magnetic field at P due to the current elements are equal in magnitude . The magnitude of $d\vec{B}$ is

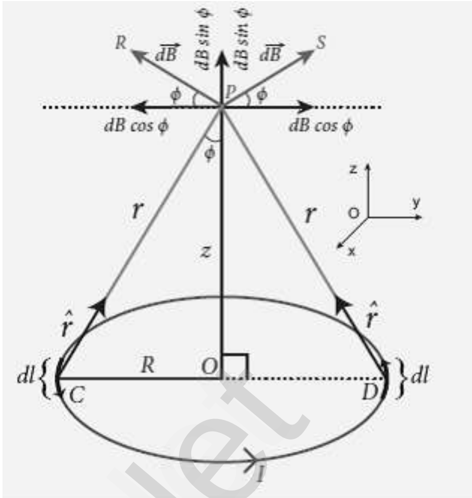
$$dB = \frac{\mu_0 I}{4\pi}\frac{dl}{r^2} \quad [\because \theta = 90^0] \text{ -------- } (1)$$

- The magnetic field $d\vec{B}$ due to each current element is resolved into two components.
- The horizontal components cancel out while the vertical components ($dB\sin\phi\ \hat{k}$) alone contribute to the net magnetic field at the point P.

$$\vec{B} = \int d\vec{B} = \int dB\sin\emptyset\,\hat{k} \text{ -------- } (2)$$

Substitute (1) in (2)

$$\vec{B} = \frac{\mu_0 I}{4\pi}\int \frac{dl}{r^2}\sin\phi\ \hat{k} \quad \text{--------} \quad (3)$$



Substitute $\left.\begin{array}{l} \sin\phi = \frac{R}{(R^2+Z^2)^{\frac{1}{2}}} \\ r^2 = R^2 + z^2 \\ \int dl = 2\pi R \end{array}\right]$ in eqn (3)

- $\vec{B} = \frac{\mu_0 I}{4\pi}\frac{2\pi R}{(R^2+z^2)}\frac{R}{(R^2+Z^2)^{\frac{1}{2}}}\hat{k}$

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

- If the circular coil contains *N* turns

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

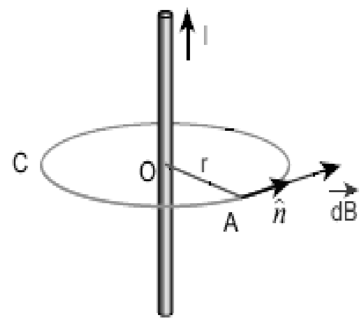
- The magnetic field at the centre of the coil $\vec{B} = \frac{\mu_0 IN}{2R}\hat{k}$ **[∵ z = 0]**

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

- Let I be the current flowing through in a infinite length of current carrying wire.
- We construct an Amperian loop in the form of a circular shape at a distance *r* from the centre of the conductor.
- From the Ampere's law

$$\oint_C \vec{B}.\vec{dl} = \mu_0 I$$

$$\oint_C Bdl = \mu_0 I \qquad (\because \theta = 0)$$



- If $\oint_C dl = 2\pi r$

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

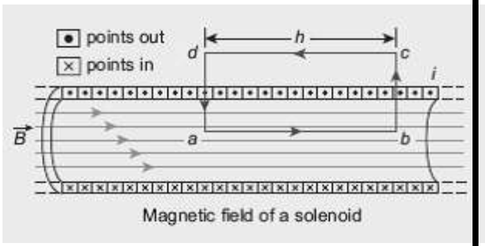
$$B = \frac{\mu_0 I}{2\pi r}$$

- In vector form $\vec{B} = \frac{\mu_0 I}{2\pi r}\hat{n}$

($\hat{n}$ is the unit vector along the tangent to the amperian loop.)

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

- Consider a solenoid of length L having N turns.
- Consider a rectangular loop 'abcd' inside the solenoid in the magnetic field at any point.
- From Ampère's circuital law



$\oint_C \vec{B}.d\vec{l} = \mu_0 I_{enclosed}$ ------- (1)

- L.H.S of the equation

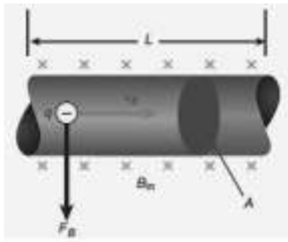
$\oint_C \vec{B}.d\vec{l} = \oint_a^b \vec{B}.d\vec{l} + \int_b^c \vec{B}.d\vec{l} + \int_c^d \vec{B}.d\vec{l} + \int_d^a \vec{B}.d\vec{l}$

- $\int_b^c \vec{B}.d\vec{l} = \int_d^a \vec{B}.d\vec{l} = 0$ ($\because$ $\vec{B}$ and $d\vec{l}$ are perpendicular)

$\int_c^d \vec{B}.d\vec{l} = 0$ ($\because$ element present outside the solenoid)

- So , $\oint_C \vec{B}.d\vec{l} = \oint_a^b \vec{B}.d\vec{l} = BL$ ------(2)
- Let I be the current passing the solenoid of N turns, $I_{enclosed} = NI$ ------(3)
- Substitute (2) and (3) in (1)
- $BL = \mu_0 NI$ ------(4)
- $B = \mu_0 \frac{N}{L} I$ ------(5)
- Let $n = \frac{N}{L}$ then
- Magnetic field due to long current carrying solenoid, $B = \mu_0 n I$.

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



- Consider a wire of length L, with cross- sectional area A placed in a magnetic field . I be the current flowing through the wire .
- Consider a small segment of wire of length dl.
- The relation between current I and drift velocity v_d , $I = nAe\vec{v}_d$ ---(1)
- Current element in the conductor , $Id\vec{l} = -nAe\ \vec{v}_d\ dl$ ------(2)
- Average force experienced by a electron in the wire , $\vec{f} = -e(\vec{v}_d \times \vec{B})$
- Total number of free electrons in the small element $N = n\,A\,dl$.
- Lorentz force on the wire of length dl , $d\vec{F} = -nAdl\, e(\vec{v}_d \times \vec{B})$ ------(3)

Sub (2) in (3) $d\vec{F} = (Id\vec{l} \times \vec{B})$ ------(4)

- The force on the wire of length l , $\vec{F} = (I\vec{l} \times \vec{B})$
- In magnitude, **F=** $\boldsymbol{BIl\sin\theta}$ -----(5)

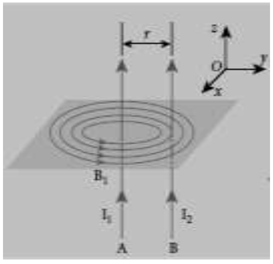
<u>**special case :**</u>

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.

9. Obtain a force between two long parallel current carrying conductors. Hence define ampere.

- Two long straight parallel current carrying conductors A and B separated by a distance r are kept in air.



Conductor A	Conductor B
Current in the conductor I_1	Current in the conductor I_2
Magnetic filed at r, $\vec{B}_1 = -\frac{\mu_0 I_1}{2\pi r}\hat{\imath}$	Magnetic filed at r, $\vec{B}_2 = \frac{\mu_0 I_2}{2\pi r}\hat{\imath}$
Force on the element d*l* of conductor B $d\vec{F} = I_2\vec{l} \times \vec{B}_1 = -\frac{\mu_0 I_1 I_2 dl}{2\pi r}\hat{\jmath}$	Force on the element d*l* of conductor A $d\vec{F} = I_1\vec{l} \times \vec{B}_2 = \frac{\mu_0 I_1 I_2 dl}{2\pi r}\hat{\jmath}$
Force per unit length of conductor B due to A $\frac{\vec{F}}{l} = -\frac{\mu_0 I_1 I_2}{2\pi r}\hat{\jmath}$	Force per unit length of conductor B due to A $\frac{\vec{F}}{l} = \frac{\mu_0 I_1 I_2}{2\pi r}\hat{\jmath}$

- current in the conductors same direction - attractive force .
- current in the conductors opposite direction - repulsive force .
- 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 conductor.

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4. ELECTROMAGNETICINDUCTION AND ALTERNATING CURRENT

2 -MARK QUESTIONS AND ANSWERS:

1. What is electromagnetic induction or Faraday's I law?

- Whenever the magnetic flux linked with a closed coil changes, an emf (electromotive force) is induced in the circuit.

2. Write Faraday's laws of electromagnetic induction?

- **First law :** Whenever magnetic flux linked with a closed circuit changes, an emf is induced in the circuit.
- **Second law :**The magnitude of induced emf in a closed circuit is equal to the time rate of change of magnetic flux linked with the circuit. $(i.e)\ \varepsilon = \frac{d\varphi_B}{dt}$

3. State Lenz's law.

- The direction of the induced current always opposes the cause responsible for its production. $(i.e)\ \varepsilon = -\frac{d\varphi_B}{dt}$

4. State Fleming's right hand 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.

5. What are eddy currents? (or) What are Foucault currents? How do they flow in a conductor?

- when magnetic flux linked with a sheet or plate changes, electric currents are induced. As these electric currents resemble eddies of water, these are known as Eddy currents (or) Foucault currents.
- The induced currents flow in concentric circular paths.

6. Mention the ways of producing induced emf.

i) By changing the magnetic field (B)
ii) By changing the area (A) of the coil and
iii) By changing the relative orientation (θ) of the coil with magnetic field

7. Define Q factor

- It is defined as the ratio of voltage across L or C at resonance to the applied voltage.
- $Q - factor = \frac{Voltage\ \ across\ \ L\ or\ C\ at\ resonance}{Applied\ \ Voltage}$

8. What are advantages of three phase AC generator?

Three phase AC generator has

i) Higher power output.
ii) Smaller in size .
iii) Transmission system is cheaper.

9. Define power factor.

- Power factor is the ratio of true power of AC circuits to apparent power of it.
- $Power\ factor = \frac{True\ power}{Apparent\ \ power}$

10. Define the efficiency of transformer.

- Efficiency of transformer is the ratio of the useful output power to the input power.
- $\eta = \frac{Output\ power}{Input\ power} \times 100\%$

11. 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.

12. What are the uses of RLC circuits?

i) RLC circuits are used in filter circuits, oscillators, voltage multipliers etc.

ii) It is used in tuning circuits of radio and TV systems.

13. Distinguish step-up and step-down transformer

S.N	Step-up transformer	Step-down transformer
1	Increases potential difference.	Decreases potential difference.
2	Decreases current.	Increases current.
3	Number of turns in secondary is high.	Number of turns in secondary is low.
4	voltage transformation ratio (K) is greater than 1.	voltage transformation ratio (K) is lesser than 1.

14. What is wattless current?

- The current in an AC circuit is said to be wattless current if the power consumed by it is zero.

15. What do you mean by self-induction?

- When an electric current passing through a coil changes , magnetic flux linked with that same coil also changes then an emf is induced in the same coil.

16. What is meant by mutual induction?

- When an electric current passing through a coil changes , an emf is induced in the neighbouring coil.

17. Define average value of an alternating current.

- The average of all values of current over a positive half-cycle or negative half-cycle.

18. Define RMS value of an alternating current.

- The square root of the mean of the squares of all currents over one cycle.

19.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

20. 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.

21. What do you mean by resonant frequency?

- The frequency at which current in the RLC circuit is maximum is called resonant frequency.

22. Write the principle used in AC generator (Alternator)?

- The principle used in AC generator is Electromagnetic induction.
- The relative motion between a conductor and a magnetic field changes the magnetic flux linked with the conductor which in turn, induces an emf .

23. What are LC oscillations?

- Whenever energy is given to a LC circuit, the electrical oscillations of definite frequency are generated. These oscillations are called LC oscillations.

24. Define the unit of self - inductance (or) Define one henry.

- The inductance of the coil is said to be one henry if a current changing at the rate of 1 A s^{-1} induces an opposing emf of 1 V in it.

25. An inductor blocks AC but it allows DC. Why? and How?

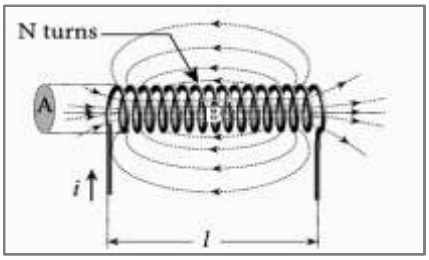
- Inductive reactance of an inductor is directly proportional to the frequency of AC .When AC flows through an inductor produces time varying magnetic field which in turn induces back emf. This back emf opposes any change in the Ac current and hence inductor blocks AC.
- The frequency of the DC , f = 0. So X_L = 0. Hence there is no self induction and self induced emf (opposing emf). So DC flows through an inductor.

3 -MARK QUESTIONS AND ANSWERS:

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

- Consider a long solenoid of length l and cross-sectional area A. Let n be the number of turns per unit length (or turn density) of the solenoid.
- When an electric current i is passed through the solenoid, magnetic induction inside solenoid

  $B = \mu_0 ni$ - - - - - (1)



- The magnetic flux passing through each turn is

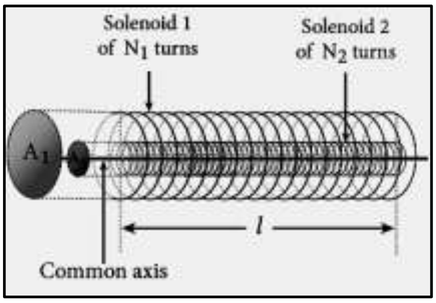
  $\Phi_B = BA = (\mu_0 ni)A$ - - - - - (2)
- The total number of turns $N = nl$
- The total magnetic flux linked

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

  But $N\Phi_B = Li$ - - - - - (4)

  Compare (3) and (4) $Li = \mu_0 n^2\ Al\ i$.
- Self-inductance of a long solenoid $\boxed{L = \mu_0 n^2\ Al}$

2. Explain the mutual induction between two long solenoids. Obtain an expression for the Mutual inductance.



- Consider two long co-axial solenoids of same length l. Let A_1 and A_2 be the area of cross section of the solenoids. The turn density of these solenoids are n_1 and n_2 respectively.
- Let i_1 be the current flowing through solenoid 1, then the magnetic field produced inside it is, $B_1 = \mu_0 n_1 i_1$ - - - - - (1)
- The magnetic flux is linked with each turn of solenoid 2

  $\Phi_2 = B_1 A_2 = \mu_0 n_1 i_1 A_2$ - - - - - - (2)
- The flux linkage with solenoid 2 with total turns $N_2 = n_2 l$ is

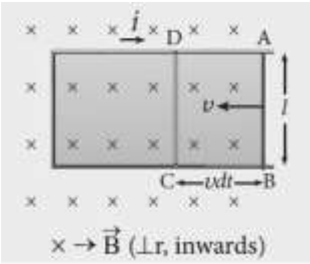
  $N\Phi_2 = (n_2 l)\mu_0 n_1 i_1 A_2 = \mu_0 n_1 n_2 i_1 A_2 l$ - - - - - - - (3)
- By definition, $N\Phi_2 = M i_1$ - - - - - - (4)
- Compare (3) and (4) $M i_1 = \mu_0 n_1 n_2 i_1 A_2 l$
- The mutual induction between two long solenoids $M = \mu_0 n_1 n_2 A_2 l$

3. 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. In order to establish a current in the circuit, work is done against this opposition by some external agency. This work done is stored as magnetic potential energy
- Induced emf $\varepsilon = -L\frac{di}{dt}$
- Let dw be work done in moving a charge dq, $dw = -\varepsilon\, i\, dt = L\, i\, di$ $\quad (\because dq = i\, dt)$

  $W = \int_0^i L\, i\, di = \frac{1}{2} L\, i^2$
- Magnetic potential energy $U_B = \frac{1}{2} L\, i^2$

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

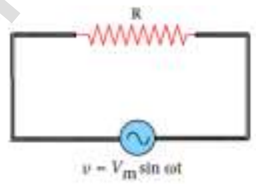


- Consider a conducting rod of length l moving with a velocity υ towards left on a rectangular fixed metallic frame work as shown in Figure.
- This arrangement is placed perpendicular in a uniform magnetic field B. As the rod moves from AB to DC in a time dt, the area enclosed by the loop and hence the magnetic flux through the loop decreases.
- 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 $\varepsilon = \frac{d\phi_B}{dt} = \frac{Blv\, dt}{dt} = Bl\, v$

5. 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.

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

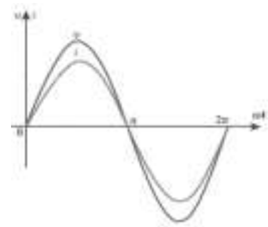


- Consider a circuit containing a pure resistor of resistance R connected across an alternating voltage source.
- The instantaneous value of the alternating voltage is given by

  $V = V_m \sin \omega t$ - - - - - (1)
- According to Ohm's law $V_R = i\,R$
- According to Kirchoff's law $V - V_R = 0 \rightarrow V = V_R$

  $V_m \sin \omega t = i\,R$

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



- $\frac{V_m}{R} = I_m$ then $i = I_m \sin \omega t$ - - - - - - (2)
- Current is in phase with the applied voltage .

7. Write any three applications of eddy currents .

Eddy current brake.

- Strong electromagnets are fixed just above the rails. To stop the train, electromagnets are switched on.
- The magnetic field of these magnets induces eddy currents in the rails which oppose or resist the movement of the train.

Eddy current testing

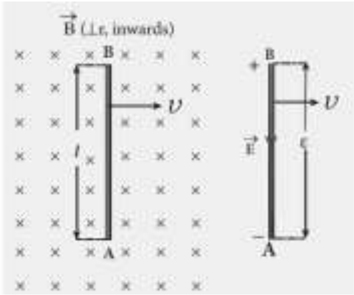
- Find defects like surface cracks, air bubbles present in a specimen. A coil of insulated wire is given an alternating electric current,
- When this coil is brought near the test surface, eddy current is induced in the test surface defects causes the change in phase and amplitude of the eddy current.

Electro magnetic damping

- The armature of the galvanometer coil is wound on a soft iron cylinder.
- Relative motion between the soft iron cylinder and the radial magnetic field induces eddy current in the cylinder. The damping force due to eddy current brings the armature to rest immediately.

8. Obtain an expression for motional emf from Lorentz force.

- Consider a straight conducting rod AB of length l in a uniform magnetic field B which is directed perpendicularly into the plane of the paper.



- The Lorentz force acts on free electrons in the direction from B to A

$$\vec{F_B} = -e\,(\vec{v}\,X\,\vec{B})$$

- The action of this Lorentz force is to accumulate the free electrons at the end A, which in turn establishes an electric field. Due to the electric field E, the coulomb force starts acting on the free electrons along AB

$$\vec{F_E} = -e\,\vec{E}$$

- The magnetic Lorentz force $\vec{F}_B$ and the coulomb force $\vec{F}_E$ balance each other and no further accumulation of free electrons at the end A

$Bev = eE$

$Bv = E$

- Potential difference across the rod $V = El.$

$V = Bvl.\,(\because E = Bv)$

- The Lorentz force on the free electrons is responsible to maintain this potential difference and hence produces an emf, $\boldsymbol{\varepsilon = Blv}$

9. 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.

10. Prove that the total energy is conserved during LC oscillations.

- During LC oscillations in LC circuits, the energy of the system oscillates between the electric field of the capacitor and the magnetic field of the inductor.
- LC oscillations take place in accordance with the law of conservation of energy

$$U = U_E + U_B = \frac{q^2}{2C} + \frac{1}{2}Li^2$$

S.No	Charge on capacitor	Current in inductor	Electric energy U_E	Magnetic energy U_B	Total energy U
1	$q = Q_m$	$i = 0$	$\frac{Q_m^2}{2C}$	0	$\frac{Q_m^2}{2C}$
2	$q = 0$	$i = I_m$	0	$\frac{1}{2}LI_m^2$	$\frac{Q_m^2}{2C}$
3	$q = Q_m \cos\omega t$	$i = Q_m\,\omega \sin\omega t$	$\frac{Q_m^2 \cos^2\omega t}{2C}$	$\frac{1}{2}LQ_m^2\omega^2 \sin^2\omega t$	$\frac{Q_m^2}{2C}$

5 -MARK QUESTIONS AND ANSWERS:

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

Principle : Electromagnetic induction

Stator:

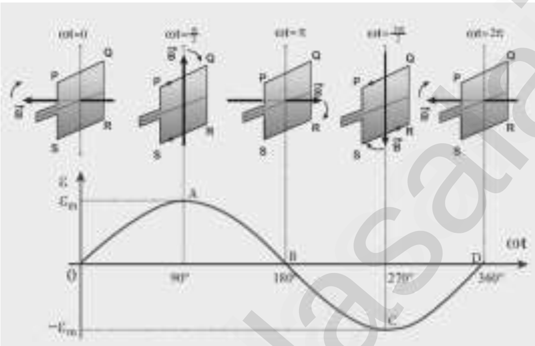
- The stationary part which has armature windings mounted in generator is called stator.
- It has two components, namely stator core and armature winding.

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'

2.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.
- The flux linkage with a coil

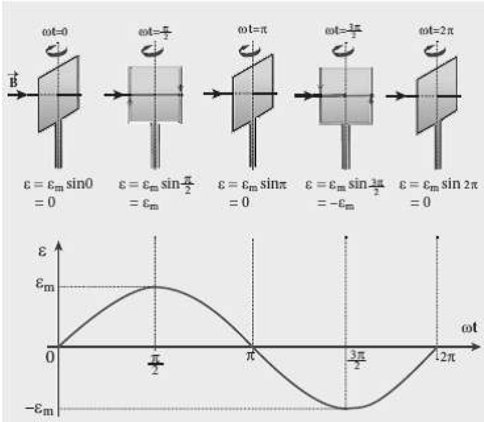
  $N\phi_B = NBA \cos \omega t \; (\because \;\; \phi_B = BA \cos \omega t)$

- According to Faraday's law, the induced emf

$$\varepsilon = -\frac{d(N\phi_B)}{dt} = -\frac{d\,(NBA\cos\omega t)}{dt}$$

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

- 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 $i = I_m \sin\omega t$.



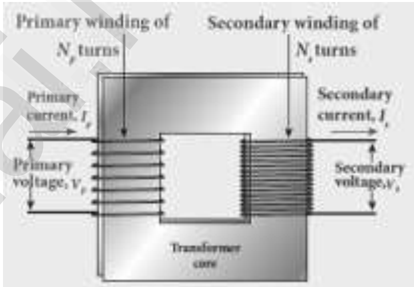
3. Explain the construction and working of a transformer

Principle

- The principle of transformer is the mutual induction between two coils.

construction

- There are two coils of high mutual inductance wound over the same transformer core.
- The laminated core made up of silicon steel.
- The coil across which voltage is applied is known as primary coil.
- The coil from which output power is drawn is known as secondary coil.



Working

- If the primary coil is connected to a source of alternating voltage, an alternating magnetic flux is set up in the laminated core. All the magnetic flux linked with primary coil is also linked with secondary coil.
- As a result of flux change, emf is induced in both primary and secondary coils
- V_P, ε_P, N_P are the voltage across the primary coil, induced back emf and number of turns of primary coil then

$$V_P = \varepsilon_P = -N_P\frac{d\phi_B}{dt}$$

- V_s, ε_s, N_s are the voltage across the secondary coil, induced emf and number of turns of secondary coil then

$$V_s = \varepsilon_s = -N_s\frac{d\phi_B}{dt}$$

- The rate at which magnetic flux changes through each turn is same for both primary and secondary coils. So
$\frac{V_s}{V_P} = \frac{N_s}{N_P} = K$ (K - voltage transformer ratio)
- For an ideal transformer, Input power = Output power.

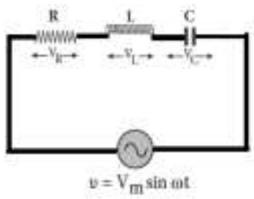
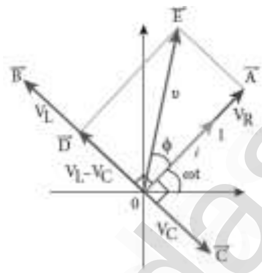
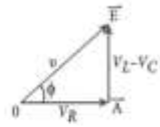
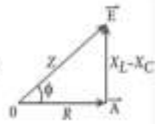
$V_P I_P = V_s I_s$ (or) $\frac{V_s}{V_P} = \frac{I_P}{I_s}$

- For a transformer, $\frac{V_s}{V_P} = \frac{N_s}{N_P} = \frac{I_P}{I_s} = K$
- For Step up transformer, K > 1.
- For Step down transformer, K < 1.

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, an 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

$$V = V_m \sin \omega t$$

Type of Impedance	Value of Impedance	Potential difference across element	Phase angle of current with voltage
Resistor	R ($\overrightarrow{OA}$)	$V_R = IR$	0
Inductor	X_L ($\overrightarrow{OB}$)	$V_L = I X_L$	Lags by 90^0
Capacitor	X_C ($\overrightarrow{OC}$)	$V_C = I X_C$	Leads by 90^0
			 
RLC	$Z = \sqrt{R^2 + (X_L - X_C)^2}$	$V_m = \sqrt{V_R^2 + (V_L - V_C)^2}$	$\tan\phi = \frac{V_L - V_C}{V_R} = \frac{X_L - X_C}{R}$

➢ Current flowing through the RLC circuit $I_m = \frac{V_m}{Z} = \frac{V_m}{\sqrt{R^2+(X_L-X_C)^2}}$

Other important questions

1. Find out the phase relationship between voltage and current in a pure inductor circuit.
2. Find out the phase relationship between voltage and current in a pure capacitor circuit.
3. Show that Lenz's law is in accordance with law of conservation of energy.

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5 . ELECTROMAGNETIC WAVES

2 MARK - QUESTIONS AND ANSWERS:

1. What is displacement current?

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

2. What are electromagnetic waves?

- Electromagnetic waves are non-mechanical waves which move with speed equals to the speed of light in vacuum. It is a transverse wave.

3. What are Fraunhofer lines?

- The dark lines in the solar spectrum are known as Fraunhofer lines.

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

- Maxwell modified Ampere's law as, $\oint_l \vec{E}.d\vec{l} = \mu_o i = \mu_o (i_c + i_d)$
- Here $i = i_c + i_d$ .Where,i - Total current ;i_c–Conduction current ; i_d–Displacement current.

5. Write notes on Gauss's law in magnetism.

- $\oint_s \vec{B}.\, d\vec{A} = 0$
- The surface integral of magnetic field over a closed surface is zero.
- This equation implies that the magnetic lines of force form a continuous closed path. It means that no isolated magnetic monopole exists in nature.

6. Why are electromagnetic waves non-mechanical?

- Electromagnetic waves do not require any medium for propagation.

7. Write notes on Ampere-Maxwell law.

- **Equation** : $\oint_l \vec{B}\,.d\vec{l} = \mu_0 i_c + \mu_0 \varepsilon_0 \frac{d}{dt}\oint_s \vec{E}.d\vec{A}$
- This law relates the magnetic field around any closed path to the conduction current and displacement current through that path.

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

(i) IR radiation

- It is used to provide electrical energy to satellites .
- It is used to produce dehydrated fruits.

(ii) Microwaves

- It is used in microwave oven for cooking.
- It is used in very long distance wireless communication through satellites

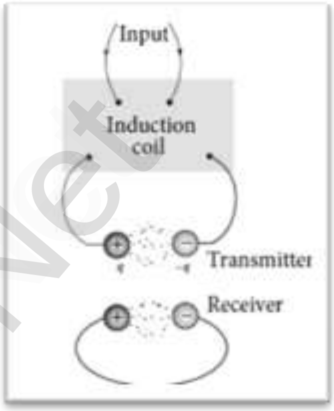
(iii) UV radiation

- It is used in the study of molecular structure
- It is used to destroy bacteria and sterilizing the surgical instruments.

3 - Mark Questions And Answers:

1. Discuss briefly the experiment conducted by Hertz to produce and detect electromagnetic spectrum.

- It consists of two metal electrodes which are made of small spherical metals as shown in figure.
- Transmitter electrodes are connected to induction coil with very large number of turns. This is used to produce very high electromotive force (emf).
- Transmitter electrodes are maintained at very high potential, air between the electrodes get ionized and spark is produced. The gap between electrodes of receiver also gets spark. This implies that the energy is transmitted from transmitter to the receiver in the form of waves, known as electromagnetic waves.



- If the receiver is rotated by 90^0, then no spark is observed by the receiver. This confirms that electromagnetic waves are transverse waves as predicted by Maxwell.
- Hertz detected radio waves and also computed the speed of radio waves which is equal to the speed of light.

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

(i) Microwaves:

- It is produced by special vacuum tubes (magnetron, gun diode)
- It undergoes reflection and polarization.

(ii) 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.

(iii) 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.

(iv) 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.Write down the properties of electromagnetic waves.

i) Electromagnetic waves are produced by any accelerated charge.

ii) Electromagnetic waves do not require any medium for propagation. So electromagnetic wave is a non-mechanical wave.

iii) Electromagnetic waves travel with the speed of light in vacuum or free space.

iv) Electromagnetic waves are not deflected by electric field or magnetic field.

v) Electromagnetic waves can exhibit interference, diffraction and polarization.

vi) Electromagnetic waves carry energy, linear momentum and angular momentum.

5 - MARK QUESTIONS AND ANSWERS:

1.What is emission spectra? Explain their types.

- When the spectrum of self luminous source is taken, we get emission spectrum. Each source has its own characteristic emission spectrum.

Types of emission spectrum:

a) Continuous emission spectra

b) Line emission spectrum

c) Band emission spectrum

(a) Continuous emission spectra

- If the light from incandescent lamp is allowed to pass through prism, it splits into seven colours. It consists of wavelengths containing all the visible colours ranging from violet to red.
- Examples: spectrum obtained from carbon arc and incandescent solids.

(b) Line emission spectrum

- Light from hot gas is allowed to pass through prism, line spectrum is observed.
- The line spectra are sharp lines of definite wavelengths or frequencies.
- It arises due to excited atoms of elements.
- These lines are the characteristics of the element.
- Examples: spectra of atomic hydrogen, helium.

(c) Band emission spectrum

- Band spectrum consists of several number of very closely spaced spectral lines which overlapped together forming specific bands which are separated by dark spaces.
- This spectrum has a sharp edge at one end and fades out at the other end.
- Examples: spectra of ammonia gas in the discharge tube.

2.What is absorption spectra? Explain their types.

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

Types of absorption spectrum:

i) Continuous absorption spectrum.

ii) Line absorption spectrum.

iii) Band absorption spectrum.

(i) Continuous absorption spectrum

- When we pass white light through a blue glass plate, it absorbs all the colours except blue and give continuous absorption spectrum.

(ii) Line absorption spectrum

- When light from the incandescent lamp is passed through cold gas , the spectrum obtained through the dispersion due to prism is line absorption spectrum
- **Example:** If the light from the carbon arc is made to pass through sodium vapour, a continuous spectrum of carbon arc with two dark lines in the yellow region are obtained.

(iii) Band absorption spectrum

- When the white light is passed through the iodine vapour, dark bands on continuous bright background is obtained.
- **Example:** when white light is passed through diluted solution of blood or chlorophyll, band absorption spectrum is obtained.

3. Write down Maxwell equations in integral form.

a) Maxwell's 1st equation: (Gauss's law in electrostatics)

- It relates the net electric flux to net electric charge enclosed in a surface.
- $\oint_s \vec{E} \cdot d\vec{A} = \frac{Q_{enclosed}}{\varepsilon_0}$; Where $\vec{E}$ is the electric field and $Q_{enclosed}$ is the net charge enclosed.

(b) Maxwell's 2nd equation: (Gauss's law in magnetism)

- The surface integral of magnetic field over a closed surface is zero.
- $\oint_s \vec{B} \cdot d\vec{A} = 0$. where $\vec{B}$ is the magnetic field.

(c) Maxwell's 3rd equation: (Faraday's law of electro magnetic induction)

- This law relates electric field with the changing magnetic flux.
- $\oint_l \vec{E} \cdot d\vec{l} = -\frac{d\Phi_B}{dt}$ where $\vec{E}$ is the electric field.

(d) Maxwell's 4th 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.
- $\oint_l \vec{B} \cdot d\vec{l} = \mu_0 i_c + \mu_0 \varepsilon_0 \frac{d}{dt} \oint_s \vec{E} \cdot d\vec{A}$

These four equations are known as Maxwell's equations in electrodynamics. This equation ensures the existence of electromagnetic waves.

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6. RAY OPTICS

2 - MARK QUESTIONS AND ANSWERS:

1. Mirage	2. Looming
• In hot places, air near the ground is hotter than air at a height. • Refractive index of air increases with height. • Due to total internal reflection, observer feels as if the object is getting reflected by wet surface beneath the object.	• In cold places, air near the ground is colder than air at a height. • Refractive index of air decreases with height. • Due to total internal reflection, inverted image is formed little above the surface.

3. Laws of reflection	4. Laws of refraction (Snell's law)
• The incident ray, reflected ray and normal to the reflecting surface are all coplanar. • Angle of incidence=angle of reflection (i.e) $\angle i = \angle r$	• The incident ray, refracted ray and normal to the refracting surface are all coplanar. • $n_1 \sin i = n_2 \sin r$

5. What is principle of reversibility?

- The principle of reversibility states that light will follow exactly the same path if its direction of travel is reversed.

6.What is power of a lens?

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

7.What is total internal reflection? Write the two conditions for total internal reflection.

- For any angle of incidence greater than the critical angle, the entire light is reflected back into the denser medium itself. This phenomenon is called ***total internal reflection.***

Conditions:

i) light must travel from denser to rarer medium.

ii) angle of incidence in the denser medium must be greater than critical angle ($i>i_c$).

8. 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.
- Light entering the diamond is total internally reflected from many cut faces before getting out.

9. What is Rayleigh's scattering?

- The scattering of light by particles of size less than that of the wavelength of light is called Rayleigh's scattering.
- The intensity of light scattered is inversely proportional to fourth power of wavelength. $I \propto \frac{1}{\lambda^4}$.

10. 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.

11. 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.

12. Why do clouds appear white?

- Clouds contain large size of dust and water droplets.(i.e Size a >>λ).
- In clouds all the colours get equally scattered irrespective of wavelength. So it appears white.

13. Why does rain cloud appear dark?

- Rain clouds appear dark because of the condensation of water droplets on dust particles that makes cloud opaque.

14. 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.

15. 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.

16. 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.

17. How does an endoscope work?

- Endoscope works on the phenomenon of **total internal reflection**.
- An endoscope is an instrument which has a bundle of optical fibres are used by doctors to see inside of a patient's body.
- The optical fibres are inserted in to the body through mouth, nose or a special hole made in the body. Even operations could be carried out with the endoscope cable which has the necessary instrument attached at their ends.

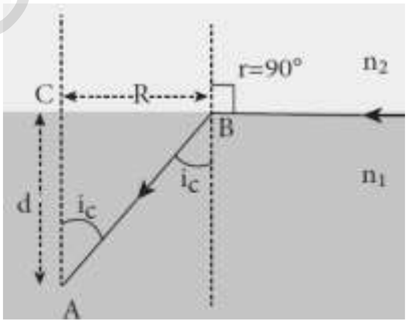
18. What is optical path?

- 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. (i.e) d' **= n d.**

3 - MARK QUESTIONS AND ANSWERS:

1. Obtain the equation for radius of illumination (OR) Snell's window.

- When light entering the water from outside is seen through the water, the view is restricted to a particular angle equal to the critical angle i_c . The restricted illuminated circular area is called Snell's window.
- From figure, $\tan i_c = \frac{R}{d}$ ------- (1)



- From figure, $n_1 \sin i_c = n_2 \sin 90^0$

$\sin i_c = \frac{n_2}{n_1}$ and $\cos i_c = \sqrt{1 - \frac{n_2^2}{n_1^2}}$

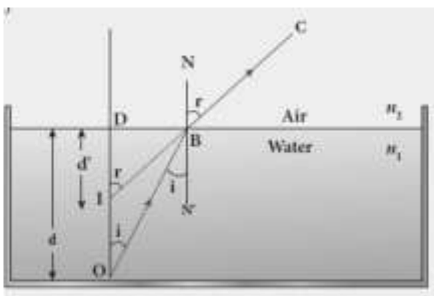
- Substitute in equation (1), we get,

$\frac{R}{d} = \frac{\sin i_c}{\cos i_c} = \frac{n_2}{\sqrt{n_1^2 - n_2^2}}$. Here substitute, $n_2 = 1$ (air medium) & $n_1 = n$.

- Radius $\boldsymbol{R = d\left(\frac{1}{\sqrt{n^2-1}}\right)}$

2. Obtain the equation for apparent depth.

- It is a common observation that bottom of a tank filled with water appears to be raised.
- In figure,



d⟶ Real depth.

d' ⟶ apparent depth.

- From figure,

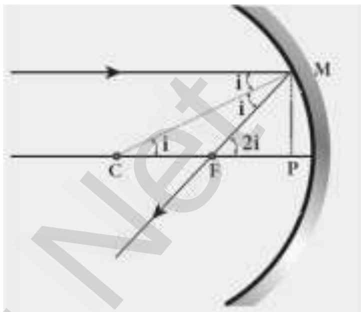
$n_1 \sin i = n_2 \sin r$

$n_1 \tan i = n_2 \tan r$ (for small angle, $\sin\theta = \tan\theta$)

- $\frac{n_1}{d} = \frac{n_2}{d'}$
- Substitute, $n_1 = n$ & $n_2 = 1$ (air medium)
- Apparent depth $d' = \frac{d}{n}$

3. 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, $\tan i = \frac{PM}{PC} = i$ ($\because$ i is small)
- ΔMFB, $\tan 2i = \frac{PM}{PF} = 2i$
- So, $\frac{PM}{PF} = \frac{2\,PM}{PC}$ ➔ $\frac{1}{PF} = \frac{2}{PC}$
- Substitute, PF = f & PC = R .
- $\frac{1}{f} = \frac{2}{R}$ → $\mathbf{f = \frac{R}{2}}$

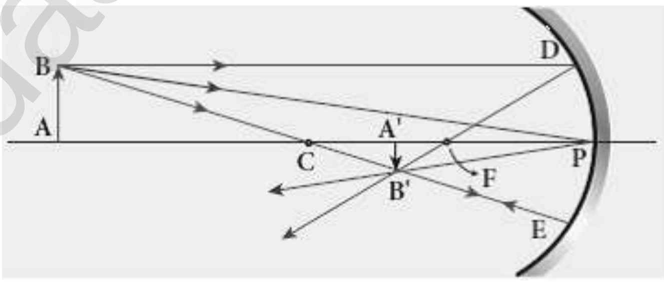


5 - MARK QUESTIONS AND ANSWERS:

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

- AB ⟶ object
- $A'B'$ ⟶image
- From figure, ΔABP & $\Delta A'B'P$ are similar triangles.

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



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

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

- As PD=AB, $\frac{A'B'}{AB} = \frac{A'F}{PF}$ - - - - - (3)
- Compare (1) & (3) We can write,

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

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

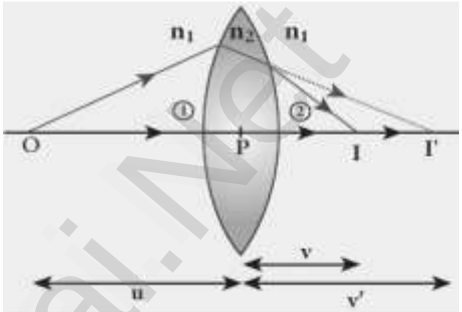
2. Obtain lens maker's formula

- R_1, R_2 ⟶ Radii of curvature of two spherical surfaces 1 & 2.
- n_2 ⟶ refractive index of the lens
- For the refracting surface 1, the light goes from n_1 to n_2. so

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

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

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



- Equation **(1)** + **(2)** gives

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

- Dividing by n_1, we get $\frac{1}{v} - \frac{1}{u} = \left(\frac{n_2}{n_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$
- substitute $n_2 = n$ and $n_1 = 1$ (air medium)

$$\frac{1}{v} - \frac{1}{u} = (n - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \quad \text{-------} (3)$$

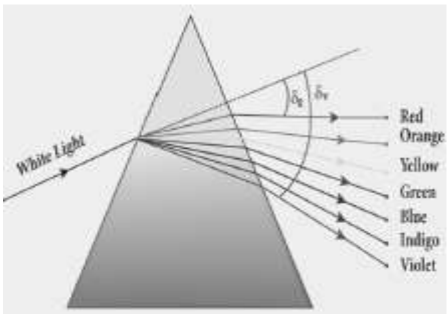
- If the object is at infinity, image is formed at the focus of the lens. Then substitute $u = \infty$, $v = f$. in equation (3)

$\frac{1}{f} = (n - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ --------- (4). This equation is called as lens maker's formula.

- Compare (3) & (4)

$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$. This equation is known as lens equation.

3. What is dispersion? Obtain the equation for dispersive power of a medium.

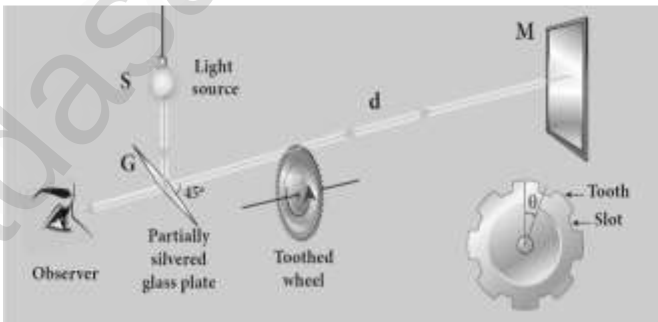


- A beam of light passes through a prism, it gets dispersed into its constituent colours.
- A -Angle of the prism (Small of the order of 10°)

  D –Angle of minimum deviation.
- When rays of light pass through such prism, the angle of deviation (δ) also becomes small.

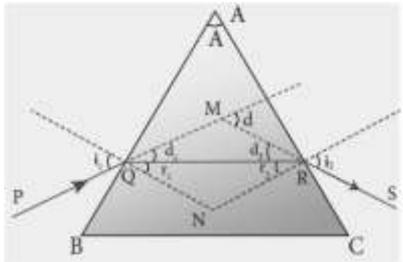
- Refractive index of the prism, $n = \frac{\sin\left(\frac{A+D}{2}\right)}{\sin\left(\frac{A}{2}\right)}$
- As θ *is small,* $\sin\theta \approx \theta$. So, $n = \frac{\left(\frac{A+\delta}{2}\right)}{\left(\frac{A}{2}\right)} \Rightarrow n = \frac{(A+\delta)}{(A)}$
- Angle of deviation, $\delta = (n-1)A$
- For violet colour, $\delta_V = (n_V - 1)A$
- For red colour, $\delta_R = (n_R - 1)A$
- Angular dispersion, $\delta_V - \delta_R = (n_V - n_R)A$
- Middle deviation (for yellow rays) , $\delta = (n-1)A$
- Dispersive power , $\omega = \frac{Angular\ \ dispersion}{middle\ \ deviation}$
- So, $\omega = \frac{\delta_V - \delta_R}{\delta} = \frac{n_V - n_R}{n-1}$

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



- Light from the source S was first allowed to fall on a partially silvered glass plate G kept at an angle of 45°.
- Light was then allowed to pass through a rotating toothed wheel. Light passing through one cut in the wheel, will get reflected by a mirror M kept at long distance 'd' .
- Angular speed of wheel was increased until light passing through one cut would completely be blocked by the adjacent tooth.
- This is ensured by the disappearance of light while looking through the partially silvered glass plate.
- Toothed wheel has N teeth and N cuts of equal width.
- '2d' is the distance travelled by the light during the time 't'
- Angular speed of wheel is $\omega = \frac{\theta}{t} = \frac{\pi}{Nt}$ $\left(\because \boldsymbol{\theta = \frac{\pi}{N}}\right)$ **------(1)**
- Time taken for the angular displacement θ is t. From (1) , $\mathbf{t} = \frac{\pi}{N\omega}$
- Speed of light = $\frac{distance\ \ travelled\ \ by\ light}{Time\ \ taken}$
- Speed of light , $\mathbf{V} = \frac{2d}{t} = \frac{2dN\omega}{\pi}$

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.



- PQ⟶ Light ray incident on one of the refracting faces AB.
- i_1&r_1 be the angle of incidence and refraction at the first face AB.
- The angle of deviation d_1 at the surface AB is $d_1 = i_1 - r_1$.
- The angle of deviation d_2 at the surface AC is $d_2 = i_2 - r_2$.
- Total angle of deviation produced , $d = (i_1 - r_1) + (i_2 - r_2) = (i_1 + i_2) - (r_1 + r_2)$ - - - - - - - (1)
- From quadrilateral AQNR, $\angle A + \angle QNR = 180°$ - - - - - - - (2)
- From triangle ΔQNR, $r_1 + r_2 + \angle QNR = 180°$ - - - - - - - - (3)
- Comparing (2) and (3) we get

  $r_1 + r_2 = A$ - - - - - - - - (4)
- Substitute (4) in (1) $d = i_1 + i_2 - A$. - - - - - - - - (5)
- At minimum deviation, $i_1 = i_2 = i$ and $r_1 = r_2 = r$. also $d = D$.

  Then (5) becomes $D = 2i - A \implies i = \frac{A+D}{2}$

  and (4) becomes $r = \frac{A}{2}$.
- From Snell's law we get, refractive index of the material of the prism,

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

OTHER IMPORTANT QUESTIONS:

1. What are primary and secondary focus?
2. Why does sky appear dark for astronauts?
3. What are the sign Cartesian conventions for a spherical mirror?
4. Obtain the equation for lateral displacement of light passing through a glass slab.
5. Derive the equation for acceptance angle and numerical aperture of optical fibre.

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7 . WAVE OPTICS

2 - MARK QUESTIONS AND ANSWERS:

1. What is myopia (Nearsightedness)?

- Unable to see distant objects clearly.
- It happens due to short focal length of the eye lens (or) larger diameter of the eye ball
- Corrected by concave lens

2. What is hypermetropia (Farsightedness) ?

- Unable to see closer objects clearly.
- It occurs due to eye lens has long focal length (or) shortening of the eye ball.
- Corrected by convex lens.
- Far sightedness arising due to aging is called **Presbyopia.**

3. What is astigmatism?

- Due to different curvatures along different planes in eye lens.
- Unable to see the all directions equally well.
- Corrected by using cylindrical lens.

4. 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.

5. 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.

6. 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.

7. What is diffraction?

- Bending of waves around sharp edges into the geometrically shadowed region.

8. Define Fresnel's distance?

- Distance upto which the ray optics is obeyed and beyond which the wave optics is obeyed. (i.e) Fresnel's distance $z = \frac{a^2}{2\lambda}$ (a - slit width , λ - wavelength.)

9. Differentiate Fresnel and Fraunhofer diffraction

S.N	**Fresnel diffraction**	**Fraunhofer diffraction**
1	Spherical (or) cylindrical wavefront undergoes diffraction	Plane wavefront undergoes diffraction
2	Light wave is from a source at finite distance	Light wave is from a source at infinity
3	Convex lenses are not used	Convex lenses are used
4	Difficult to observe and analyse	Easy to observe and analyse

10. State Rayleigh's criterion?

- Two points on an image are said to be just resolved when the central maximum of one diffraction pattern coincides with the first minimum of the other and vice versa.

11. What is polarisation?

- The phenomenon of restricting the vibrations of light to any one direction perpendicular to the direction of propagation of wave.

12. 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. $I = I_0 cos^2\theta$

13. Define wavefront.

- The locus of points which are in the same state (or) phase of vibration.

14. 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.

15. Define grating element.

- The combined width of a ruling and a slit in a grating. (i.e) e = a + b.

16. Define corresponding points.

- The points on the slit separated by a distance equal to the grating element.

17. Define polarising angle .

- The angle of incidence for which the reflected light is found to be plane polarised.

18. What is double refraction?

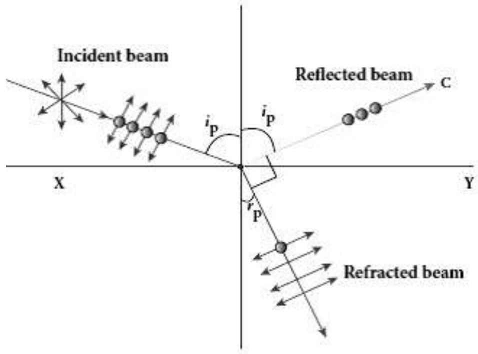
- When a ray of unpolarised light is incident on a calcite crystal, two refracted rays are produced. Hence two images of an object are formed.

19. What is uniaxial and biaxial crystals?

- **Uniaxial :**These crystals have only one optic axis. **Example:** calcite, quarts, ice, tourmaline.
- **Biaxial :**These crystals have two optic axes. **Example:** Mica, topaz, selenite, aragonite.

3 - MARK QUESTIONS AND ANSWERS:

1. State and explain Brewster's law.

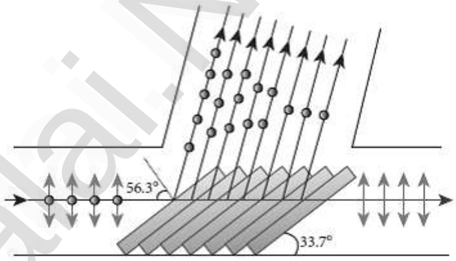


- From figure, $i_p + 90^o + r_p = 180^o$ (or) $r_p = 90^0 - i_p$
- Snell's law,

$$n = \frac{\sin i_p}{\sin r_p}$$

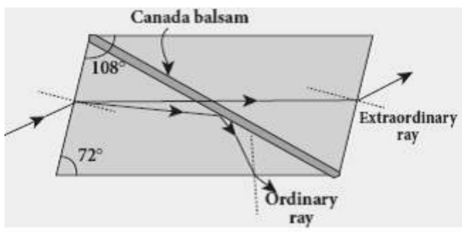
- $n = \frac{\sin i_p}{\sin(90^o - i_p)} = \frac{\sin i_p}{\cos i_p} = \tan i_p.$
- $n = \tan i_p$
- **LAW :** The tangent of the polarising angle for a transparent medium is equal to its refractive index.

2. Explain the pile of plates.



- It makes use of Brewster's law.
- Several plates are kept one behind the other at an angle $90^o - i_p$ 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.

3. 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.
- Refractive index for ordinary ray 1.658, extraordinary ray 1.486 and canada balsam 1.523.
- Ordinary ray undergoes total internal reflection.
- Extraordinary ray is transmitted and serves as a plane polarised ray.
- Its act as a polariser and analyser.

4.Write uses of polaroids.

Polaroids are

1. Used in goggles and cameras to avoid glare of light.
2. Used to take 3D pictures. Example: Holography.
3. Used to improve contrast in old oil painting.
4. Used in optical stress analysis.
5. Used as window glasses to control the intensity of incoming light.
6. Used in liquid crystal display.

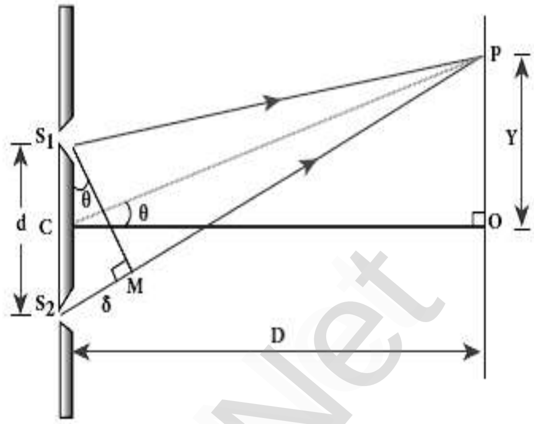
5 - MARK QUESTIONS AND ANSWERS:

1. Obtain the equation for band width in young's double slit experiment.

- S_1 & S_2 → Coherent sources.

  d → distance between the slits.

  D → Distance between slit and screen.



- The path difference between the light waves from S_1 and S_2 to the point P is δ.

  $\delta = S_2P - S_1P = d \sin\theta$

  $\delta = \theta . d$

- $\tan\theta = \frac{y}{D}$ (OR) $\theta = \frac{y}{D}$

  $\delta = \frac{y}{D} d$

Condition for bright fringes:

- The path difference, $\delta = n\lambda$

  $\frac{y}{D} d = n\lambda$ (n = 0,1,2,3…….)

The distance of n^{th} bright fringe:

- $y_n = \frac{D}{d} n\lambda$

Condition for dark fringe:

- The path difference, $\delta = (2n-1)\frac{\lambda}{2}$
- $\frac{y}{D} d = (2n-1)\frac{\lambda}{2}$ (n = 1,2,3,………)

The distance of n^{th} dark fringe:

- $y_n = \frac{D}{d}(2n-1)\frac{\lambda}{2}$

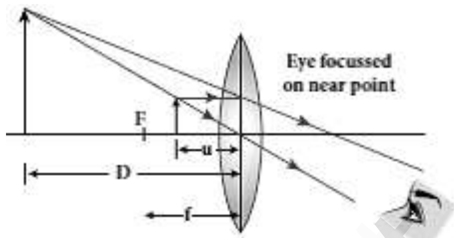
Band width:

- The distance between any two consecutive bright (or) dark fringes. $\beta = \frac{\lambda D}{d}$

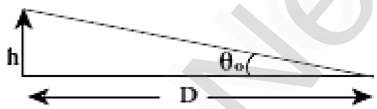
2. Discuss about simple microscope and obtain equation for magnification.

Near point focusing:

- It is a single magnifying lens produce erect, magnified and virtual image.
- Object should be placed less than the focal length of lens. Image distance is near to the least distance of distinct vision.
- m = $\frac{v}{u} = \frac{-D}{-u}$
- Lens equation, $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$
- Magnification; m = $\frac{v}{u}$ = 1+ $\frac{D}{f}$

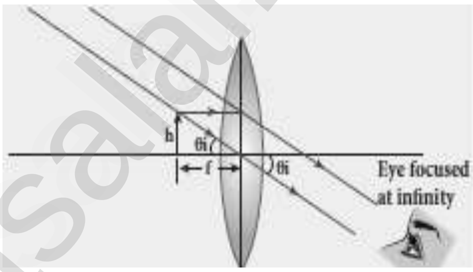


Normal focusing:



- Image is formed at infinity.
- Angular magnification m =$\frac{\theta_i}{\theta_0}$
- $tan\ \theta_0 \approx \theta_0 = \frac{h}{D}$

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



- The angular magnification is $m = \frac{\theta_i}{\theta_0} = \frac{h/f}{h/D}$

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

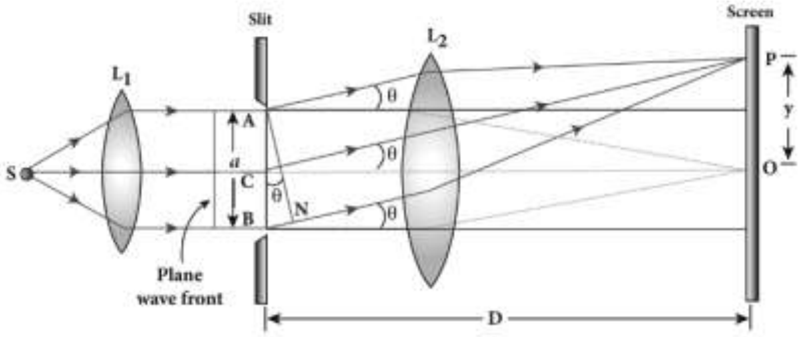
3. Explain about compound microscope and obtain equation for magnification.

- Objective lens produces real, inverted and magnified image.
- Image produced by objective lens act as an object to the eyepiece.
- Eyepiece produces an enlarged and virtual image.
- Magnification of objective lens, $m_0 = \frac{h'}{h}$

  tan β $= \frac{h}{f_0} = \frac{h'}{L}$

- $m_0 = \frac{L}{f_0}$
- Magnification of eyepiece, $m_e = 1 + \frac{D}{f_e}$
- Total magnification m =m_o m_e
- Near point focusing : $m = \left[\frac{L}{f_0}\right] \left[1 + \frac{D}{f_e}\right]$
- Normal focusing : $m = \left[\frac{L}{f_0}\right] \left[\frac{D}{f_e}\right]$

4. Discuss about diffraction in single slit.



- AB – width of a single slit = a

  C – centre of the slit

  D – distance between screen and slit

- Path difference between the corresponding points $\delta = \frac{a}{2}\sin\theta$

- Condition for first minimum, $a\ \sin\theta = \lambda$

- Condition for second minimum, $a\ \sin\theta = 2\lambda$

- Condition for n^{th} minimum , $a\ \sin\theta = n\lambda$ where n = 1,2,3………

- Condition for first maximum , $a\ \sin\theta = 3\lambda/2$

- Condition for second maximum , $a\ \sin\theta = 5\lambda/2$

- Condition for n^{th} maximum , $a\ \sin\theta = (2n + 1)\ \lambda/2$ Where n = 0,1,2,3,……..

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8. DUAL NATURE OF RADIATION AND MATTER

2 - MARK QUESTIONS AND ANSWERS:

1. Define stopping potential.

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

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. 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.

4. Define surface barrier.

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

5. 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
  - i) Photo emissive cell.
  - ii) Photo voltaic cell.
  - iii) Photo conductive cell.

6. What is De Broglie hypothesis?

- Due to the symmetry in nature, de Broglie suggested that if radiation like light can act as particles at times, then material particles like electrons can also act as waves at times.
- According to de Broglie hypothesis, all material particles like electrons, protons, neutrons in motion are associated with waves. These waves are called de Broglie waves or matter waves.

7. Define threshold frequency.

- For a given surface, the emission of photoelectrons takes place only if the frequency of incident light is greater than a certain minimum frequency called threshold frequency.

3 - MARK QUESTIONS AND ANSWERS :

1. Derive the expression of De Broglie wavelength.

- Let an electron of mass m be accelerated through a potential difference of V volt. The kinetic energy acquired by the electron is given by $\frac{1}{2}\, m\, v^2 = e\, V$
- The speed of the electron is $v = \sqrt{\frac{2e\,V}{m}}$
- 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 the characteristics of photons.

i) Each photon will have energy $E = hv$.

ii) The energy of a photon is determined by the frequency of the radiation.

iii) The photons travel with the speed of light.

iv) They are unaffected by electric and magnetic fields.

v) When a photon interacts with matter, the total energy and angular momentum are conserved.

3. 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.

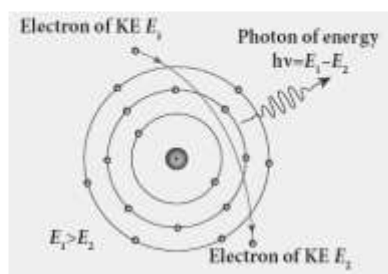
iii) Street lights that switch on and off according to whether it is night or day.

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.

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



i) When a fast moving electron penetrates and approaches a target nucleus, the electron either accelerates or decelerates.

ii) It results in a change of path of the electron.

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

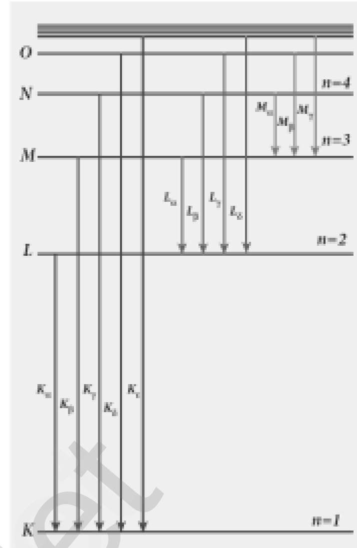
iv) The energy of the photon emitted=The loss of kinetic energy of the electron.

(i.e) $h\nu_0 = \frac{hc}{\lambda_0} = eV.$

v) Substitute the known values,

Minimum wavelength $\lambda_0 = \frac{12400\;\; A^0}{V}$. This relation is known as **Duane-Hunt** formula.

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



i) When the target is hit by fast electrons, the obtained X-ray spectra shows some narrow peaks at some well-defined wavelength.

ii) The line spectrum showing these peaks is called characteristic X-ray spectrum.

iii) This X-ray spectrum is due to the *electronic transitions* within the atoms.

iv) For example, when an energetic electron penetrates into the target atom and removes the electrons in K-shell and create a vacancy in it.

v) So the electrons from outer orbits (L, M, N, O…) jump to fill up the vacancy in K-shell.

vi) The energy difference between the levels is given out in the form of X-ray photon.

vii) K-series (K_α, K_β, K_γ…) originates due to electronic transition from L,M,N,O….shells to K-shell.

viii) L-series (L_α, L_β, L_γ…) originates due to electronic transition from M,N,O….shells to L-shell.

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.

FIVE MARK QUESTIONS AND ANSWERS:

1. State the Laws of Photoelectric effect.

a. For a given frequency of incident light, the number of photoelectrons emitted is directly proportional to the intensity of incident light.

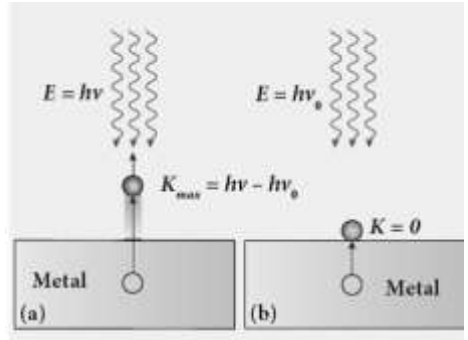
b. Maximum kinetic energy of the photo electrons is independent of intensity of the incident light.

c. Maximum kinetic energy of the photo electrons is directly proportional to the frequency of incident light.

d. For a given surface, the emission of photoelectrons takes place only if the frequency of incident light is greater than a certain minimum frequency called threshold frequency.

e. There is no time lag between incidence of light and ejection of photoelectrons.

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

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

Here m—mass of the electron and v —velocity.

- At threshold frequency, the kinetic energy of ejected electrons will be zero.

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

- Substitute (2) in (1)

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

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.

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

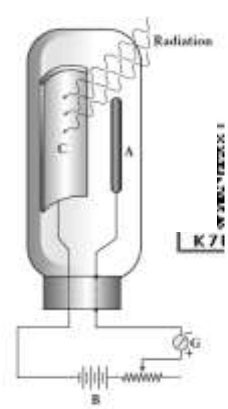
- Maximum kinetic energy of photoelectron $K_{max.} = \frac{1}{2}mv_{max}^2$

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

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

Principle: Photoelectric effect.

Construction:

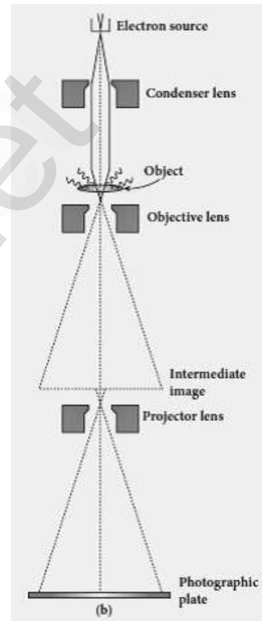


- It consists of an evacuated glass or quartz bulb.
- The cathode C is semi-cylindrical in shape and is coated with a photo sensitive material.
- The anode A is a thin rod or wire.
- A potential difference is applied between the anode and the cathode through a galvanometer G.

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. Explain the principle and working of electron microscope.



Principle: The wave nature of the electron.

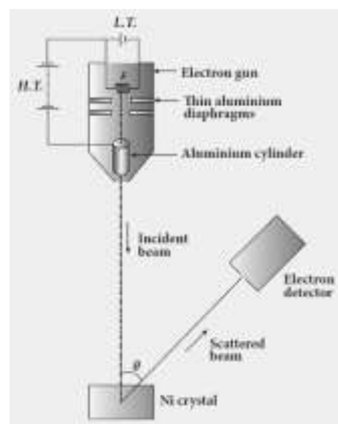
Construction:

In electron microscope focusing of electron beam is done by the electrostatic or magnetic lenses.

Working:

i) The electrons emitted from the source are accelerated by high potentials.
ii) The beam is made parallel by magnetic condenser lens.
iii) When the beam passes through the sample whose magnified image is needed, the beam carries the image of the sample.
iv) With the help of magnetic objective lens and magnetic projector lens system, the magnified image is obtained on the screen.

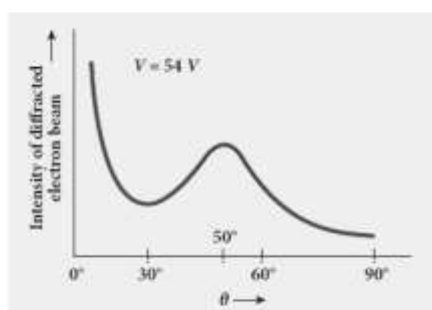
5. Describe briefly Davisson – Germer experiment which demonstrated the wave nature of electrons.



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 aluminum cylinder by a high tension (H.T.) battery
- Electron beam is collimated by using two thin aluminum 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(54V), the scattered wave shows a maximum intensity at an angle of 50^0

Conclusion:

The wavelength of electron

i) By experiment (angle=50^0) = 1.65Å

ii) De-broglie equation(V=54V) = 1.67 Å.

OTHER IMPORTANT QUESTIONS:

1. Write the expression for the de Broglie wavelength associated with a charged particle of charge q and mass when it is accelerated through a potential *V*.

- De- Broglie wavelength = $\lambda = \frac{h}{mv} = \frac{h}{\sqrt{2mqV}}$ (h - *Planck constant)*

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

- De Broglie wavelength $\boldsymbol{\lambda \, \alpha \, \frac{1}{\sqrt{m}}}$ (i.e) $\lambda = \frac{h}{\sqrt{2mK}}$
- Mass of electron < Mass of proton
- Therefore, Wavelength of electron > Wavelength of proton

4. Write the relationship of de Broglie wavelength λ associated with a particle of mass *m* in terms of its kinetic energy *K*.

- De Broglie wavelength $\boldsymbol{\lambda = \frac{h}{\sqrt{2meV}}}$
- Kinetic energy K = eV then $\boldsymbol{\lambda = \frac{h}{\sqrt{2mK}}}$

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9. ATOMIC AND NUCLEAR PHYSICS

2 - MARK QUESTIONS AND ANSWERS:

1. Define one Curie.

- One curie is equal to activity of one gram of radium.
- $1 \text{ curie} = 3.7 \times 10^{10}$ decays per second

2. Define one atomic mass unit (u).

- One atomic mass unit is defined as the $\frac{1}{12}^{th}$ of the mass of the isotope of carbon $_6C^{12}$.
- $1 \text{ u} = 1.660 \times 10^{-27}$ Kg

3. Define (a) Isotope (b) Isobar (c) Isotone

a) Isotopes:

- The atoms of same elements with same atomic number and different mass number.
- Example: $_1H^1$, $_1H^2$

b) Isobars: The atoms of different elements with different atomic number and same mass number.

- Example: $_{16}Si^{40}$, $_{17}Cl^{40}$

c) Isotones: The atoms of different elements with same number of neutrons.

- Example: $_5B^{12}$, $_6C^{13}$

4. Define activity.

- It is the rate at which the atoms decay. $R = -\frac{dN}{dt}$
- Its unit is Becquerel.

5. Mass defect:

- Mass defect = Total mass of nucleons – mass of the nucleus

6. What are the properties of neutrino?

i) It has zero charge.
ii) It has an antiparticle called anti neutrino.
iii) It has very small mass.
iv) It interacts weakly with matter.

7. What are the properties of Nuclear Force?

i) The Strongest force in nature.
ii) Very short range of force.
iii) It is an attractive force.
iv) Nuclear force is same for (n-n), (p-p), (p-n).
v) It doesn't act on electrons.

8. Define Half life time.

- Half life time is defined as the time required for the number of atoms to reduce to one half of the initial amount. $T_{\frac{1}{2}} = \frac{0.6931}{\lambda}$

9. Define mean life.

- Mean life = sum of lifetime of all the nuclei / total number of nuclei present initially.
- Mean life = 1/ decay constant.

10. Define Impact factor.

- It is the perpendicular distance between the centre of the gold nucleus and the direction of velocity vector of alpha particle when it is at a larger distance

11. Define excitation energy.

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

12. 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.

13. Explain Proton – Proton cycle

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

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

$_2He^3 + {}_2He^3 \rightarrow {}_2He^4 + {}_1H^1 + {}_1H^1$

Overall Energy produced = 27 MeV

14. Define distance of closest approach.

- The minimum distance between the centre of the nucleus and the alpha particle just before it gets reflected back through 180^0

15. On what particles neutron and proton are made up of ?

- 1 neutron = 2 down quark + 1 up quark
- 1 proton = 2 up quark + 1 down quark

3 - MARK QUESTIONS AND ANSWERS :

1.What are the properties of cathode rays?

i) Possess energy and momentum.
ii) Travel in a straight line .
iii) Can be deflected by both electric and magnetic fields.
iv) They produce heat when they fall on matter.
v) They affect photographic plates.
vi) They produce fluorescence.
vii) They produce X-rays when they fall on material of high atomic weight.
viii) Ionize the gas through which they pass.

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

i) Alpha decay:

- Here atomic number of the nucleus decreases by 2 and mass number decreases by 4.
- Example: ${}_{92}U^{238} \rightarrow {}_{90}Th^{234} + {}_{2}He^{4}$

ii) Beta (-) decay:

- Here atomic number of the nucleus increases by 1 and mass number remains the same.
- Example: ${}_{6}C^{14} \rightarrow {}_{7}N^{14} + e^{-} + \bar{\nu}$

iii) Beta(+) decay:

- Here atomic number of the nucleus decreases by 1 and mass number remains the same.
- Example: ${}_{11}Na^{22} \rightarrow {}_{10}Ne^{22} + e^{+} + \nu$

iv) Gamma emission:

- Here there is no change in atomic and mass number but energy level of the nucleus is changed.
- Example: ${}_{5}B^{12} \rightarrow {}_{6}C^{12*} + e^{-} + \bar{\nu}$

  ${}_{6}C^{12*} \rightarrow {}_{6}C^{12} + \gamma$

3. Write down the properties of neutron.

i) They are stable inside the nucleus.

ii) Outside the nucleus it decays with a half life of 13 minutes.

iii) They are neutral in charge.

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

4. State the postulates of Bohr atom model

1. The centripetal force for the electron is given by coulomb force.
2. The angular momentum of electron $L = nh/2\pi$
3. Electron can jump from one orbit to other by absorbing or emitting a photon.

5. Explain the following in symbolic representation.(a) Alpha decay (b) Beta decay (c) Gamma emission

- α decay $\Rightarrow {}_{Z}X^{A} \rightarrow {}_{Z-2}Y^{A-4} + {}_{2}He^{4}$
- $\beta-$ decay $\Rightarrow {}_{Z}X^{A} \rightarrow {}_{Z+1}Y^{A} + e^{-} + \bar{\nu}$
- $\beta+$ decay $\Rightarrow {}_{Z}X^{A} \rightarrow {}_{Z-1}Y^{A} + e^{+} + \nu$
- γ emission $\Rightarrow {}_{Z}X^{A*} \rightarrow {}_{Z}X^{A} + \gamma$

6. Drive an expression for the Energy of an electron in the n^th^ orbit.

- Potential Energy $U_n = -\frac{1}{4\pi\varepsilon_0}\frac{Ze^2}{r_n}$ (or) $U_n = -\frac{Z^2me^4}{4\varepsilon_0^2h^2n^2}$
- Kinetic Energy $KE_n = \frac{Z^2me^4}{8\varepsilon_0^2h^2n^2}$
- This implies that $U_n = -2KE_n$
- Total energy $E_n = KE_n + U_n = KE_n - 2\,KE_n = -\,KE_n = -\frac{Z^2me^4}{8\varepsilon_0^2h^2n^2}$
- For hydrogen atom (Z = 1) and substitute the known value $E_n = -\frac{13.6}{n^2}\ eV$

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

i) Most of the alpha particles goes without any deviation.

ii) Some of the alpha particles are deflected with small angle.

iii) A few of alpha particles are deflected above 90^0.

iv) Very few numbers of alpha particles retrace their path with 180^o.

8. Explain Thomson atom model.

i) In a positively charged sphere, the electrons are embedded as the seeds in the water melon.

ii) Total positive charge = Total negative charge.

Drawbacks:

i) According to this model, an atom cannot be stable.

ii) It does not explain the origin of spectral lines.

9. Drawbacks of Rutherford atom model

- This model fails to explain the distribution of electron around the nucleus and also the stability of the atom
- Accelerated charges emit electromagnetic radiations. Due to this, it undergoes spiral motion and fall into the nucleus.
- According to this model, radiation from the atom must be continuous spectra, but experiments shows that it emits line spectra

5 - MARK QUESTIONS AND ANSWERS :

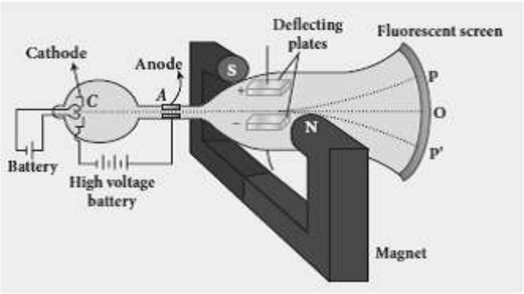
1. Explain JJ Thomson experiment to determine specific charge

Principle: Deflection of electron in electric and magnetic field.

Construction:

- A highly evacuated discharge tube is used.
- Cathode rays are produced and accelerated towards the anode.
- Cathode rays are made into a narrow beam by a pin hole in anode disc.
- Electric field is provided by the parallel plates and magnetic field is provided by the magnets.
- When cathode rays fall on the screen (at O), they produce fluorescence .

Velocity selector



- For a fixed electric field between the plates, the magnetic field is adjusted such that the cathode rays strike at the original position 'O'.
- $eE = Bev$
- $\boxed{v = \frac{E}{B} - - - (1)}$

Specific charge

- Cathode rays are accelerated towards anode, Potential energy is converted into Kinetic Energy
- By law of conservation of Energy

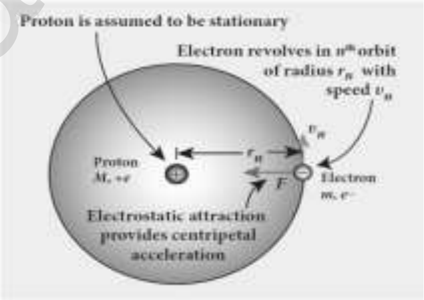
Potential energy = Kinetic energy

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

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

$$\text{Using (1) } \boxed{\frac{e}{m} = \frac{E^2}{2VB^2} = 1.7 \times 10^{11} \text{ C kg}^{-1}}$$

2. Obtain the expression for Radius of n^{th} orbit of an electron



Ze ➔ charge of the nucleus
e ➔ charge of the electron
r_n ➔ radius of the n^{th} orbit
ω ➔ angular velocity of the electron
z ➔ atomic number of the atom

- From Coulomb's law $\vec{F}_{coulomb} = -\frac{1}{4\pi\epsilon_0}\frac{Ze^2}{r_n^2}\hat{r}$.
- This force provides necessary centripetal force $\vec{F}_{centripetal} = \frac{mv_n^2}{r_n}\hat{r}$
- $\left|\vec{F}_{coulomb}\right| = \left|\vec{F}_{centripetal}\right|$

$$\frac{1}{4\pi\epsilon_0}\frac{Ze^2}{r_n^2} = \frac{mv_n^2}{r_n}$$

$$\frac{1}{4\pi\epsilon_0}\frac{Ze^2}{r_n^2} = \frac{mv_n^2}{r_n}\frac{m}{m}$$

$$r_n = \frac{4\pi\epsilon_0 (mv_n r_n)^2}{Zm e^2} \text{ ------ (1)}$$

- From Bohr's assumption, $mv_n r_n = \frac{nh}{2\pi}$ ------ (2)
- Substitute (2) in (1) $r_n = \frac{4\pi\epsilon_0}{Zm e^2}\frac{n^2h^2}{4\pi^2}$
- Equating and rearranging $\boxed{r_n = \frac{n^2h^2\varepsilon_o}{\pi m Z e^2}}$ ------ (3)
- $\varepsilon_0, h, e, and\ \pi$ are constants . So radius $r_n = a_0\frac{n^2}{Z}$
- Here $a_0 = \frac{\epsilon_0 h^2}{\pi m e^2} = 0.529\ A^0$. This is known as Bohr radius.
- For hydrogen (Z = 1), $\boxed{r_n = a_0 n^2}$ (i.e) $r_n \propto n^2$

3.Obtain the expression for number of atoms present at any instant and also derive the equation for half life period. (or) State and explain Radioactive law of disintegration.

Statement:

- Rate of decay at any instant is directly proportional to the number of nuclei at the same instant.

(i.e) $\boxed{\frac{dN}{dt} \alpha N}$

(or) $\frac{dN}{dt} = -\lambda N$.   λ ➔ decay constant

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

$$\ln\left(\frac{N}{N_0}\right) = -\lambda t$$

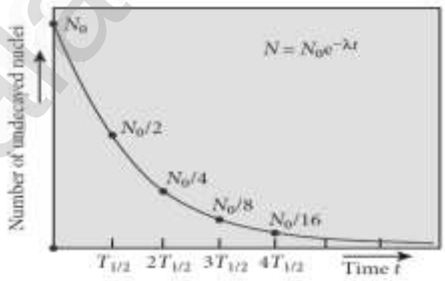
- Taking exponentials

$$\boxed{N = N_0 \, e^{-\lambda t}}$$

- Number of atoms decreasing exponentially with time.
- Infinite time is needed for decay of all the atoms.

Half life

- The time required for the number of atoms to reduce one half of the initial amount



- $N = \frac{N_0}{2}$ and $t = T_{\frac{1}{2}}$
- $\frac{N_0}{2} = N_0 \, e^{-\lambda T_{\frac{1}{2}}}$

$$e^{\lambda T_{\frac{1}{2}}} = 2$$

- Taking log $\boxed{T_{\frac{1}{2}} = \frac{0.6931}{\lambda}}$

4. Explain the spectral series of an hydrogen atom.

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

Series	n	m	Wave number $\left(\frac{1}{\lambda}\right)$	Region
Lyman	1	2, 3,...	$R\left[\frac{1}{1^2} - \frac{1}{m^2}\right]$	UV
Balmer	2	3,4...	$R\left[\frac{1}{2^2} - \frac{1}{m^2}\right]$	Visible
Paschen	3	4,5...	$R\left[\frac{1}{3^2} - \frac{1}{m^2}\right]$	IR
Brackett	4	5,6...	$R\left[\frac{1}{4^2} - \frac{1}{m^2}\right]$	IR
P Fund	5	6,7...	$R\left[\frac{1}{5^2} - \frac{1}{m^2}\right]$	IR

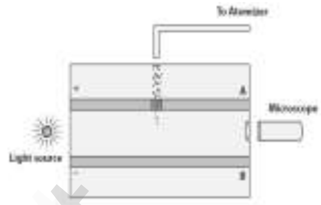
5. Discuss the Millikan's oil drop experiment for the determination of charge of an electron.

Principle:

- By adjusting the electric field, motion of the oil drop can be controlled, can be made to move up or down or even kept balanced in the field of view for sufficiently long time

Construction:

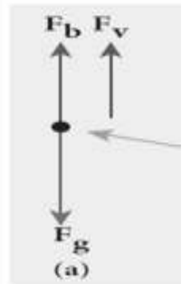
- A and B each with diameter around 20 cm are separated by a distance of 1.5 cm
- Parallel plates are enclosed in an evacuated glass chamber
- 10 KV potential difference is applied between the plates.
- A small hole is made at the centre of the plate A
- An atomizer is kept exactly above the hole to spray the liquid.
- Chamber is illuminated by light and oil drops can be seen clearly using microscope



Uncharged oil drop

- Let m be the mass of the oil drop which is accelerating downwards
- Due to air drag, oil drop easily attains the terminal velocity.
- Hence it moves with constant velocity

Force	Equation	Direction
Gravitational Force	$F_g = \frac{4\pi}{3} r^3 \rho g$	downwards
Buoyant Force	$F_b = \frac{4\pi}{3} r^3 \sigma g$	Upwards
Viscous Force	$F_v = 6\pi\eta r v$	Upwards
Net Force	$F_v = F_g - F_b$	

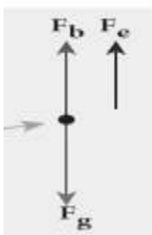


$$\frac{4\pi}{3} r^3 (\rho - \sigma) g = 6\pi\eta r v$$

Radius of the drop $\boxed{r = \left(\frac{9\eta v}{2(\rho-\sigma)g}\right)^{\frac{1}{2}}}$

- Charged oil drop between the plates are ionized by passing X rays
- Few oil drops in the chamber can acquire electric charge.
- Now electric field is switched on.
- Charged oil drop is balanced between the plates. Hence no viscous force acts on it

Force	Equation	Direction
Gravitational Force	$F_g = \frac{4\pi}{3} r^3 \rho g$	downwards
Buoyant Force	$F_b = \frac{4\pi}{3} r^3 \sigma g$	Upwards
Electric Force	$F_e = qE$	Upwards
Net force	$F_e = F_g - F_b$	



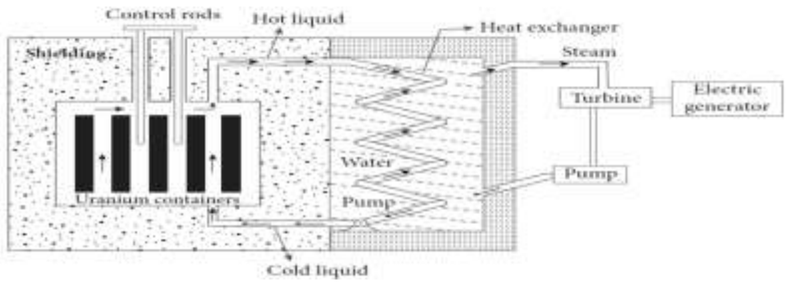
$$\frac{4\pi}{3} r^3 (\rho - \sigma) g = qE$$

Sub from (1) and rearranging $q = \frac{18\pi}{E}\left(\frac{\eta^3 v^3}{2(\rho - \sigma)g}\right)^{\frac{1}{2}}$

Charge of an electron $\boxed{q = -1.6 \times 10^{-19}\ C}$.

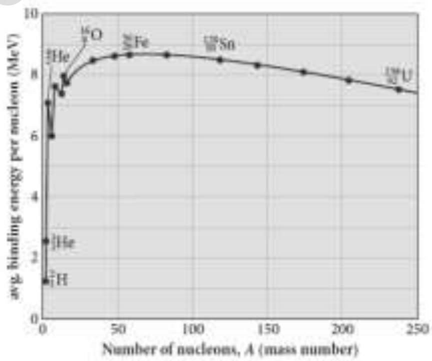
6. What is nuclear reactor? Explain its essential parts.

- In nuclear reactor, nuclear fission takes place in a self sustained controlled manner.



Parts	Function of the part	Material used
Fuel	Fissionable material	$_{92}U^{235}$, Plutonium, Polonium
Moderator	To slow down the neutron	Water, 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

7.**Explain the Binding energy curve**



Description:

- $\overline{BE}$ - The energy required to separate a single nucleon from the particular nucleus.
- $\overline{BE}$ is taken along y axis, mass number A is taken along x axis.
- A = 56 → $\overline{BE} = 8.8\ MeV$ reaches the maximum at A = 56 corresponding to Iron nucleus.
- A= 40 to 120 → Average $\overline{BE} = 8.5\ MeV$, more stable and non radioactive.
- A > 120 →Average $\overline{BE}$ reduces slowly.
- $\overline{BE} = 7.6\ MeV$ for Uranium , unstable and radioactive.
- During nuclear fusion and fission, a large amount of energy will be released.

Nuclear Fusion:

i) Two lighter nuclei fuse to produce a heavier nucleus is called fusion. (Final $\overline{BE}$ > initial $\overline{BE}$)

ii) This is the principle of Hydrogen bomb.

Nuclear Fission:

i) Heavy nucleus splits into two or more nuclei of medium value A is called fission.

ii) This is the principle of atom bomb.

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10. ELECTRONICS AND COMMUNICATION SYSTEMS

2- MARK QUESTIONS AND ANSWERS:

1. Distinguish intrinsic semiconductor and extrinsic semiconductor.

S.N	INTRINSIC SEMICONDUCTOR	EXTRINSIC SEMICONDUCTOR
1	Pure form of semiconductor without impurity. Eg: 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.

2. What is called doping?

- The process of adding impurities to the intrinsic semiconductor is called as doping.

3. 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.

4. What is called depletion region?

- The thin region near the junction which is free from charge carriers is known as depletion region.

5. Define potential barrier

- The potential difference across the depletion region is called as potential barrier
- At 25^{0}C, the value of potential barrier is 0.3 V for Germanium and 0.7V for Silicon.

6. What is rectification?

- The process of converting AC into DC (alternating current into direct current.)

7. 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.

8. 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.

9. Define input impedance.

- The ratio of the change in the base-emitter voltage (ΔV_{BE}) to the corresponding change in base current (ΔI_B)at constant V_{CE} is called the input impedance (r_i). Its unit is ohm.
- (i.e) $r_i = \left(\frac{\Delta V_{BE}}{\Delta I_B}\right)_{V_{CE}}$

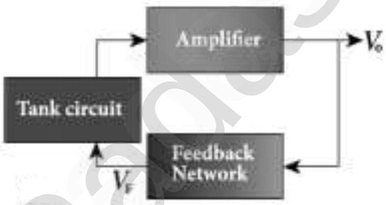
10. Define output impedance.

- The ratio of the change in the collector- emitter voltage (ΔV_{CE})to the corresponding change in the collector current (ΔI_C) at constant I_B is called output impedance (r_0). Its unit is ohm.
- (i.e) $r_o = \left(\frac{\Delta V_{CE}}{\Delta I_C}\right)_{I_B}$

11. What are the essential components of an Oscillator? Draw the block diagram of an oscillator.

Essential components are:

1. Tank circuit.
2. Amplifier.
3. Feedback Network.



12. Give the Barkhausen conditions for sustained oscillations.

1. Feedback should be positive.
2. The loop phase shift must be 0^0 or integral multiples of 2π.
3. The loop gain must be unity. (i.e) $|A\beta|$ =1.

13. Give the applications of oscillators.

Transistor oscillators are used

i) to generate periodic sinusoidal or non sinusoidal wave forms.

ii) to generate RF carriers and audio tones.

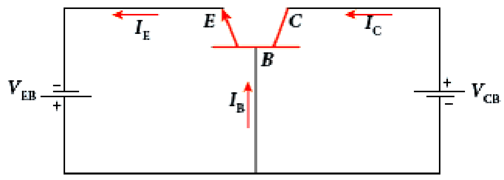
iii) to generate clock signal in digital circuits.

iv) as sweep circuits in TV sets and CRO.

14. What are logic gates?

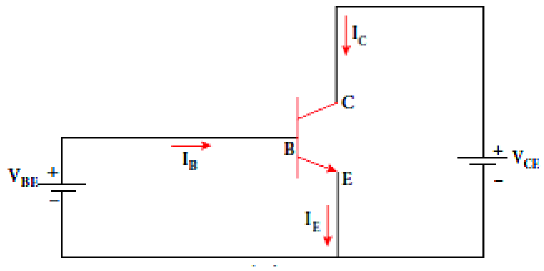
- A logic gate is an electronic circuit whose function is based on digital signals.
- The gates which have one or more inputs with one output.
- There are three types of basic logic gates: AND, OR, NOT.

15. Draw the circuit diagram for CB configuration.

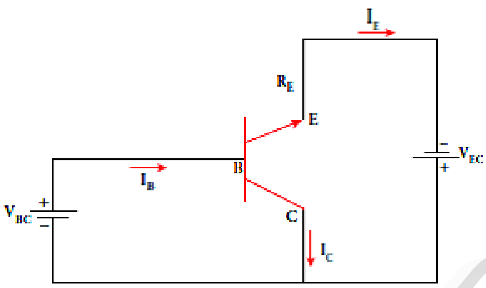


(b)

16. Draw the circuit diagram for CE configuration.



17. Draw the circuit diagram for CC configuration.



18. What is modulation?

- Superimposition of the low frequency baseband signal onto a high frequency radio signal is called modulation.

19. What is Amplitude modulation?

- If the amplitude of the carrier signal is modified in proportion to the instantaneous amplitude of the baseband signal is called amplitude modulation.

20. What is frequency modulation?

- If the frequency of the carrier signal is modified in proportion to the instantaneous amplitude of the baseband signal is called frequency modulation.

21. What is phase modulation?

- If the phase of the carrier signal is modified in proportion to the instantaneous amplitude of the baseband signal is called phase modulation.

22. Compare PM and FM.

S.N	Phase Modulation	Frequency Modulation
1	It uses lesser bandwidth .	It uses wider bandwidth.
2	Transmission speed is high	Transmission speed is less
3	More information can be sent	Less information can be sent

23.What is Range?

- Range is the maximum distance between the source and the destination upto which the signal is received with sufficient signal strength.

24.What is meant by Attenuation?

- The loss of strength of signal while propagating through a medium is called attenuation.

25. Define Bandwidth of transmission system (channel bandwidth).

- The range of frequencies required to transmit information in a particular channel is called bandwidth of transmission system.

26.What are the types of propagation?

i) Ground wave propagation.

ii) Sky wave propagation.

iii) Space wave propagation.

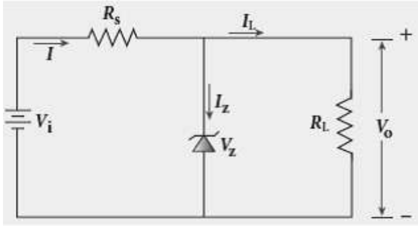
27.What is skip distance?

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

28. Differentiate wireline communication and wireless communication.

S.N	Wireline communication	Wireless communication
1	It uses wires, cables and optic fibres as medium for transmission	It uses free space as medium for transmission
2	It cannot be used for long distance transmission .	It can be used for long distance transmission.
3	Eg: telephone, intercom.	Eg: mobile, radio .

3 - MARK QUESTIONS AND ANSWERS:



1. Explain how Zener diode acts as a voltage regulator.

- Zener diode working in the breakdown region can serve as a voltage regulator.
- The output is maintained constant as long as the input voltage is greater than Zener breakdown voltage (V_z).

Input DC Voltage	P.D across R_s	Zener Current (I_z)	Load Current (I_L)	P.D.across (R_L)	Output Voltage (V_0)
Increase	Increase	Increase	Constant	Constant	Constant
Decrease	Decrease	Decrease	Constant	Constant	Constant

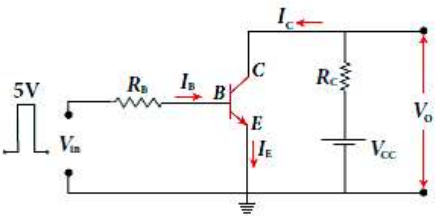
- Because of the parallel connection, V_0 (constant) = V_z .
- If there is any change in input voltage, the voltage across Zener diode or R_L remains constant.
- Thus, the Zener diode acts as a voltage regulator.

2. 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.

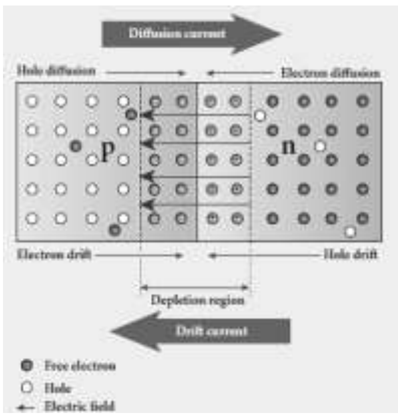
Input Voltage	Collector Current	P.D. across R_c	Output Voltage	Region	Action of the transistor
0 V	Zero	Zero	High	Cut-off	Open (Switch Off)
+ 5 V	Increases	Increases	Low	Saturation	Close (Switch ON)

- The output voltage is opposite to the applied input voltage.
- Therefore a transistor can be used as an inverter (NOTgate) in computer logic circuitry.



3. Explain the formation of depletion layer.

- The contact surface between the p – type and n - type semiconductor is called p-n junction.
- Whenever *p-n* junction is formed, the *n*-side has higher electron concentration and the *p*-side has higher hole concentration.
- A layer of immobile positive ions and a layer of immobile negative ions are created on either side of the junction due to DIFFUSION process .
- Thus, the thin region near the junction which is free from charge carriers is called depletion region.



4. 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.

5. 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.

6. List the applications of RADAR.

Radar ---- basically stands for Radio Detection and Ranging System

Applications:

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

ii) It is used in navigation systems such as ship borne surface search, air search and missile guidance systems.

iii) It is used in meteorological observations.

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

7.Write merits and demerits of fiber optic communication.

Merits:

i) Fiber cables are very thin and weigh less than copper cables.

ii) This system has much larger bandwidth .

iii) This system is immune to electrical interferences.

iv) Fiber optic cables are cheaper than copper cables.

Demerits :

i) Fiber optic cables are more fragile when compared to copper wires.

ii) It is an expensive technology.

8. What is meant by satellite communication? Give its applications.

Satellite communication:

- The satellite communication is a mode of transmission of the signal between transmitter and receiver via satellite.

Application:

i) **Weather satellites:**
To monitor the weather and climate of the Earth.

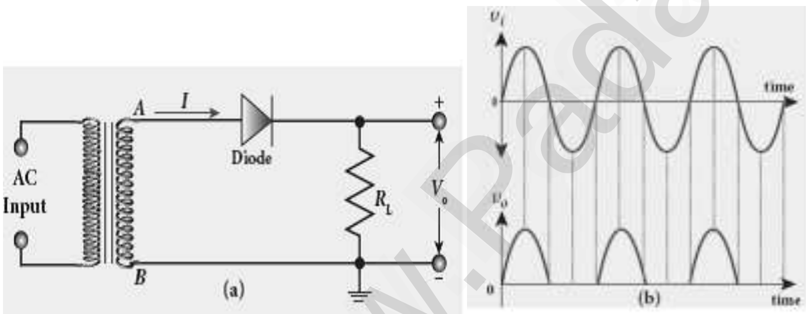
ii) **Communication satellites:**
To transmit television, radio, internet signals etc.
Multiple satellites are used for long distance communication.

iii) **Navigation satellites:**
To determine the geographic location of ships, aircrafts or any other object.

5 - MARK QUESTIONS AND ANSWERS :

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

- Half wave rectifier blocks half of the input wave and hence it known as unidirectional device.
- The half wave rectifier circuit consists of a transformer, a p-n junction diode and a resistor.



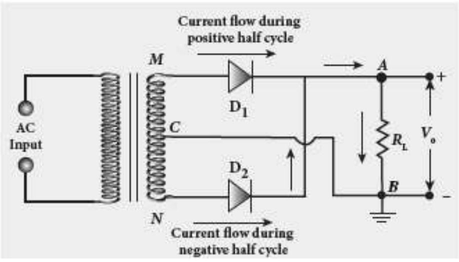
- Working :

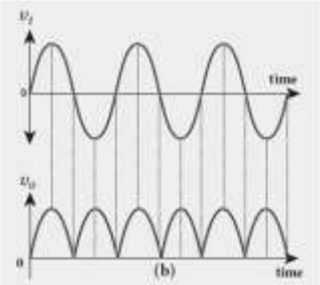
Input signal	Terminal A w.r.t. terminal B	Biasing of Diode	Action of the diode
Positive half cycle	Positive	Forward bias	Conducts current.
Negative half cycle	Negative	Reverse bias	Does not conduct current.

- The output of the half wave rectifier is not a steady DC voltage but a pulsating wave.
- A steady voltage can be obtained with the help of filter circuits.
- $Efficiency(\eta) = \frac{Output\ \ DC\ Power}{Input\ \ A\ C\ Power} \times 100\ = 40.6\%$

2. Draw the circuit diagram of a full wave rectifier and explain its working.

- Full wave rectifier consists of two *p-n* junction diodes, a centre tap transformer and load resistor R_L.
- The centre is usually taken as the ground or zero voltage reference point.



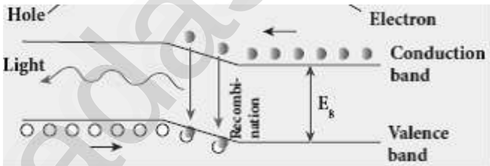


- **Working :**

Input signal	Terminal M	Terminal N	Diode D_1	Diode D_2	Path of the current
Positive half cycle	Positive	Negative	Forward bias	Reverse bias	MD_1ABC
Negative half cycle	Negative	positive	Reverse bias	Forward bias	ND_2ABC

- Efficiency of the fullwave rectifier = 81.2%

3. What is an LED? Give the principle of its operation with a diagram.



- LED is a *p-n* junction diode which emits visible or invisible light when it is forward biased.
- When the *p-n* junction is forward biased, the conduction band electrons on *n*-side and valence band holes on *p*-side diffuse across the junction.
- When they cross the junction, they become excess minority carriers (electrons in *p*-side and holes in *n*-side).
- The electrons in the conduction band recombine with holes in the valence band.
- For radiative recombination, a photon of energy *hν* is emitted.
- For non-radiative recombination, energy is liberated in the form of heat.
- The colour of the light is determined by the energy band gap of the material.

Applications

The light emitting diodes are used in

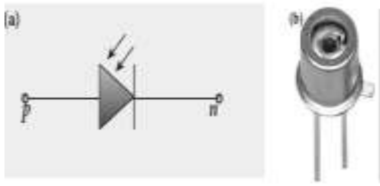
i) Indicator lamps in scientific equipments.

ii) seven-segment displays.

iii) traffic signals, emergency vehicle lighting etc.

iv) remote control of television, air conditioner etc.

4. Write notes on photodiode.



- A reverse biased *p-n* junction diode which converts an optical signal into electric signal is known as photodiode.
- The device consists of a *p-n* junction semiconductor made of photosensitive material kept safely inside a plastic case.
- It has a small transparent window that allows light to be incident on the *p-n* junction.
- When a photon of sufficient energy (*hν*) strikes the depletion region of the diode, some of the valence band electrons are elevated into conduction band, in turn holes are developed in the valence band.
- The amount of electron-hole pairs generated depends on the intensity of light incident on the *p-n* junction.
- When the external circuit is made, the electrons flow through the external circuit and constitute the photocurrent.

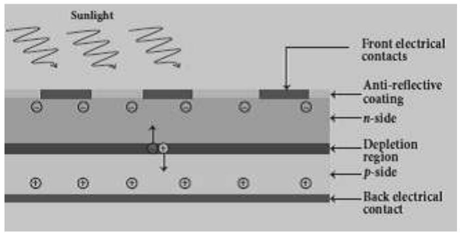
Applications:

The photodiodes are used in

i) alarm system.
ii) count items on a conveyor belt.
iii) Photoconductors.
iv) compact disc players, smoke detectors.
v) medical applications such as detectors for computed tomography etc.

5. Explain the working principle of a solar cell. Mention its applications.

- A solar cell, also known as photovoltaic cell, works on the principle of **photovoltaic effect**.
- The *p-n* junction of the solar cell generates emf when solar radiation falls on it.
- In a solar cell, electron hole pairs are generated due to the absorption of light photons near the junction.
- Electrons move towards *n*–type silicon layer and holes move towards *p*-type silicon layer due to electric field of depletion region.



- The electrons reaching the *n*-side are collected by the front contact (metal finger contact) and holes reaching *p*-side are collected by the back electrical contact. Thus, a potential difference is developed across solar cell.
- When an external load is connected to the solar cell, photocurrent flows through the load.
- Many solar cells are connected together to form a solar panel. Many solar panels are connected with each other to form solar arrays.

Applications:

Solar cells are widely used in

i) calculators, watches, toys, portable power supplies, etc.
ii) satellites and space applications.
iii) Solar panels are used for commercial production of electricity.

6. State and prove De Morgan's theorem

De Morgan's first theorem.

First theorem :

- The complement of the sum of two logical inputs is equal to the product of complements.
- $\overline{A+B} = \bar{A}\,.\,\bar{B}$

A	B	A+B	$\overline{A+B}$	$\bar{A}$	$\bar{B}$	$\bar{A}.\bar{B}$
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.
- $\overline{A\,.\,B} = \bar{A} + \bar{B}$

A	B	A.B	$\overline{A.B}$	$\bar{A}$	$\bar{B}$	$\bar{A}+\bar{B}$
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

7. Fiber optic communication is gaining popularity among the various transmission - Justify.

- The method of transmitting information from one place to another in terms of light pulses through an optical fiber is called fiber optic communication.
- It works on the principle of total internal reflection.

Merits:

i) Fiber cables are very thin and weigh less than copper cables.

ii) This system has much larger bandwidth hence its information carrying capacity is larger.

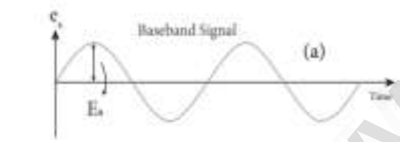
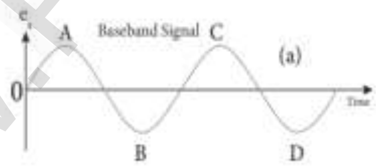
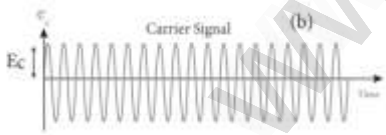
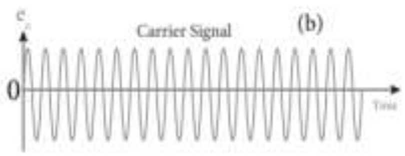
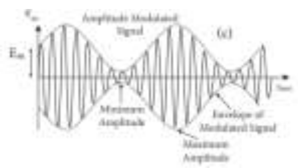
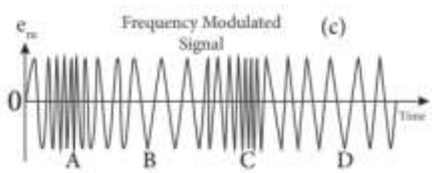
iii) It is immune to electrical interferences.

iv) It is cheaper than copper cables.

- It finds application in international communication, inter-city communication, data links, plant and traffic control and defense applications.
- Due to the above reasons, Fiber optic communication is gaining popularity among the various transmission.

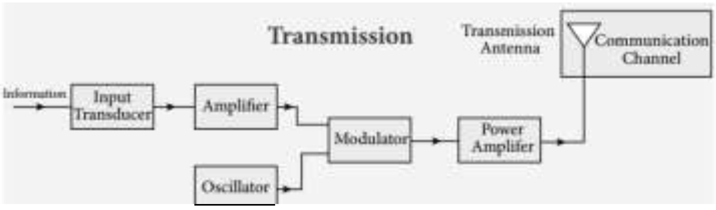
8. What is modulation? Explain the types of modulation with necessary diagrams.

- For long distance transmission, the low frequency baseband signal (input signal) is superimposed onto a high frequency radio signal by a process called modulation.

AMPLITUDE MODULATION	FREQUENCY MODULATION	PHASE MODULATION
Amplitude of the carrier signal is modified in proportion to the instantaneous amplitude of the base band signal.	The frequency of the carrier signal is modified in proportion to the instantaneous amplitude of the base band signal.	If the phase of the carrier signal is modified in proportion to the instantaneous amplitude of the baseband signal.
The frequency and the phase of the carrier signal remains constant.	The amplitude and the phase of the carrier signal remains constant.	The amplitude and the frequency of the carrier signal remains constant.
Amplitude modulation is used in radio and TV broadcasting.	If the voltage of the baseband signal is 1) Zero: The frequency of the modulated wave is as that of carrier wave. It is at its normal frequency and is called as **centre frequency or resting frequency.** 2) Positive half cycle: the frequency of the modulated wave increases. 3) Negative half cycle: the frequency of the modulated wave decreases.	It is similar to frequency modulation except that the phase of the carrier is varied instead of varying frequency.
		
		
		

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

TRANSMISSION



1. INPUT TRANSDUCER:

- Converts the information into corresponding electrical signal.
- Example: Microphone that converts sound energy into electrical energy.

2. AMPLIFIER:

- The transducer output is very weak and is amplified by the amplifier.

3. OSCILLATOR:

- It generates high frequency carrier wave.

4. MODULATOR:

- Generates the modulated signal. (baseband + carrier wave).

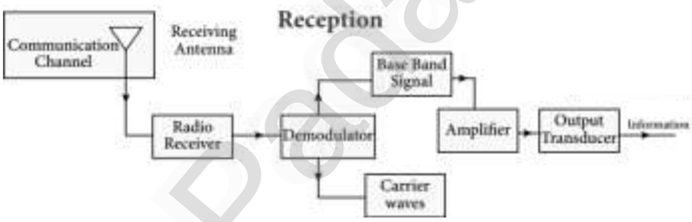
5. POWER AMPLIFIER:

- It increases the power level of the electrical signal in order to cover a large distance.

6 . ANTENNA:

- It radiates the radio signal into space in all directions.

RECEPTION



1. COMMUNICATION CHANNEL:

- It carries the electrical signal from transmitter to receiver with less noise.

Types:

a) Wireline communication Eg : telephone, cable tv.

b) Wireless communication. Eg : mobile, satellite connection.

2. RECEIVER:

i) ANTENNA:

- Transmitted signals are received by the receiving antenna.
- It converts the EM waves into RF signals and are fed into the receiver. Receiver consists of demodulator and amplifier.

ii) DEMODULATOR:

- It extracts the baseband signal from the modulated signal.

iii) AMPLIFIER:

- It amplifies the demodulated baseband signal.

3. OUTPUT TRANSDUCER:

- It converts the electrical signal back to its original form such as sound, music, pictures or data.

10. Explain the three modes of propagation of electromagnetic waves through space.

- The electromagnetic wave transmitted by the transmitter travels in three different modes.
  - i) Ground wave propagation (2KHz to 2MHz).
  - ii) Sky wave propagation (3MHz to 30MHz).
  - iii) Space wave propagation (30MHz to 400GHz).

i) GROUND WAVE PROPAGATION:

- If the electromagnetic waves transmitted by the transmitter glide over the surface of the earth to reach the receiver, then the propagation is called ground wave propagation.
- The corresponding waves are called ground waves.
- Both transmitting and receiving antennas must be close to the earth.
- It is mainly used in local broadcasting and radio navigation.

ii) SKY WAVE PROPAGATION:

- The electromagnetic waves by an antenna, directed upwards at right angles, get reflected by the ionosphere back to the earth is called sky wave propagation.
- The corresponding waves are called sky waves.
- Ionosphere acts as a reflecting surface.
- The electromagnetic waves undergo total internal reflection in ionosphere and reaches the ground without escaping into space.
- The shortest distance between the transmitter and the point of reception of the sky wave along the surface is called as the skip distance.
- The zone where there is no reception of EM waves neither ground nor sky is known as skip Zone or skip area
- It is used for short wave broad casting services.

iii) SPACE WAVE PROPAGATION:

- The process of sending and receiving information signal through space is called space wave propagation. These waves travel in a straight line from the transmitter to the receiver.
- The transmission towers must be high enough so that the signals will not encounter the curvature of the earth.
- The range of coverage of propagation depends on the height of the antenna (h).

  Range d = $\sqrt{2Rh}$ (R-radius of the earth)
- The communication systems like television telecast, satellite communication and RADAR are based on space wave propagation.

ADDITIONAL QUESTIONS:

1. What is valence band?
2. What is conductivity?
3. What is forbidden energy gap?
4. What do you mean by Biasing a diode? Mention its types.
5. What is operating point?
6. Give the circuit symbol and truth table for the logic gates AND, OR, NOT, NOR, NAND, and EX-OR.
7. Define current gain (α, β) and deduce the relationship between them.
8. Why is temperature co-efficient negative for semiconductor?
9. A diode is called as a unidirectional device. Explain.
10. What do you mean by leakage current in a diode?
11. What do you mean by diffusion current
12. Explain the flow of current in a NPN transistor.
13. What is integrated circuit?
14. Why are NOR and NAND gates called universal gates?
15. What is resting frequency.
16. What is mobile communication?
17. What is internet?
18. What is IOT?
19. Describe the function of a transistor as an amplifier with the neat circuit diagram. Sketch the input and output wave forms.
20. Prove the Boolean identity $AC + ABC = AC$ and give its circuit description.

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11. RECENT DEVELOPMENTS IN PHYSICS

TWO MARK QUESTIONS AND ANSWERS:

1. Distinguish between Nanoscience and Nanotechnology.

Nanoscience:

- It is the science of objects with typical size 1 – 100 nm.

Nanotechnology:

- It is a technology involving the design, production, characterization and application of nano structured materials.

2. What is the difference between Nanomaterials and Bulk materials?

- If the particle of a solid is of size less than 100 nm, it is said to be a 'nano solid'. When the particle size exceeds 100 nm, it is a 'bulk solid'.
- Though nano and bulk solids have same chemical composition, nano form of the material shows strikingly different properties when compared to its bulk counterpart.

3. Give examples for Nano structure in nature.

i) Single strand DNA
ii) Morpho butterfly
iii) Peacock feathers
iv) Parrot fish

4. Mention advantages and disadvantages of Robotics.

Advantages of robotics:

i) The robots are much cheaper than humans
ii) Robots never get tired like humans.
iii) Stronger and faster than humans.
iv) In warfare, robots can save human lives.

Disadvantages of robotics:

i) Robots have no sense of emotions or conscience.
ii) They lack empathy.
iii) Unemployment problem will increase.
iv) Humans cannot be replaced by robots in decision making.

5. Why steels are preferred to make robots?

- Steel is several times stronger and because of the inherent strength of steel, robot bodies are made using sheet, bar, rod, channel, and other shapes.

6. 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.
- It has very strong gravitational force such that no particle or even light can escape from it.
- Every galaxy has black hole at its centre
- *Sagittarius A** is the black hole at the centre of the Milky Way galaxy.

7.What are sub atomic particles?

- Electrons, Protons and Neutrons.

8.What is robotics?

- Robotics is an integrated study of mechanical engineering, electronic engineering, computer engineering and science.

3 - AND 5 - MARK QUESTIONS AND ANSWERS:

1. Discuss the function of key components in Robots.

Components	Function
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 consists motors, pistons, wheels, and 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.

2. Discuss the applications of Nanomaterials in various fields.

Field	Applications
Automotive Industry	1. Lightweight construction. 2. Catalysts . 3. Coatings for car bodies.
Chemical industry	1. Magnetic fluids. 2. Impregnation of papers. 3. Switchable adhesives.
Engineering	1. Wear protection for tools and machines. 2. Lubricant-free bearings.
Electronic industry	1. Laser diodes. 2. Glass fibres. 3. Optical switches.
Construction	1. Construction materials. 2. Thermal insulation . 3. Flame retardants.
Medicine	1. Medical rapid tests . 2. Prostheses and implants . 3. Agents in cancer therapy.
Food and drinks	1. Storage life sensors. 2. Additives. 3. Clarification of fruit juices.
Energy	1. Fuel cells. 2. Solar cells. 3. Capacitors.
Textile /fabrics / non-wovens	1. Surface-processed textiles. 2. Smart clothes.
Household	1. Ceramic coating for irons. 2. Odors catalyst. 3. Ceramic, floor, windows.
Cosmetics	1. Lipsticks 2. Skin creams 3. Tooth paste
Sports/ outdoor	1. Ski wax 2. Antifogging of glasses/goggles 3. Reinforced tennis rackets and balls.

3. What are the possible harmful effects of usage of nanoparticle? Why?

- Nanoparticles have the dimensions same as that of the biological molecules such as proteins.
- They may easily get absorbed on to the surface of living organisms and they might enter the tissues and fluids of the body.
- 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.

4. Explain any two types of robots with example.

Outer space robots:

- Exploring stars, planets etc., investigation of the mineralogy of the rocks and soils on Mars, analysis of elements found in rocks and soils.
- Example: Mars Rovers of NASA.

Nanorobots:

- They are used to perform a task in very small spaces.
- Nanorobots in blood stream to perform small surgical procedures, to fight against bacteria, repairing individual cell in the body.
- It can travel into the body and once after the job is performed it can find its way out.

5. What is particle physics? Write down its recent development.

- The study of the theory of fundamental particles of nature is called particle physics.
- Initially it was thought that atom is the fundamental entity of matter.
- In 1960, it was discovered that protons and neutrons were made up of quarks.
- Later it was found that quarks interact through gluons.
- Recently in 2013, famous Higgs particles also known as God particles were discovered which gives mass to many particles like protons, neutrons etc.

6. Give the types of robots.

Human robot :

- Certain robots are made to resemble humans in appearance.
- They replicate the human activities like walking, lifting and sensing etc.

Industrial robots:

- Six main types of industrial robots are Cartesian, SCARA, Cylindrical, Delta, Polar and Vertically articulated.
- They are ideal for Arc welding, Spot welding, Material handling, Machine tending and other applications.

7. Comment on the recent advancement in medical diagnosis and therapy.

Virtual reality	• It is used to cure soreness in the hospitalized patients. • It helps in the treatment of Autism, Memory loss, and Mental illness.
Precision medicine	• It is an emerging approach for disease treatment and prevention that takes into account individual variability in genes, and lifestyle for each person.
Health wearables	• It is a device used for tracking a wearer's fitness related data, location, etc.
Artificial organs	• It is an engineered device or tissue that is implanted into a human.
3D printing	• Advanced 3D printer systems and materials assist physicians in a range of operations in the medical field from audiology, dentistry, orthopaedics and other applications.
Wireless brain sensors	• It is monitor intracranial pressure and temperature. • There is no need for surgery to remove these device.
Robotic surgery	• It is a type of surgical procedure that is done using robotic systems. • It helps to enhance the capabilities of surgeons performing open surgery.
Smart inhalers	• Inhalers are the main treatment option for asthma. • It use Bluetooth technology to remind patients when to take their medicine.

8. What are called gravitational waves?

- The disturbances in the curvature of space-time is called gravitational waves.
- Its travels with speed of light.
- Any accelerated charge emits electromagnetic waves.
- But these gravitational waves are very weak even for masses like earth.
- The strongest source of gravitational waves are black holes.
- The recent discoveries of gravitational waves are emitted by two black holes when they merge to a single black hole.

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