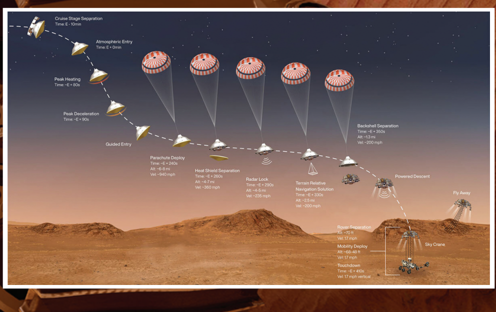
Telangana State Board of
INTERMEDIATE Education

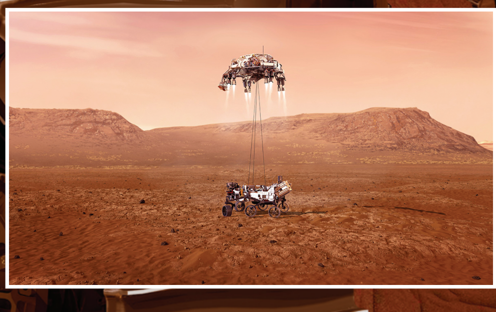
PHYSICS-II

BASIC LEARNING MATERIAL

For The Academic Year : 2021-2022

TELANGANA STATE BOARD OF INTERMEDIATE EDUCATION
HYDERABAD





TELANGANA STATE BOARD OF
INTERMEDIATE EDUCATION

PHYSICS

Second Year

(English Medium)

BASIC LEARNING MATERIAL

ACADEMIC YEAR

2021-22

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PREFACE

The ongoing Global Pandemic Covid-19 that has engulfed the entire world has changed every sphere of our life. Education, of course is not an exception. In the absence and disruption of Physical Classroom Teaching, Department of Intermediate Education Telangana has successfully engaged the students and imparted education through TV lessons. In the back drop of the unprecedented situation due to the pandemic TSBIE has reduced the burden of curriculum load by considering only 70% syllabus for class room instruction as well as for the forthcoming Intermediate Examinations. It has also increased the choice of questions in the examination pattern for the convenience of the students.

To cope up with exam fear and stress and to prepare the students for annual exams in such a short span of time , TSBIE has prepared “Basic Learning Material” that serves as a primer for the students to face the examinations confidently. It must be noted here that, the Learning Material is not comprehensive and can never substitute the Textbook. At most it gives guidance as to how the students should include the essential steps in their answers and build upon them. I wish you to utilize the Basic Learning Material after you have thoroughly gone through the Text Book so that it may enable you to reinforce the concepts that you have learnt from the Textbook and Teachers. I appreciate ERTW Team, Subject Experts, who have involved day in and out to come out with the Basic Learning Material in such a short span of time.

I would appreciate the feedback from all the stake holders for enriching the learning material and making it cent percent error free in all aspects.

The material can also be accessed through our website**www.tsbie.cgg.gov.in.**

Commissioner & Secretary

Intermediate Education, Telangana.

Contents

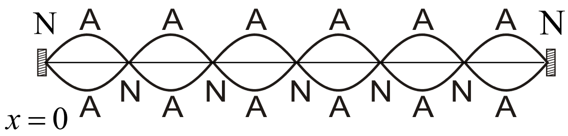
Chapter 1

WAVES

LONG ANSWERS TYPE QUESTIONS (5 MARKS)

1. **Explain the formation of stationary waves in stretched strings.**

Ans: When the stretched string is plucked at the middle transverse waves are generated these transverse waves get reflected at its ends. These reflected waves travel in opposite directions along the length of the string they combine together to form stationary waves with nodes at ends.



Explanation:

Let two transverse progressive waves with displacements y_1, y_2 , same amplitude a and wave length λ are travelling in opposite directions.

$y_1 = a\sin(kx - \omega t)$; $y_2 = a\sin(kx + \omega t)$

According to principle of superposition,

$$y_1 + y_2 = a\sin(kx - \omega t) + a\sin(kx + \omega t)$$
$$y = 2a\sin kx \cos\omega t$$

When $x = 0, \frac{\lambda}{2}, \frac{2\lambda}{2}, \frac{3\lambda}{2}$ etc. the amplitude becomes zero. These positions of zero amplitude are known as Nodes.

When $x = \frac{\lambda}{4}, \frac{3\lambda}{4}, \frac{5\lambda}{4}$ etc. the amplitude becomes maximum (2a). These positions of 2a amplitude are known as Antinodes.

Expression to the frequency of transverse wave:

1) If 'L' is the length of the string, then the velocity of transverse wave (v) travelling along length of the stretched string is given by $V = \sqrt{\frac{T}{\mu}}$............(1)

'T' is the tension applied to the string, 'μ' is the mass per unit length of the string or linear density.

The distance between adjacent nodes is $\frac{\lambda}{2}$ so that in string fixed at both ends there must be integrated number P of half wave lengths.

2) $p\left(\frac{\lambda}{2}\right) = l$

$\lambda = \frac{2l}{p}$ ....(2)

Where P = 1, 2, 3..................

But $V = \upsilon\lambda$

$\upsilon = \frac{V}{\lambda}$ .... (3)

From (1), (2), (3) we get

$\upsilon = \frac{p}{2l}\sqrt{\frac{T}{\mu}}$

p = 1 then first harmonic $\upsilon_1 = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$

p = 2 then second harmonic $\upsilon_2 = 2\upsilon_1$

p = 3 then third harmonic $\upsilon_3 = 3\upsilon_1$

$\upsilon_1 : \upsilon_2 : \upsilon_3 = 1 : 2 : 3$

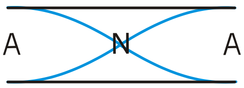
2. **Explain the formation of stationary waves in an air column enclosed in open pipe. Derive the equations for the frequencies of the harmonics produced.**

Ans: **Formation of stationary waves in an air column Formation enclosed in open pipe:**

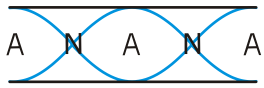
Formation of stationary waves in open pipe:-

If both ends of the tube are opened then it is known as an open organ pipe.

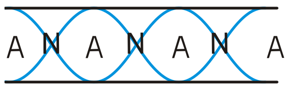
When sound wave is sent through a pipe from one open end it gets reflected from the other open end due to pressure difference. Anti nodes are formed at the two open ends and a node is between them.



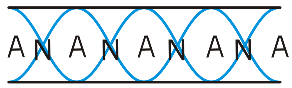
Fundamental
or
first harmonic



Second harmonic



Third harmonic



Fourth harmonic

Frequencies of Harmonics in open pipes:

1) **First harmonic or fundamental frequency:** In first mode of vibration two antinodes and one node is formed between them.

1. The vibrating length (l) is equal to half the wavelength i.e., $l = \frac{\lambda_1}{2} \Rightarrow \lambda_1 = 2l$

   The fundamental frequency $\upsilon_1 = \frac{V}{\lambda_1}$

   $\therefore \upsilon_1 = \frac{V}{2l}$ (since $\lambda_1 = 2l$)

2. Similarly second harmonic frequency or first overtone, three anitnodes and 2 nodes are formed between them.

   If λ_2 is the corresponding wavelength, $l = \frac{2\lambda_2}{2} = \lambda_2$

   $\therefore$ The corresponding frequency, $\upsilon_2 = \frac{V}{\lambda_2} = \frac{V}{l} = \frac{2V}{2l} = 2\upsilon_1$

3. Similarly the third harmonic or second overtone, four antinodes and 3 nodes are formed.

   If λ_3 is the wave length, $l = \frac{3\lambda_3}{2}$

   $\therefore$ The frequency of the second overtone $\upsilon_3 = \frac{3V}{2l} = 3\upsilon_1$

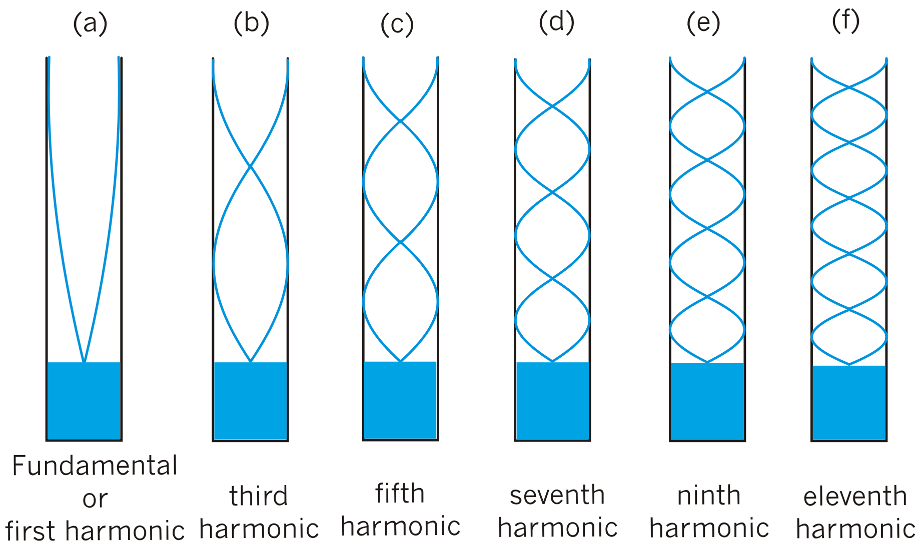
   The frequencies of the higher harmonics can also be derived in the same way.

   $\upsilon_1 : \upsilon_2 : \upsilon_3 ...... = 1 : 2 : 3 : ....$

3. How are stationary waves formed in closed pipes? Explain the various modes of vibrations and obtain relations for their frequencies.

Ans: **Formation of stationary waves in a closed pipe:-**

If one end of pipe is closed and other end is opened that pipe is called closed pipe.



Explanation:

When a sound wave is send through an closed organ pipe the wave gets reflected at the end of the pipe. These incident and reflected waves having same frequency travelling in the opposite directions are superimposed along the length of the pipe and form longitudinal stationary wave. At the open end always an anti node and at closed end always node is formed.

First harmonic or fundamental frequency:

The first harmonic in a closed pipe should have a node at the closed end and an anti node at the open end.

The vibrating length $l = \frac{\lambda}{4} \Rightarrow \lambda = 4l$

$$n_1 = \frac{v}{\lambda} \Rightarrow \boxed{n_1 = \frac{v}{4l}}$$

This is known as fundamental frequency.

Third harmonic or first overtone:

The next possible harmonic should have one more node and anti node then fundamental frequency. (two nodes and two anti nodes)

The vibrating length $l = \frac{3\lambda}{4} \Rightarrow \lambda = \frac{4l}{3}$

$$n_3 = \frac{v}{\lambda} \Rightarrow \boxed{n_3 = \frac{3v}{4l} = 3n_1}$$

This is known as Third harmonic or first overtone.

Fifth harmonic or second overtone:

It will have three nodes and three anti nodes.

The vibrating length $l = \frac{5\lambda}{4} \Rightarrow \lambda = \frac{4l}{5}$

$$n_5 = \frac{v}{\lambda} \Rightarrow \boxed{n_5 = \frac{5v}{4l} = 5n_1}$$

This is known as Fifth harmonic or second overtone.

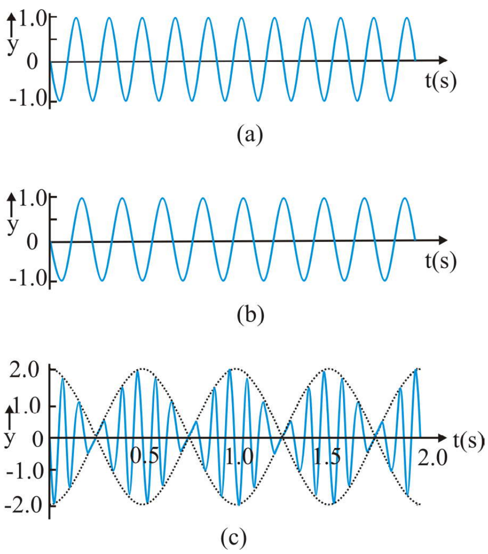
The ratio of harmonics in closed pipe are in the ratio of odd natural numbers $n_1 : n_3 : n_5 : ... = 1 : 3 : 5 : ...$

4. What are beats? Obtain an expression for the beat frequency. Where and how are beats made use of ?

Ans. Beats are produced due to interference of sound waves. When two sounds of nearly equal frequency are superposed they will create a waxing and waning intensity of sound. This effect is called beats.

Beat frequency $\upsilon_{beat} = \upsilon_1 - \upsilon_2$

Expression for beat frequency:



Formation of Beats

Let us consider two sound wave y_1 and y_2 of nearly equal freuency n_1 and n_2 each of amplitude a superpose each other then the resultant wave is given by

$y = y_1 + y_2 = a\sin\omega_1 t + a\sin\omega_2 t$

where $\omega_1 = 2\pi v_1$ and $\omega_2 = 2\pi v_2$

$$y = a\sin 2\pi v_1 t + a\sin 2\pi v_2 t$$

$$y = 2a\cos 2\pi\left(\frac{v_1 - v_2}{2}\right)t\sin 2\pi\left(\frac{v_1 + v_2}{2}\right)t$$

$$y = A\sin 2\pi\left(\frac{v_1 + v_2}{2}\right)t, \text{ where } A = 2a\cos 2\pi\left(\frac{v_1 - v_2}{2}\right)t$$

The frequency of the resultant wave is $\left(\frac{v_1 + v_2}{2}\right)$

The frequency of the amplitude is $\left(\frac{v_1 - v_2}{2}\right)$

The intensity of the sound will be maximum

when $2a\cos 2\pi\left(\frac{v_1 - v_2}{2}\right)t$ is maximum.

$$2\pi\left(\frac{v_1 - v_2}{2}\right)t = k\pi$$

Where k = 0 , 1, 2,..... maximum sound will be heard at interval 0,

$\frac{1}{v_1 - v_2}, \frac{2}{v_1 - v_2}, \frac{3}{v_1 - v_2}$.......

The time interval between two consecutive maxima $= \frac{1}{v_1 - v_2}$

The number of maximum (beat frequency) is equal to $= v_1 - v_2$

The Intensity of sound will be minimum when $\cos 2\pi\left(\frac{v_1 - v_2}{2}\right)t$ is minimum i.e. zero.

The time interval between two consecutive minima $= \frac{1}{v_1 - v_2}$

The number of minima heard per second = $v_1 \sim v_2$

Importance of Beats:

1) Beats can be used in tuning musical instruments.
2) Beats are used in detecting dangerous gases in mines.

3) Beats are used to produce special effects in cinematography
4) Beats can be used to determine unknown frequency of a tuning fork.
5) Beats are used in heterodyne receivers range.

Problems :

1. A closed organ pipe 70 cm long is sounded. If the velocity of sound is 331 m/s, what is the fundamental frequency of vibration of the air column ?

Ans. Length of closed organ pipe $l = 70$ cm

Velocity of sound $v = 331\ ms^{-1}$

Fundamental frequency of closed pipe

$$n = \frac{v}{4l}$$

$$= \frac{331}{4 \times 0.7} = 118.2\, Hz$$

2. A vertical tube is made to stand in water so that the water level can be adjusted. Sound waves of frequency 320 Hz are sent into the top the tube. If standing waves are produced at two successive water levels of 20 cm and 73 cm, what is the speed of sound waves in the air in the tube ?

Ans. Frequency of sound wave n = 320 Hz

Resonating length $l_1 = 20$ cm

Resonating length $l_2 = 73$ cm

Speed of sound wave is $v = 2n(l_2 - l_1) = 2 \times 320\ (73 - 20)$

$v = 640 \times 53 = 33920\ cms^{-1} = 339\ ms^{-1}$

3. Two organ pipes of lengths 65 cm and 70 cm respectively, are sounded simultaneously. How many beats per second will be produced between the fundamental frequencies of the two pipes ? (Velocity of sound = 330 m/s).

Ans. First open organ pipe of length $l_1 = 65$ cm

Second open organ pipe of length $l_2 = 70$ cm

$$n = n_1 - n_2 = \frac{v}{2l_1} - \frac{v}{2l_2}$$

$$= \frac{330}{2}\left(\frac{1}{65} - \frac{1}{70}\right) \times \frac{1}{10^{-2}} = 18\text{Hz}.$$

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Chapter **2**

RAY OPTICS AND OPTICAL INSTRUMENTS

VERY SHORT ANSWERS TYPE QUESTIONS (2 MARKS)

1. Define focal length and radius of curvature of a concave lens.

Ans. **Focal length (f) :** The distance between centre of lens and its principal focus is called focal length (f).

Radius of curvature (R): The distance between centre of lens to centre of curvature is called Radius of curvature (R).

2. What do you understand by the terms 'focus' and 'principal focus' in the context of lenses ?

Ans. This point of convergence or divergence in a focal plane is called focus. If the focus is on principal axis it is called principal focus.

3. What is optical density and how is it different from mass density ?

Ans. An optically denser medium is one in which velocity of light is less.

Mass density is defined as the ratio of mass to volume density ρ = mass / volume.

An optically denser medium may have less mass density.

Ex : Mass density of turpentine is less than water but optical density of turpentine is more than water.

4. Define power of a convex lens. What is its unit?

Ans: The power of a convex lens is equal to reciprocal of focal length

$$P = \frac{1}{f}$$

OR

The power of a convex lens is defined as the tangent of the angle by which it converges a beam of light falling at unit distant from the optical centre.

S.I units: - Dioptre (or) m^{-1}

5. What is dispersion? Which colour gets relatively more dispersed?

Ans: i) The phenomenon of splitting of white light into its component colours is known as dispersion

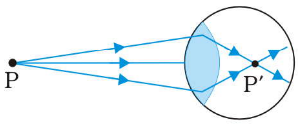
ii) Violet disperses more than all other colours in white light

6. What is myopia? How can it be corrected?

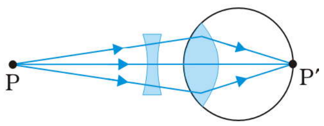
Ans: The light from a distant object arriving at the eye lens may not get converged at a point in front of the retina. This type of defect is called 'Myopia' or 'Near sightedness'.

To compensate this by using concave lens it can be corrected.

(OR)



Myopic eye



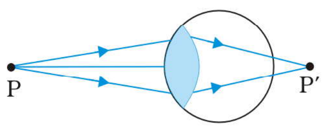
Correction

7. What is hypermetropia? How can it be corrected?

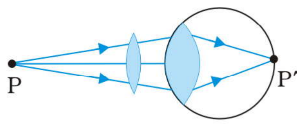
Ans: i) If the eye lens focus the incoming light at a point behind the retina then the defect is called hypermetropia.

ii) This defect can be corrected by using a convex lens

(OR)



Hypermetropic eye



Correction

8. A small angled prism of 4^0 deviates a ray through 2.48^0. Find the refractive index of the prism.

Ans: $A=4^0$, $D_m = 2.48^0$, $n_{21}=?$

Formula: For a thin angled prism,

$D_m = (n_{21} - 1) A$

$2.48 = (n_{21} - 1)4$

$n_{21} = 1.62$

9. The focal length of a concave lens is 30 cm. Where should an object be placed so that its image is 1/10 of its size ?

Ans: Focal length f = 30 cm ; Magnification m = 1 / 10

Magnification $m = \frac{v}{u} = \frac{1}{10} \Rightarrow u = 10v$

In concave lens $\frac{1}{f} = \frac{1}{u} - \frac{1}{v}$

$\frac{1}{30} = \frac{1}{10v} - \frac{1}{v}$

$\frac{1}{30} = -\frac{9v}{10v \times v}$

$v = -27$

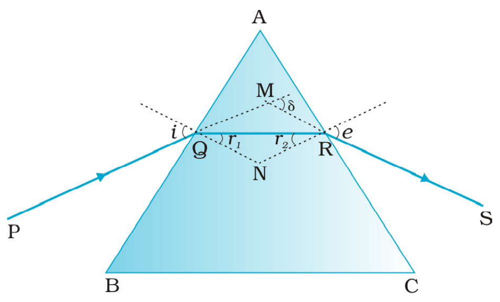
$u = 10v$

$u = -270$ cm

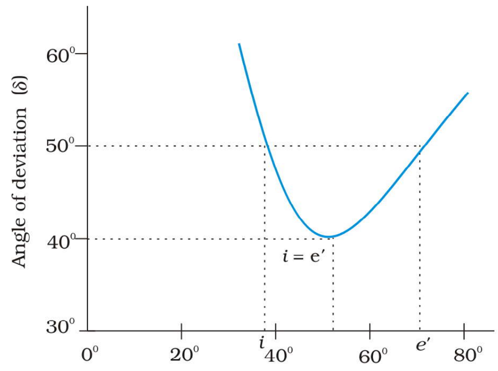
SHORT ANSWERS TYPE QUESTIONS (4 MARKS)

1. A light ray passes through a prism of angle A in a position of minimum deviation. Obtain an expression for (a) the angle of incidence in terms of the angle of the prism and the angle of minimum deviation (b) the angle of refraction in terms of the refractive index of the prism.

Ans. Let a light ray PQ enters the prism with angle of incidence i and emerges out with an angle 'e'. When it is at minimum deviation position.



Refraction through prism.



From figure $\angle A + \angle QNR = 180^0$ ....(1)

In triangle QNR,

$r_1 + r_2 + \angle QNR = 180^0$ ....(2)

From equation (1) and (2) ; $r_1 + r_2 = A$ ....(3)

Deviation $\delta = (i_1 - r_1) + (i_2 - r_2) = (i_1 + i_2) - (r_1 + r_2)$

At minimum deviation position $i_1 = i_2$ and $r_1 = r_2$

$\therefore\ \delta = i_1 + i_2 - A \Rightarrow 2i = A + \delta$

$\therefore$ Relation between i , A and δ at minimum deviation position is

$$i = \frac{A+\delta}{2} \quad \text{.............(4)}$$

b) From equation (3) $i_1 + i_2 = A$ at minimum deviation position $r_1 = r_2$

$$\therefore\ r_1 + r_2 = 2r = A \Rightarrow r = \frac{A}{2}$$

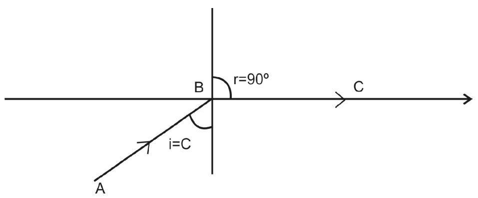
From Snell's law $n_{21} = \frac{n_2}{n_1} = \frac{\sin i}{\sin r} \Rightarrow \sin r = \frac{\sin i}{n_{21}}$

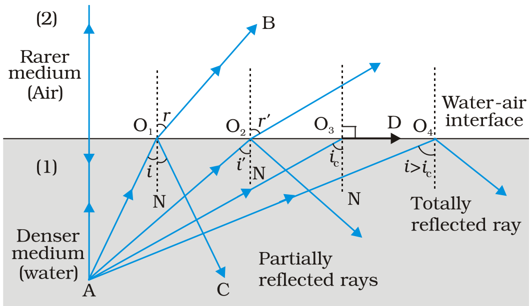
$$\text{(Or) } \sin r = \frac{\sin\left(\frac{A+\delta}{2}\right)}{n_{21}}$$

$$\therefore \text{ Angle of refraction } r = \sin^{-1}\left[\frac{\sin\left(\frac{A+\delta}{2}\right)}{n_{21}}\right]$$

2. Define critical angle. Explain total internal reflection using a neat diagram.

Ans: Definition: Critical angle is the angle of incidence in denser medium for which the angle of refraction becomes 90° in rarer medium.

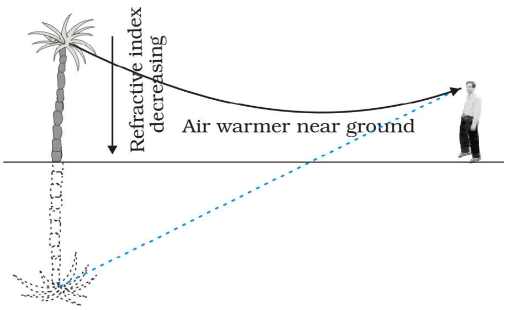




1. As the light ray is travelling from denser medium to rarer medium the refracted ray moves away from the normal drawn at the point of incidence of light ray.
2. As the angle of incidence in denser medium increases the angle of refraction in rarer medium increases. At one particular angle of incidence in denser medium the refracted light ray just grazes out the interface of the two media. For this the angle of incidence in denser medium is called critical angle.
3. When the light ray is traveling from densor to rarer medium and the angle of incidence is greater than critical angle ($i > i_c$) then the light ray is reflected back to the same densor medium. This phenomena is called total internal reflection.

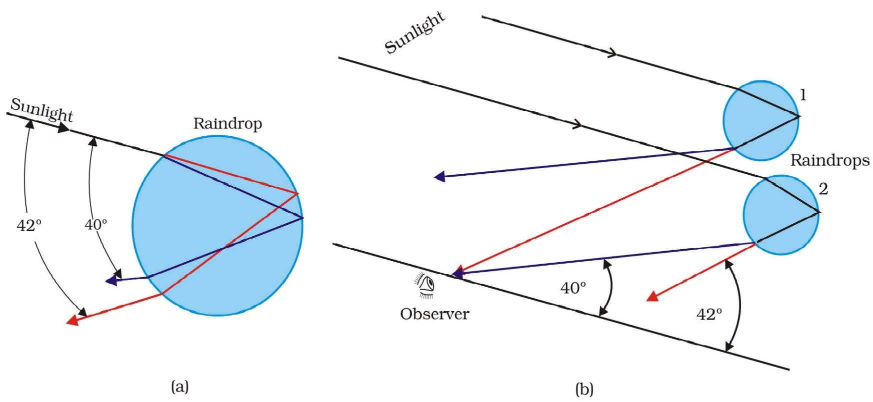
3. Explain the formation of a mirage

Ans:



1. On hot summer days the air near the ground becomes hotter. Hence it becomes less dense.
2. Light ray from a tall object passes through air with decreasing refractive index towards ground.
3. So, the angle of incidence near the ground exceeds critical angle, as a result total internal reflection takes place.
4. For a distant observer light appears to come from somewhere below ground. So the observer assumes that the light reflected from the ground like by a pool of water.
5. This forms an inverted image of tall object and causes optical illusions to the observers. This phenomenon is known as 'mirage'.

4. Explain the formation of a rainbow.



1. Rainbow is the dispersion of sunlight by the water drops in the atmosphere
2. This is a phenomenon due to combined effect of dispersion, refraction and reflection of sun light by spherical water droplets of rain.
3. The sun should be shining near western horizon while it is raining in the opposite part of the sky (say eastern horizon).

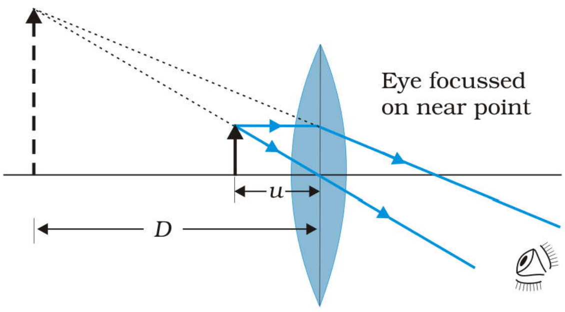
4. Sunlight is first refracted as it enters a rain drop, and get dispersed, red light bent least while voilet bent most.

5. These component rays strike the inner surface with the angle greater than the critical angle (48^o) and get internally reflected.

6. The violet light emerges at an angle of 40^o, red light emerges at an angle of 42^o related to the incoming sunlight. Hence rainbow is formed.

5. With a neat labelled diagram explain the formation of image in a simple microscope.

Working:- A simple micro scope consist of a single convex lens fitted in a metal frame. The object is adjusted within the principal focus of the convex lens to form the image at the near point. The image is virtual, erect and magnified as shown in Fig., The image is on the same side as the object at the least distance of distinct vision.



(a)

Equation of linear magnification $m = \left(1 + \frac{D}{f}\right)$

6. What is the position of the object for a simple microscope ? What is the maximum magnification of a simple microscope for a realistic focal length ?

An: In simple microscope object is placed in between centre of lens (C) and its principal focus (F). As a result a magnified virtual image is made to form either at near point or at infinity with suitable object distance 'u'

In simple microscope at near point magnification $m = \left(1 + \frac{D}{f}\right)$

When image is at infinity magnification $m = \frac{D}{f}$.

Magnification - Limits : Theoretically we can achieve very high magnification 'm' for simple microscope. But due to practical consideration we can not increase magnification beyond a limit.

Ex : For a magnification of 5 at for point focal length of convex lens

f = D/m = 25/5 = 5cm

with this focal length thickness of lens is high, so dispersion takes place and chromatic aberration will come into account.

Even with a very careful design of convex lens we can not get a magnification of more than ten with simple microscope. Magnification of m = 5 to 10 is the possible limit.

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Chapter **3**

WAVE OPTICS

SHORT ANSWER QUESTIONS (4 MARKS)

1. Explain Doppler effect in light. Distinguish between red shift and blue shift.

Ans: **Doppler effect in light**: According to Doppler effect, whenever there is a relative motion between a source of light and observer, the apparent frequency of light received by the observer is different from the true frequency of light emitted actually from the source of light.

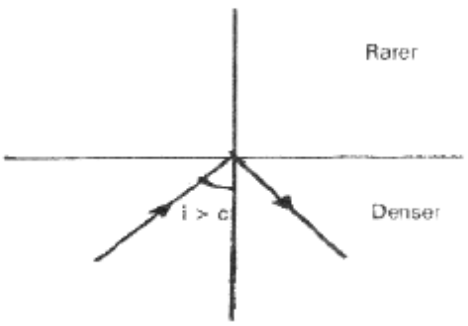
The apparent frequency of light increases when the distance between source of light and observer is decreasing and the apparent frequency of light decreases if the distance between source of light and observer is increasing.

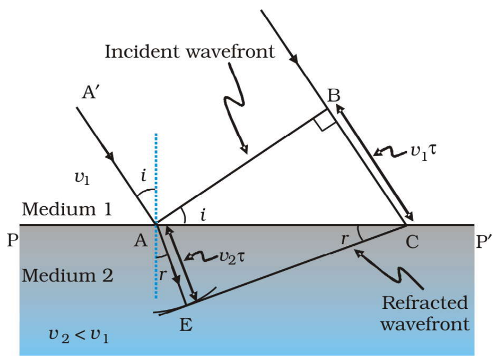
Blue shift: When source and observer approach each other, $\Delta\upsilon$ is +ve, i.e., apparent frequency increases or apparent wavelength decreases and spectral lines shift towards blue. This is called Blue shift.

Red Shift: When source and observer recede away from each other, $\Delta\upsilon$ is –ve i.e., apparent frequency decreases or apparent wavelength increases and spectral lines shift towards red. This is called Red Shift.

2. What is total internal reflection. Explain the phenomena using Huygen's principle?

Ans: **Total internal reflection :** When a light ray travels from denser to rarer medium, the angle of incident is greater than critical angle then it reflects in to the same medium. This phenomenon is called total internal reflection.





Huygen's principle:

We assume a plane wavefront AB propagating in the direction A'A incident on the interface at an angle *i*.

Now consider the refraction of a plane wave in a raser medium i.e. $V_2 > V_1$. The angle of refraction will now be greater then angle of incidence; however we will still have $n_1 \sin i = n_2 \sin r$.

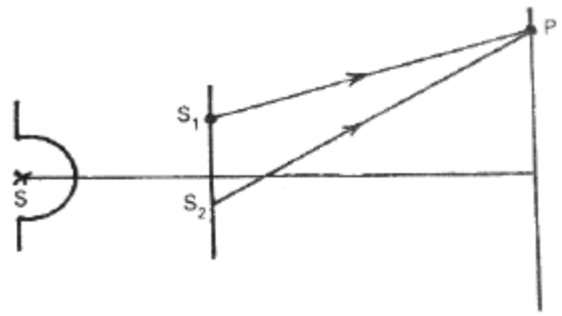
$\frac{n_2}{n_1} = \frac{\sin i}{\sin r}$, let r be equal to 90º and $i = i_c$

$\sin i_c = \frac{n_2}{n_1}$. Thus if $i = i_c$ then sinr = 1 and r = 90º.

Obviously, for $i > i_c$ there cannot be any refracted wave. The angle i_c is known as the critical angle and for all angles of incidence greater then the critical angle, we will not have any refracted wave and the wave will undergo total internal reflection.

3. Derive the expression for the intensity at a point where interference of light occurs. Arrive at the conditions for maximum and zero intensity?

Ans:



Let S_1 and S_2 be the two coherent sources vibrating in phase ϕ

$y_1 = a\cos\omega t$, $y_2 = a\cos(\omega t + \phi)$

$$y = y_1 + y_2 = 2a\cos\left(\frac{\phi}{2}\right)\cos\left(\omega t + \frac{\phi}{2}\right)$$

Amplitude of the resultant $A = 2a\cos\left(\frac{\phi}{2}\right)$

Intensity = $I = A^2 = 4a^2\cos^2\left(\frac{\phi}{2}\right)$

Condition for maximum intensity

$\phi = 0, \pm 2\pi, \pm 4\pi, ...n(2\pi) \qquad n = 0,1,2,3.....$

Hence maximum intensity $I_{max.} = 4a^2$

Condition for minimum intensity

$\phi = \pm\pi, \pm 3\pi, ...(2n+1)\pi \qquad n = 0,1,2,3.....$

Hence minimum intensity $I_{min} = 0$

4. **Does the principle of conservation of energy hold for interference and diffraction phenomena? Explain briefly**?

Ans: Yes.

Explanation: In the interference and diffraction light energy is redistributed. If it reduces in one region producing a dark fringe, it increases in outer region producing bright fringe. There is no loss (or) gain of energy, hence total energy remains constant.

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Chapter **4**

ELECTRIC CHARGES AND FIELDS

SHORT ANSWER QUESTIONS (4 MARKS)

1. State and explain Coulomb's inverse square law in electricity?

Ans: Coulomb's law:-

The force of attraction (or) repulsion between two electric charges is directly proportional to product of their charges and is inversely proportional to the square of distance between them and acts along the line joining the charges.

The force of attraction (or) repulsion (F) between two charges $q_1 q_2$ separated by a distance 'r' is given by

$$F \propto q_1 q_2$$

$$F \propto \frac{1}{r^2}$$

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

$$F = \frac{1}{4\pi \in_0} \frac{q_1 q_2}{r^2}$$

$\in_0$ is permittivity of free space.

2. Define intensity of electric field at a point. Derive an expression for the intensity due to a point charge?

Ans: **Intensity of electric field (E)** : Intensity of electric field at any point in an electric field is defined as the force experinced by a unit positive charged placed at that point.

Intensity of electric field: It is defined as the force experienced per unit positive test charge placed at that point in the field

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

i) The intensity of electric field due to a charge 'Q' at a point in space is defined as the force experienced by a unit positive charge placed at the point.

ii) The force acting on a small charge 'q' placed at a point 'p', the

$$F = \frac{1}{4\pi \in_0} \frac{qQ}{r^2}$$

$$\frac{F}{q} = \frac{1}{4\pi \in_0} \frac{Q}{r^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

iii) But intensity $E = \frac{F}{q}$ .... (2)

iv) From equations (1) and (2) we get

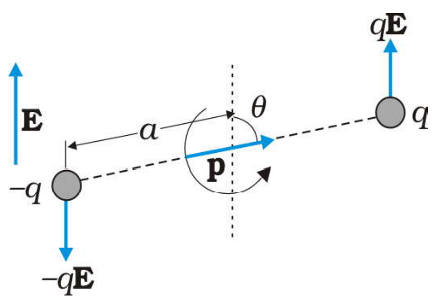
$$E = \frac{1}{4\pi \in_0} \frac{Q}{r^2}$$

3. Derive the equation for the couple acting on a electric dipole in a uniform electric field?

A dipole of dipole moment $\vec{p}$ in a uniform electric field $\vec{E}$. A force qE on +q and a force –qE on –q charge. The forces act at different points, resulting in a torque on the dipole.

Magnitude of torque =

magnitude of each force x perpendicular distance between two forces.



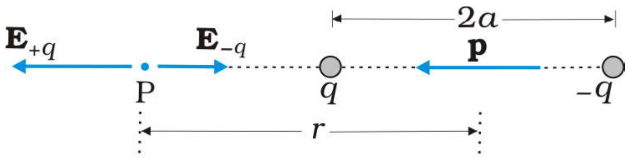
$$\tau = q\vec{E} \times 2a \sin\theta$$

$$= 2qa\vec{E} \sin\theta$$

$$\tau = \vec{p} \times \vec{E} \ (\because \vec{p} = 2qa)$$

4. Derive an expression for the intensity of the electric field at a point on the axial of an electric dipole?

Ans:



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

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

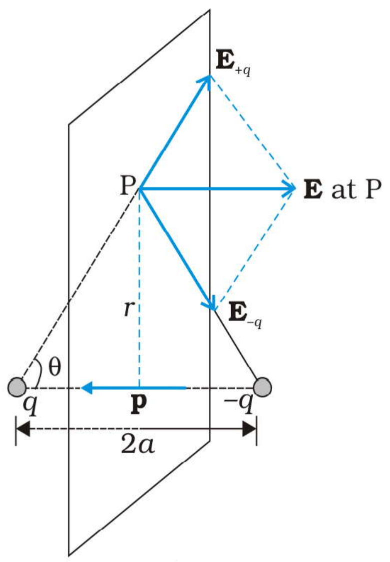
$$\vec{E} = E_+ - E_- = \frac{1}{4\pi\varepsilon_0}\left(\frac{q}{(r-a)^2} - \frac{q}{(r+a)^2}\right)$$

$$= \frac{2\vec{\mathrm{P}}\,\mathrm{r}}{4\pi\varepsilon_0\left(r^2-a^2\right)^2} \text{ for short dipole } (r >>> a)\,(\because \vec{P} = 2qa)$$

$$\vec{E} = \frac{2\vec{\mathrm{P}}}{4\pi\varepsilon_0 r^3}$$

5. Derive an expression for the intensity of the electric field at a point on the equatorial plane of an electric dipole?

Ans:



The magnitude of the electric fields due to the two charges +q and –q at point 'P' are

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

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

The resultant electric field due to dipole at P.

$$\vec{E} = -(E_{+q} + E_{-q}) \cos\theta \, \hat{p}$$

$$E_{eq} = -2E\cos\theta = -\frac{1}{4\pi\varepsilon_0} \frac{p}{(r^2 + a^2)^{3/2}} (E_{+q} = E_{-q})$$

$$E_{eq} = -\frac{1}{4\pi\varepsilon_0} \frac{p}{r^3} (r >> a)$$

6. **State Gauss's law in Electrostatics and explain its importance**

Ans: **Statement:** The total electrical flux through a closed surface is equal to $\frac{1}{\varepsilon_0}$ times the total charge enclosed by the surface.

Formula : $\phi_E = \oint \vec{E}.\vec{ds} = \frac{1}{\varepsilon_0} q$

Importance:

1. Valid for any closed surface of any shape and size.
2. Applicable to any distribution of charges within the closed surface.
3. It is useful towards a much easier calculation of electrostatic field when the system has symmetry.

* * * * *

Chapter **5**

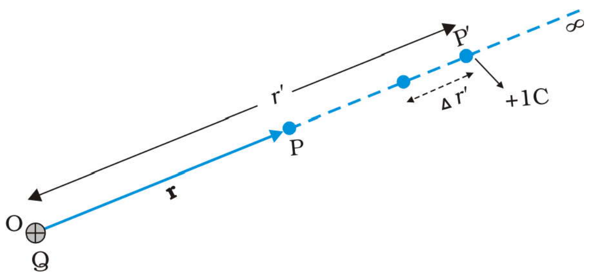
ELECTROSTATIC POTENTIAL AND CAPACITANCE

SHORT ANSWER QUESTIONS (4 MARKS)

1. Derive an expression for the electric potential due to a point charge.

Ans: Potential due to a point charge: Consider a point chage Q at the origin O as shown in the figure. The charge produces an electric field around it. We want to calculate the electric potential at a point P which is at a distance of r from the charge Q. The electric field is along the direction $\overrightarrow{OP}$. Let us consider a point P′ at a distance r′ from O on the same line OP. Electric field strength at P′ is given by,

Figure:



$$E = \frac{1}{4\pi \in_0} \frac{q}{(r')^2} \text{ and E is along } \overrightarrow{OP}$$

Force acting on unit positive charge placed at P' is

$$F = 1 \times E = 1 \times \frac{1}{4\pi \in_0 (r')^2} = \frac{1}{4\pi \in_0} \frac{Q}{(r')^2} \text{ and is along } OP'$$

Let the unit positive charge be moved from P' to P through an infinitesimal distance $\Delta r'$ against the field. The work done in this process is given by

$$\Delta W = -F \Delta r' = -\left[\frac{1}{4\pi \in_0} \frac{Q}{(r')^2}\right] \Delta r$$

By integrating ΔW between the limits ∞ to r.

$$W = \frac{Q}{4\pi \in_0} \left(\frac{1}{r'}\right)_{\infty}^{l} = \frac{Q}{4\pi \in_0} \left(\frac{1}{r} - \frac{1}{\infty}\right) = \frac{Q}{4\pi \in_0} \frac{1}{r}$$

By definition the potential at P is given by V(r) = V(r) = $\frac{W}{1}\left[\because V=\frac{W}{q}\right]$

V(r) = $\dfrac{\dfrac{Q}{4\pi\in_0}\left(\dfrac{1}{r}\right)}{1} \Rightarrow V(r)=\dfrac{1}{4\pi\in_0}\dfrac{Q}{r}$

2. Derive an expression for the electrostatic potential energy of a system of two point charges and find its relation with electric potential charge?

Ans: Expression for the electrostic potential energy of a system of two point charges:

1) Let two point charges and are separated by distance 'r' in space.

2) An electric field will develop around the charge. To bring the charge from infinity to the point B some work must be done.

work done $= q_2V_B$, But $V_B=\frac{1}{4\pi\in_0}, \frac{q_1}{r}$

$$W=\frac{1}{4\pi\in_0}.\frac{q_1.q_2}{r}$$

3) The amount of workdone is stored as electro static potential energy (U) of a system of two charged particles. Its unit is joule.

$$\therefore U=\frac{1}{4\pi\in_0}.\frac{q_1q_2}{r}$$

3. Derive an expression for the potential energy of an electric diople placed in a uniform electric field?

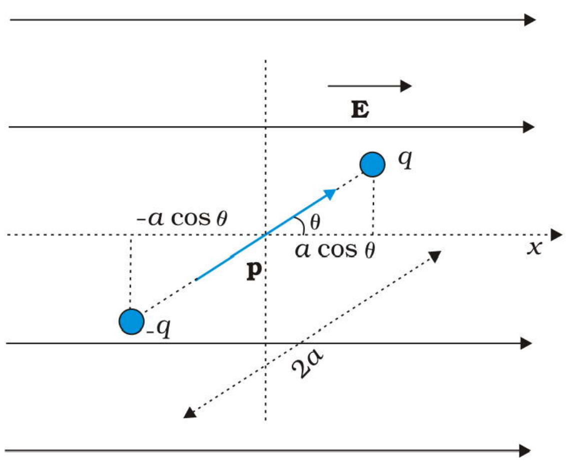
Ans: Expression for potential enegry of an electric dipole placed in a uniform electric field.

1) Consider a electric dipole of length 2a having charges +q and−q.

2) The electric dipole is placed in uniform electric field E and it's axis makes and angle θ with E.

3) Force on charge are equal but opposite sign they constitute torque on the dipole.

Torque = one of its force x perpendicular distance



$\tau = qE \times BC$ and $\sin\theta = \frac{BC}{2a} \Rightarrow BC = 2a\sin\theta$

$\therefore \tau = 2aqE\sin\theta = PE\ \sin\theta\ [\because P = 2aq]$

4) Suppose the dipole is rotated through angle $d\theta$, the work done dw is given by

$dw = \tau\, d\theta = PE\sin\theta\, d\theta$

5) For rotating the dipole from angle θ_1 to θ_2

Workdone : $W = \int_{\theta_1}^{\theta_2} PE\sin\theta\, d\theta = PE\,(\cos\theta_1 - \cos\theta_2)$

6) This work done is stored as potential energy in the dipole

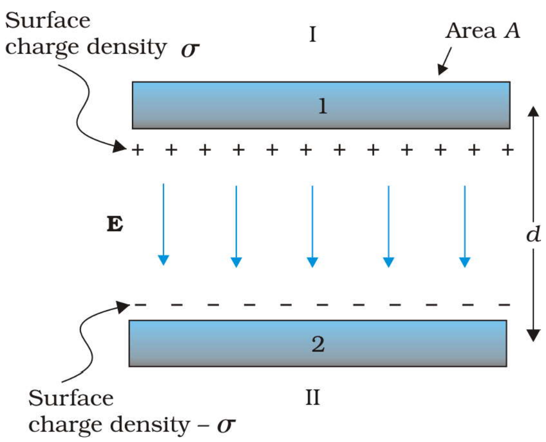
$\therefore U = PE\,(\cos\theta_1 - \cos\theta_2)$

7) If $\theta_1 = 90^0$ and $\theta_2 = 0^0$ then $U = -PE\cos\theta$.

In vector from $\overline{U} = -\overline{P}.\overline{E}$.

4. Derive an expression for the capacitance of a parallel plate capacitor.

Ans: **Parallel plate capacitor:**



Description of parallel plate capacitor

A is a area of each plate, d is separation between the two parallel plates

Q and –Q are charges on each plate

Surface charged density on 1st plate = $\sigma = \frac{Q}{A}$

Surface charged density on 2nd plate $= -\sigma = \frac{Q}{A}$

The electric field strength between the two plates of the capacitor

$$E = \frac{\sigma}{2\epsilon_0} + \frac{\sigma}{2\epsilon_0} = \frac{\sigma}{\epsilon_0} \Rightarrow E = \frac{Q}{\epsilon_0 A}$$

P.D between the two plates of the capacitor

$$V = Ed \Rightarrow V = \frac{1}{\epsilon_0}\frac{Qd}{A}$$

Capacity of a parallel plate capacitor

$$C = \frac{Q}{V} \Rightarrow C = \frac{\epsilon_0 A}{d}$$

5. Explain the behaviour of dielectrics in an external field.

Ans: Behaviour of dielectrics in an external field:

- When a dielectric made of non-polar molecules is placed in an external electric field 'E_0 'molecules are polarised.
- At the surface of the dielectric induced charges appear.
- Due to the induced surface charges induced electric field E_i developed in a direction opposite to E_0.
- Hence the net electric field inside the dielectric is reduced to $E = E_0 — E$. As a result potential difference V_0 will be reduced to V.
- Intensity of the induced electric field, $E = \frac{E_0}{\mathbf{K}}$ and potential across the dielectric is $V = \frac{V_0}{\mathbf{K}}$. Here **K** is dielectric constant.

6. Explain series combination of capacitors. Derive the formula for equivalent capacitance in each combination.

Ans: **Series combination of capacitors:** When the second plate of the first capacitor is connected to the first plate of second capacitor and the second plate of second capacitor is connected to the first plate of the third capacitor and so on. Such a combination is called series combination of capacitors.

Derivation:

Let the voltages across three capacitors be and respectively

$$V_1 = \frac{Q}{C_1}, V_2 = \frac{Q}{C_2}, V_3 = \frac{Q}{C_3}$$

Effective capacitance of series combination $C = \frac{Q}{V} \Rightarrow V = \frac{Q}{C}$

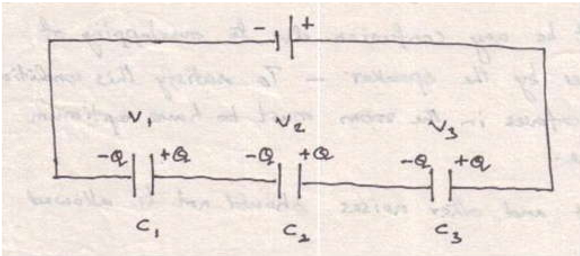
In series charge 'Q' is same on any capacitor.

Total P.D. across the series combination is

$$\therefore V = V_1 + V_2 + V3$$

$$\frac{Q}{C} = \frac{Q}{C_1} + \frac{Q}{C_2} + \frac{Q}{C_3}$$

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$



7. **Explain parallel combination of capacitors. Derive the formula for equivalent capacitance in each combination.**

Ans: **Parallel combination of capacitors:** The first plate of three capacitors are connected to one point, the second plates are connected to another point these two points are connected to a cell 'V' is called parallel combination of capacitors.

Derivation:

From the diagram $Q_1 = C_1V$; $Q_2=C_2V$; $Q_3= C_3V$

But $Q = Q_1 + Q_2 + Q_3$

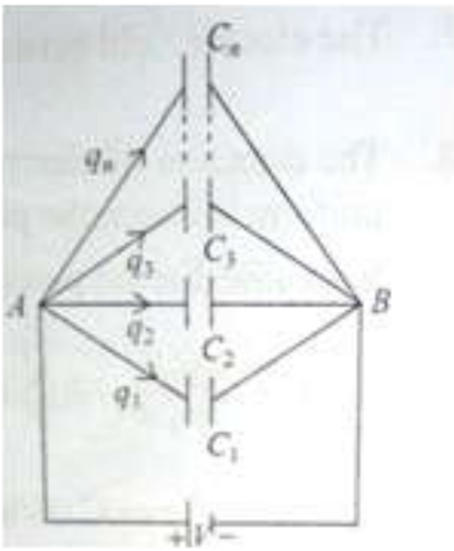
$Q=C_1V + C_2V + C_3V$

$Q=V(C_1+C_2+C_3)$

But $Q=VC$

$VC=V(C_1+C_2+C_3)$

$C=C_1+C_2+C_3$



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Chapter **6**

CURRENT ELECTRICITY

LONG ANSWERS TYPE QUESTIONS (8 MARKS)

1. State Kirchhoff's law for an electrical network. Using these laws deduce the condition for balance in a Wheatstone bridge.

Ans: ***Kirchhoff's First law:*** At any junction the sum of the currents entering the junction is equal to the sum of currents leaving the junction.

$\Sigma i = 0$

Kirchhoff's second law: The algebraic sum of potential difference around any closed loop is zero.

$\Sigma v = 0$

Wheat stone bridge explanation :-

From Kirchhoff's first law at junction C

$I_1 = I_3 + I_g$ ....(1)

From Kirchhoff's first law at junction D

$I_4 = I_2 + I_g$ ....(2)

From kirchhoff's second law for 'ACDA' loop

$I_1P + I_gG = I_2R$ ....(3)

From kirchhoff's second law for 'CBDC' loop

$I_3 Q = I_gG + I_4S$ .... (4)

Wheat stone bridge is said to be balanced when $I_g=0$.

From(1) $I_1 = I_3$

From (2) $I_2 = I_4$

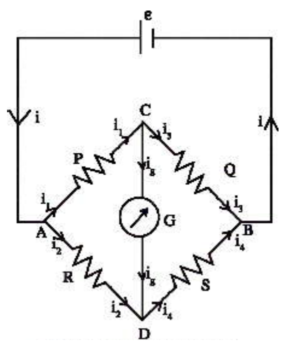
From (3) $I_1P = I_2R$........(5)

From (4) $I_3Q = I_4S$ ....(6)

$$\frac{(5)}{(6)} \Rightarrow \frac{I_1P}{I_3Q} = \frac{I_2R}{I_4S} \quad \left[\begin{array}{l} \because I_1 = I_3 \\ I_2 = I_4 \end{array}\right]$$

Explanation :-

Wheatstone bridge has four resistors P, Q, R, S. Across one pair of diagonally opposite points (A & C) a source is connected. This is called battery arm. Between the other two vertices B and D a galvanometer G is connected. This is called galvanometer arm.



$$\frac{P}{Q} = \frac{R}{S}$$

This is the principle of wheatstone's bridge.

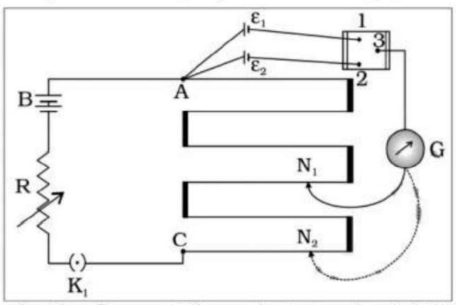
2. State the working principle of potentiometer. Explain with the help of circuit diagram how the emf of two primary cells are compared by using the potentiometer.

Ans: **Principle of potentiometer:** The potential difference across any portion of the wire is directly proportional to the length of that portion.

$V \propto 1$

$V = \phi l$

Comparing emf's of two cells using potentiometer:



1) When the first cell is brought into the circuit the balancing length is l_1 then

$\varepsilon_1 = \phi l_1$............(1)

2) Similarly when the second cell is brought into the circuit the balancing length is l_2 then

$\varepsilon_1 = \phi l_2$............(2)

3) Dividing equation (1) by equation (2)

$$\frac{\varepsilon_1}{\varepsilon_2} = \frac{\phi l_1}{\phi l_2}$$

$$\frac{\varepsilon_1}{\varepsilon_2} = \frac{l_1}{l_2}$$

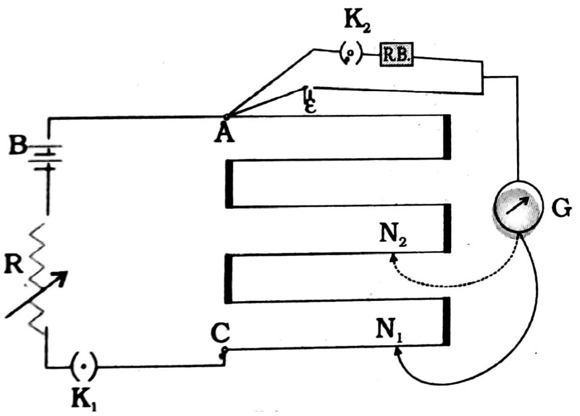
3. State the working principle of potentiometer. Explain with the help of circuit diagram how the potentiometer is used to determine the internal resistance of the given primary cell.

Ans: **Principle of potentiometer:-** The potential difference across any portion of the wire is directly proportional to the length of that portion.

$V \propto l$

$V = \phi l$

Determination of Internal resistance of a cell using potentiometer:



With key K_2 open, balance is obtained at length l_1, then

$\varepsilon = \phi l_1$

when key K_2 is closed the cell sends a current (I) through the resistance box (R).

1) Make connections as per circuit diagram given

$\varepsilon = \phi l_1$..........(1)

$V = \phi l_2$..........(2)

2) Dividing equation (1) and equation (2) then

$$\frac{\varepsilon}{V} = \frac{l_1}{l_2} \text{ ....(3)}$$

But $\varepsilon = I(r + R)$ and $V = IR$

$$\frac{\varepsilon}{V} = \frac{r+R}{R} \text{ ....(4)}$$

3) From equations (3) and (4) we get

$$\frac{r+R}{R} = \frac{l_1}{l_2}$$

$$r = R\left(\frac{l_1}{l_2} - 1\right)$$

PROBLEMS:

1. In a potentiometer arrangement, a cell of emf 1.25 V gives a balance point at 35.0 cm length Of the wire. If the cell is replaced by another cell and the balance point shifts to 63.0 cm, what is the emf of the second cell?

Ans: Here, E_1 = 1.25V; l_1 = 35.0cm; l_2 = 63.0cm

As $\frac{E_2}{E_1} = \frac{l_2}{l_1}$

$$\mathbf{E_2} = \frac{E_1 l_2}{l_1}$$

$$\mathbf{E_2} = \frac{1.25 \times 63}{35}$$

$$\mathbf{E_2 = 2.25V}$$

2. A potentiometer wire is 5m long and a potential difference of 6 V is maintained between its ends. Find the emf of a cell which balances against a length of 180 cm of the potentiometer wire.

Ans: **Given E_1=6V, l_1=5m, l_2 = 180 cm = 1.8m**

$$\frac{E_2}{E_1} = \frac{l_2}{l_1}$$

$$\mathbf{E_2} = \frac{E_1 l_2}{l_1}$$

$$\mathbf{E_2} = \frac{6 \times 1.8}{5}$$

$$\mathbf{E_2 = 2.16V}$$

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Chapter **7**

MOVING CHARGES AND MAGNETISM

VERY SHORT ANSWER QUESTIONS (2 MARKS)

1. What is the importance of Oersted's experiment?

Ans: When current is passing through a conductor magnetic field is produced around it.

2. State Ampere's law and Biot-Savart law.

Ans: ***Ampere's law:-*** The line integral of the magnetic field B around any closed curve in air or vaccum is equal to μ_0 times the net current I through the area bounded by the curve.

(OR)

$$\int B.dl = \mu_0 I$$

Biot-Savart law :-

The magnetic induction field (dB) at a point due to a current carrying element is directly proportional to length of element (dL), strength of current (i), sine of the angle between the element and the line joining the element to the pointand, inversely proportional to square of the distance of the point from the element.

(OR)

$$dB = \frac{\mu_0}{4\pi}\frac{Idl \times \vec{r}}{r^3}$$

(OR)

$$dB = \frac{\mu_0}{4\pi}\frac{I\left(\vec{dl} \times \vec{r}\right)}{r^3}$$

3. Write the expression for the magnetic induction at any point on the axis of circular current carrying coil. Hence obtain an expression for the magnetic induction at the centre of the circular coil?

Ans: (i) $B = \dfrac{\mu_0 nir^2}{2(r^2 + x^2)^{3/2}}$

(ii) At the centre of the coil $\mathrm{B} = \dfrac{\mu_0 ni}{2r} \quad (x = 0)$

4. A circular coil of radius 'r' having 'N' turns carries a current i. What is its magnetic moment?

Ans: Magnetic moment $M = NiA = Ni(\pi r^2)$.

5. What is the force on a conductor of length 'l' carries a current 'i' placed in a magnetic field of induction B? When does it becomes maximum?

Ans:- (i) $F = Bil \sin\theta$

(ii) If $\theta = 90^0$ force becomes maximum.

6. What is force on a charged particle of charge "q" moving with a velocity "v" in uniform magnetic field of induction B? When does it become maximum?

Ans : i) $F = qvB \sin\theta$

ii) If $\theta = 90^0$ force becomes maximum.

7. Distinguish between ammeter and voltmeter.

Ans:-

Ammeter	Voltmeter
1. It is used to measure the current. 2. To convert galvanometer into ammeter a low resistance is connected in parallel to galvanometer. 3. It should be connected always in series in any circuit. 4. Resistance of an ideal ammeter is zero.	1. It is used to measure Potential difference between two points. 2. To convert galvanometer into voltmeter a high resistance is to be connected in series. 3. It should be connected always in parallel in any circuit. 4. Resistance of an ideal voltmeter is infinity.

8. What is the principle of a moving coil galvanometer?

A. Principle of moving coil galvanometer : When a current carrying coil placed in a radial magnetic field is free to rotate then torque acting on it is $\tau = NIAB$.

9. What is the smallest value of current that can be measured with a moving coil galvanometer?

A. The smallest value of current that can be measured with moving coil galvanometer is in the order of 10^{-6} to 10^{-12} amperes.

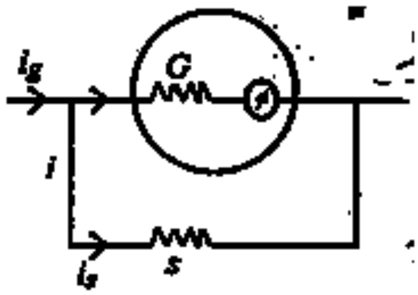
10. How do you convert a moving coil galvanometer in to an ammeter?

Ans: By connecting a low resistance parallel (shunt resistance) to moving coil galvanometer.

(OR)

A moving coil galvanometer can be converted into an ammeter by connecting a low resistance in parallel

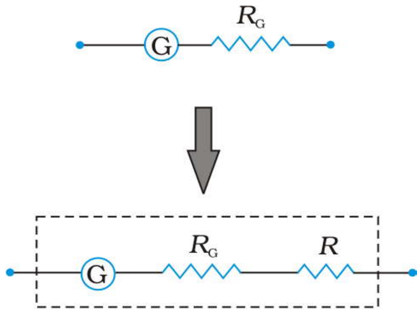
(OR)



11. How do you convert a moving coil galvanometer in to a voltmeter?

Ans: A moving coil galvanometer can be converted into a voltmeter by connecting a high resistance in series to it.

(OR)



12. What is the relation between permittivity of free space, the permeability of free space and the speed of light in vacuum?

Ans:- $C = \sqrt{\frac{1}{\varepsilon_0 \mu_0}}$

13. A current carrying circular loop lies on a smooth horizontal plane. Can a unifrom magnetic field be set up in such a manner that the loop turns about the vertical axis?

Ans. No. A uniform Magnetic field cannot be setup in such a manner that the loop turns about the verticle axis. The torque acting on the loop $\vec{\tau} = I(\vec{A} \times \vec{B})$. Since the area vector is along the vertical, the torque on the loop becomes zero.

14. A current carrying circular loop is placed in a uniform external magnetic field. if the loop is free to turn, what is its orientation when it is achieves stable equilibrium?

A. Orientation of stable equilibrium is one where the area vector A of the loop is in the direction of external magnetic field. In this orientation, the magnetic field produced by the loop is in the same direction as external field, both normal to the plane of the loop, thus giving rise to maximum flux of the total field.

15. A wire loop of irregular shape carrying current is placed in an external magnetic field. If the wire is flexible, what shape will the loop change to? Why?

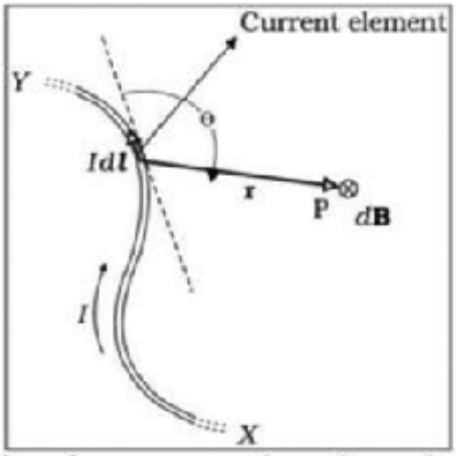
Ans. The loop will take the circular shape with its plane normal to the field in order to minimize the magnetic flux through it. More over for a given perimeter a circle has minimum area.

SHORT ANSWER QUESTIONS (4 MARKS)

1. State and explain Biot-Savart law.

Ans: ***Biot-Savart law :*** The magnetic induction field (dB) at a point due to a current carrying element is directly proportional to length of element (dl), strength of current (i), sine of the angle between the element and the line joining the element to the pointand, inversely proportional to square of the distance of the point from the element.

Explanation: A finite conductor XY carrying current i consider an infinitesimal element dl of the conductor. The magnetic field dB due to this element is to be determined at a point p which is at a distance r from it. Let be the angle between dl and the position vector r.



Explanation:

dB µ i

$dB \propto dl$

$dB \propto \sin\theta$

$$dB \propto \frac{1}{r^2}$$

$$dB \propto \frac{I\,dl \times \vec{r}}{r^3}$$

$$dB = \frac{\mu_0}{4\pi}\frac{I\,dl \times \vec{r}}{r^3}$$

In vector notation $\overrightarrow{dB} = \dfrac{\mu_0}{4\pi}\dfrac{i\,\overrightarrow{dl} \times \vec{r}}{r^3}$

2. State and explain Amper's law ?

Ans: **Ampere's Law:** The line integral of the magnetic field B around any closed curve in air or vaccum is equal to μ_0 times the net current I through the area bounded by the curve.

Proof:

Imagine a long straight current carrying conductor emerging out of the perpendicular to the plane of the paper. The magnetic line are in the form of concentric circles centred on the wire.

Consider some closed paths around the conductor as shown. Path 1 is circular and path 2 and 3 are of general shaped *dl* is an elementary path on the path 1 of radius 'r'. Let *I* be the current.

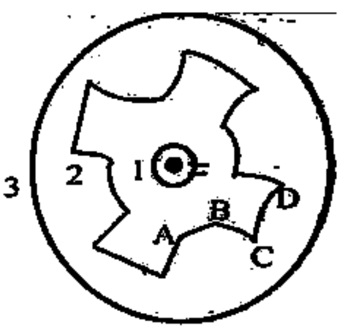
$$\therefore \vec{B}.\vec{dl} = B\,dl\cos\theta = \frac{\mu_0 I}{2\pi r} r d\theta$$

$$Since\ \vec{B}\ \&\ \vec{dl}\ are\ parallel\ \vec{B}.\vec{dl} = \frac{\mu_0 I}{2\pi} d\theta$$

$$\int \vec{B}.\vec{dl} = \oint \frac{\mu_0 I}{2\pi} d\theta = \frac{\mu_0 I}{2\pi} \oint d\theta = \mu_0 I$$

$$Similarly\ for\ other\ Path,\ \vec{B}.\vec{dl} = \frac{\mu_0 I}{2\pi}\theta_{AB}$$

$$\vec{B}.\vec{dl} = \frac{\mu_0 I}{2\pi}\theta_{CD}\ and\ so\ on.$$



$$\therefore \oint \overrightarrow{B.\vec{dl}} = \frac{\mu_0 I}{2\pi}(\theta_{AB} + \theta_{CD} + ...) = \frac{\mu_0 I}{2\pi}(2\pi)$$

$$\therefore \oint \overrightarrow{B.\vec{dl}} = \mu_0 I$$

3. Find the magnetic induction due to a long current carrying conductor?

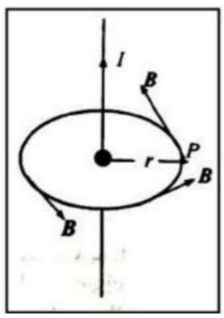
Ans: Magnetic induction due to a long current-carrying conductor:-

1. Let us consider a circular loop of radius r, drawn concentrically around a straight wire carrying a current i.
2. By symmetry, B has the same value every where along the circular loop.
3. Hence, $\oint \overline{B}.\overline{dl} = \oint Bdl\cos\theta$

   $= B2\pi r$

4. From Ampere's law, $B2\pi r = \mu_0 i$

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



This is the expression for magnetic induction due to a long conductor carying current.

4. Derive an expression for the magnetic induction at the centre of a current-carrying Circular coil using Biot-savart law?

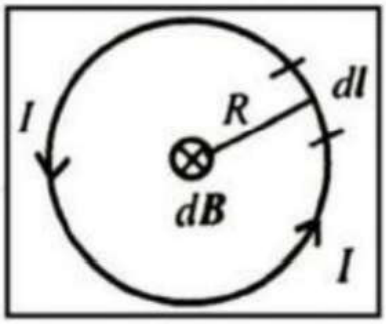
Ans: **Magnetic induction at the centre of a circular coil:-**

1. Consider a circular coil of radius r with centre 'O'. let the coil carries a current i.
2. dB is the magnetic induction at the centre 'O' due to a small element of length dl on the loop.
3. From, Biot-Savarts law, $dB = \frac{\mu_0}{4\pi}\frac{idl\sin\theta}{r^2}$
   dl is perpendicular to r, $\theta = 90°$.
4. $B = \oint dB$

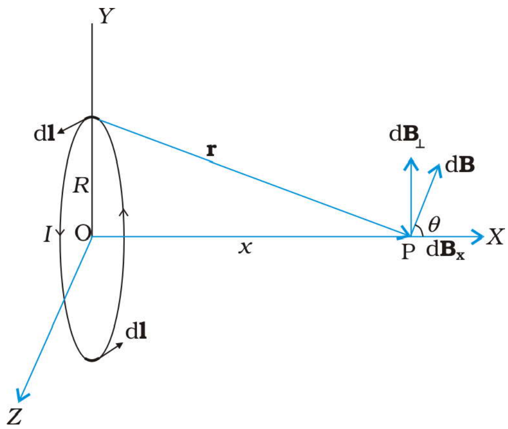
$$B = \frac{\mu_0 i}{4\pi r^2}\oint dl$$

$$B = \frac{\mu_0 i}{4\pi r^2}2\pi r$$

$$B = \frac{\mu_0 i}{2r}$$



5. Derive an expression for the magnetic induction or magnetic field at a point on the axis of of a current carrying circular coil using Biot-Savart law



From Biot savart law $dB = \frac{\mu_0}{4\pi}\frac{i|dl \times r|}{r^3}$ where $r^2 = x^2 + R^2$

$$|dl \times r| = rdl$$

$$dB = \frac{\mu_0}{4\pi}\frac{idl}{(x^2 + R^2)}$$

Magnetic field Induction along the X-axis

$$dB_x = dB\cos\theta \text{ where } \cos\theta = \frac{R}{(x^2+R^2)^{1/2}}$$

$$= \frac{\mu_0 I dl}{4\pi} \cdot \frac{R}{(x^2 + R^2)^{3/2}}$$

For arriving at $\bar{B} = B_x \bar{i} = \dfrac{\mu_0 i R^2}{2(x^2 + R^2)^{3/2}} i$

6. Derive an expression for the magnetic dipole moment of a revolving electron.

A: Magnetic dipole moment of a revolving electron:

Consider an electron revolving around stationary heavy nucleus of charge +Ze

1) Current $I = \dfrac{e}{T}$ ………………….. (1) where T is the time period of revolution.

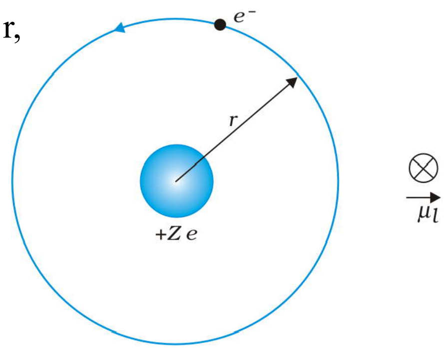
If r is the orbital radius and v is the orbital speed of the revolving electron, then

$$T = \frac{2\pi r}{v} \text{……..(2)}$$

Substituting equation (2) in equation (1)

$$I = \frac{ev}{2\pi r} \text{…………………..(3)}$$

Multiplying and dividing the above expression by r,



$$I = \frac{ev}{2\pi r^2} \times r$$

$$I(\pi r^2) = \frac{evr}{2}$$

$$IA = \frac{evr}{2}$$

$$\mu_l = \frac{evr}{2}$$

Where μ_l the magnetic dipole moment of a revolving electron.

7. How can a galvanometer can be converted to an ammeter? Why is the parallel resistance smaller that the galvanometer resistance?

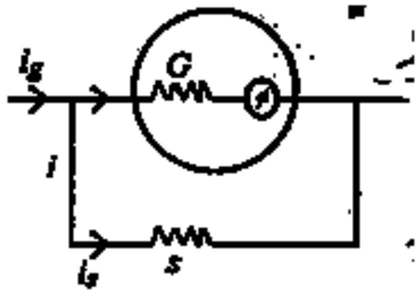
Ans: A galvanometer can be converted into an ammeter by connecting a low resistance called shunt resistance in parallel to the galvanometer. Every galvanometer has two important properties.

1) Resistance of galvanometer Rg, 2) Maximum current tolerable by it say Ig.

Ammeter:

The block diagram of ammeter is as shown. Let I is the current to be measured. When ammeter is connected in a circuit current Ig will flow through galvanometer and current Is will flow through shunt.

Let 'r' is the total resistance of ammeter, G is resistance of galvanometer and Rs is shunt connected in parallel combination of resistors



i.e., resistance of ammeter is equals to resistance of shunt.

Necessity of small shunt resistance : Ammeter is used to measure current in a circuit. in a circuit current is constant for series combination only. So ammeter must be connected in series in a circuit. To measure the value of current exactly our ammeter must have zero resistance because in series combination ($R = R_1 + R_2 +$.............etc) if resistance of shunt Rs is small effective resistance of ammeter is nearly equals to resistance of shunt and error in the value of current measured is also less.

8. How can a galvanometer be converted to a voltmeter? Why Is the series resistance greater than the galvanometer resistance?

A. A galvanometer can be converted into voltmeter by connecting a high resistance in series with galvanometer.

Conversion of galvanometer into voltmeter:

Every galvanometer has two important porperties

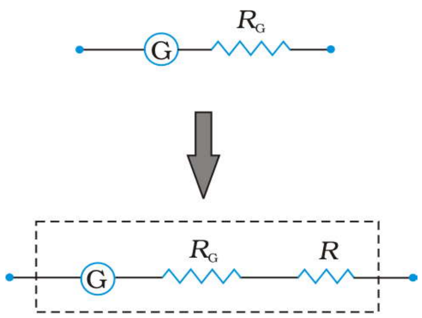
1) Resistance of galvanometer Rg

2) Maximum current tolerable by it say Ig.

The block diagram of a voltmeter is as shown in figure.

Let voltage to be measured is 'V'

Total resistance of voltmeter R =V/ Ig



Voltmeter

Necessity of high series resistance :

A voltmeter is used to measure potential difference between two given points. So it must always be connected parallelly in a circuit. In parallel combination high current will flow through low resistance. To measure potential difference exactly the voltmeter should not draw any current from circuit. Theoritically resistance of ideal voltmeter is infinity. Practically it is kept as high as possible when series resistance of voltmeter is high it draws very little current from the circuit and measurement of voltage with it is more accurate.

* * * * *

Chapter **8**

MAGNETISM AND MATTER

VERY SHORT ANSWER QUESTIONS (2 MARKS)

1. What happens to compass needles at the earth poles?

Ans: At the Earth's poles, the compass needle can point along any direction, if the needle is only capable of moving in horizontal plane as B_H=0.

OR)

At the Earth's poles the compass needle can point straight down, if the needle is moving in a vertical plane as B_H=0.

'Dip needle' can be used to find the direction at poles.

2. What do you understand by the magnetization of sample?

Ans: i) Net magnetic moment per unit volume is called magnetization

ii) unit of magnetization is A/m

3. What are the units of magnetic moment, magnetic induction or magnetic field?

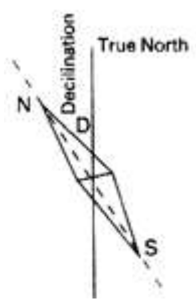
Ans: i) Unit of magnetic moment is A-m^2 (or) joule /tesla

ii) Unit of magnetic induction is Tesla (or) wbm^{-2}

4. Magnetic lines from continuous closed loop why?

Ans: Magnetic monopoles do not exit so magnetic lines from continuous closed loops.

5. **Define magnetic declination?**



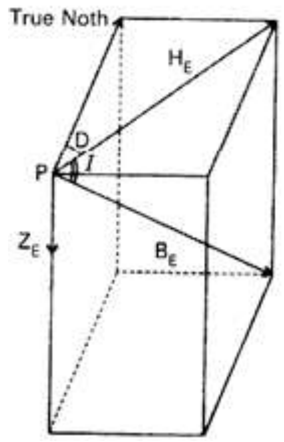
Ans: The angle between the geographic North and North shown by compass needle is called magnetic declination.

(OR)

The angle between the geographical meridian and magnetic meridian of the earth is called magnetic declination

6. Define magnetic inclination (or) angle of dip?

Ans: Its defined as the angle made by the total magnetic field(B_E) of the earth at a place with the horizontal.



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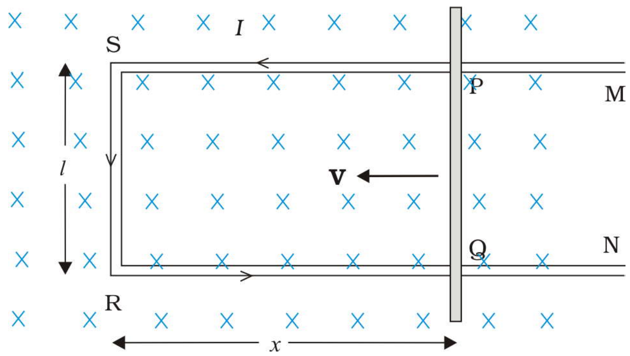
Chapter **9**

ELECTROMAGNETIC INDUCTION

SHORT ANSWER QUESTIONS (4 MARKS)

1. Obtain an expression for the emf induced across a conductor which is moved in a uniform magnetic field which is perpendicular to the plane of motion.

Ans: Consider a rectangular loop PQRS placed in uniform magnetic field such that PQ is free to move with constant velocity ν .



Magnetic flux f_B enclosed by the loop PQRS will be f_B =Blx.

Since 'x' is changing with time rate of change of flux f_B will induced an emf given by $e = \frac{-d\phi_B}{dt}$

$$e = -\frac{-d}{dt}(Blx)$$

$$e = -Bl\left(\frac{dx}{dt}\right)$$

$$e = (Bl\nu)$$

2. Describe the ways in which Eddy currents are used to advantage.

Ans: ***Eddy currents:*** When large pieces of conductors are subjected to changing magnetic flux, induced currents are produced in then they are called eddy currents.

<u>Eddy current uses:</u>

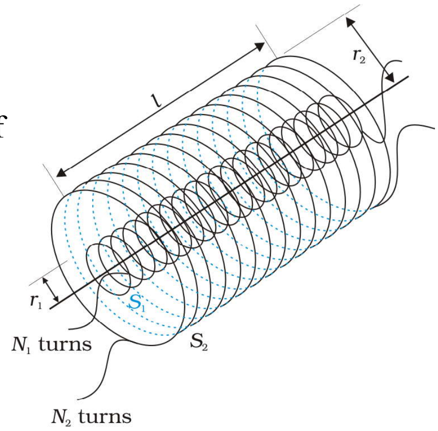
1) **Magnetic breaking in trains:** When the electromagnets are activated, the eddy currents induced in the rails oppose the motion of the train.

2) **Electromagnetic damping:** When the coil oscillates the eddy currents generated in the core oppose the motion and bring the coil to rest quickly.

3) **Induction furnace:** When alternating current is passed through a wire wound on a metal to be melted, eddy currents are developed. As a result, high temperatures are produced which melts the metals. This motten metals are used to make alloys.

4) **Electric power meters:** The shiny metal disc in the electric power meter rotates due to the eddy currents and indicates consumed units.

3. Obtain an expression for the mutual inductance of two long co-axial solenoids.



Ans: Consider two long solenoids each of length l and area of cross-section A. Let N_1,N_2 are number of turns and i_1 and i_2 are currents through the solenoids S_1 and S_2. n_1, n_2 are number of turns per unit length.

The magnetic field along the solenoid S_1 is B_1 then

$$B_1 = \mu_0 n_1 i_1$$

Mutual inductance of S_1 with respect to S_2 M_{12}, then

$$M_{12} = \frac{N_1 \phi_1}{i_2}$$

$$M_{12} = \mu_0 n_1 n_2 \times l A_1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

The magnetic field along the solenoid S_2 is B_2 then

$$B_2 = \mu_0 n_2 i_2$$

Mutual inductance of S_2 with respect to S_1 M_{21}, then

$$M_{21} = \frac{N_2 \phi_2}{i_1}$$

$$M_{21} = \mu_0 n_1 n_2 l A_1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots..(2)$$

From equations (1) and (2) inductance of solenoids is M then

$$M = \mu_0 n_1 n_2 l A_1$$

4. Obtain an expression for the magnetic energy stored in a solenoid in terms of the magnetic field, area and length of the solenoid.

Ans: The magnetic energy is

$$U_B = \frac{1}{2} L I^2$$

$$= \frac{1}{2} L \left(\frac{B}{\mu_0 n} \right)^2 \quad (\text{since } B = \mu_0 n I)$$

$$= \frac{1}{2} (\mu_0 n^2 A l) \left(\frac{B}{\mu_0 n} \right)^2 \quad (\text{since } L = \mu_0 n^2 A l)$$

$$= \frac{1}{2\mu_0} B^2 A l$$

Chapter **10**

ALTERNATING CURRENT

VERY SHORT ANSWER QUESTIONS (2 MARKS)

1. A transformer converts 200V ac into 2000V ac. Calculate the number of turns in the secondary if the primary has 10 turns.

Ans:- Input voltage, V_P= 200V

Output Voltage, V_S=2000V

Number of turns in the primary coil, N_P=10

We know that $\frac{V_P}{V_S} = \frac{N_P}{N_S}$

Number of turns in secondary coil,

$$N_S = \frac{V_S}{V_P} \times N_P = \frac{2000}{200} \times 10 = 100$$

2. What type of a transformer is used in a 6V bed lamp?

Ans: Step down transformer is used in 6V bed lamp.

3. What is the phenomenon involved in the working of a transformer?

Ans: Mutual Induction.

4. What is transformer ratio?

Ans: The ratio between number of turns in secondary coil and number of turns in primary coil is called transformer ratio

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

5. Write the expression for the reactance of 1) an inductor and 2) a capacitor?

Ans: Reactance of Inductor: $X_L = \omega L$

Reactance of Capacitor $X_C = \frac{1}{\omega C}$

Where ω is angular frequency

L is the inductance

C is the Capacitance

6. What is the phase difference between AC emf and current in the pure resistor, pure inductor and pure capacitor circuits?

Ans: (i) In pure resistor phase difference between emf and current is zero.

(ii) In pure inductor the phase difference between emf and current is 90^0 or $\frac{\pi}{2}$ Radians.

(iii) In pure capacitor the phase difference between emf and current is 90^0 or $\frac{\pi}{2}$ Radians.

7. When does a LCR series circuit have minimum Impedance?

Ans: Impedance of series LCR circuit

$$Z = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}$$

for a minimum Impednce capacitive reactance and inductive reactance must be equal.

$$\omega L = \frac{1}{\omega C}$$

$\therefore$ Z = R

in series LCR circuit Impedance is minimum at Resonance condition.

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Chapter 11

ELECTROMAGNETIC WAVES

VERY SHORT ANSWER QUESTIONS (2 MARKS)

1. **What is the average wave length of X-rays?**

Ans: Average wave length of X-ray is 5.00005nm.

2. **If the wavelength of electromagnetic radiation is doubled,What happens to the energy of photon?**

Ans: The energy of photon reduces to half to its initial value.

$$E = \frac{hc}{\lambda}$$

$$\frac{E_1}{E_2} = \frac{\lambda_2}{\lambda_1} = \frac{2\lambda}{\lambda} = 2, \quad E_2 = \frac{E_1}{2}$$

3. **What is the principle of production of electromagnetic waves?**

Ans: If the charge is accelerated both the magnetic field and electric field will be change with space and time then electromagnetic waves are produced.

4. **What is the ratio of speed of infrared rays and ultraviolet rays in vacuum?**

Ans: 1:1 i.e. both infrared and UV rays travel with same speed in vacuum.

5. **What is the relation between the amplitudes of the electric and magnetic fields in free space for an electromagnetic wave?**

Ans: $E_0=CB_0$

Where C – Velocity of light

E_0 – Amplitude of electric field

B_0 - Amplitude of magnetic field

6. **What are the applications of microwaves?**

Ans: Micro waves are used in

i) RADARS system in aircraft navigation.

ii) Micro ovens in cooking

ii) To find out the velocity of vehicles

7. Microwaves are used in Radars, Why?

Ans: Due to short wavelengths (high frequency) . They are suitable for the radar system used in aircraft navigation**.**

8. Give uses of infrared rays?

Ans: **Uses of Infrared rays**: (Any two uses)

1. Used in remote control switches
2. Infrared detectors
3. Military purposes
4. To observe the growth of the crops.
5. Electronic devises
6. Physiotherapy
7. Taking photographs during night and foggy conditions

Snakes can detect Infrared waves.

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Chapter 12

DUAL NATURE OF RADIATION AND MATTER

VERY SHORT ANSWER QUESTIONS (2 MARKS)

1. What are Cathode rays?

Ans: Cathode rays are streams of fast moving negatively charged particles(electrons)

2. What important fact did Millikan's experiment establish?

Ans: Electric charge present on a body is equal to integral multiples of electron charge i.e. $Q = \pm ne$.

3. What is work function?

Ans: The minimum energy required by an electron to escape from the surface of a metal is called work function.

$\phi_0 = h\nu_0$

4. What is photo electric effect?

Ans: When a light of suitable frequency incident on a metal surface, electron are emitted from the metal surface. This phenomenon is called as photo electric effect.

5. Give examples of photosensitive substances? Why are they called so?

Ans: i) Alkali metals are called photo sensitive metals

ii) Because the alkali metals emits electrons when they illuminated by visible light.

6. Write down Einstein's photo electric equations?

Ans: Einstein's Photo Electric Equation:

$h\nu = \phi_0 + K_{max}$

Where $h\nu$ - Energy of the incident photon

ϕ_0 - Work function

K_{max} - Maximum kinetic energy of photo electron

7. Write down de-Broglie's relation and explain the terms there in?

Ans:- $\lambda = \frac{h}{p} = \frac{h}{mv}$

Here λ - de- Broglie wave length

h – Planks constant

P – Linear momentum of the particle

m – mass

ν – velocity

8. State Heisenberg's uncertainty principle?

Ans: We cannot measure both the position and momentum of an electron (or) any particle exactly at the same time

$$\Delta x . \Delta p \approx \frac{h}{2\pi}$$

Δx = uncertainity in position

Δp = uncertainity in momentum

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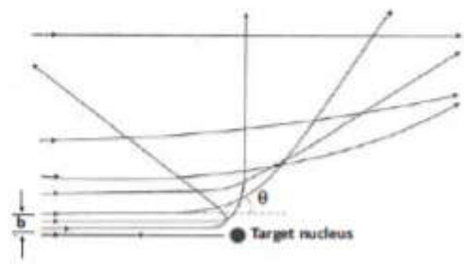
Chapter 13

ATOMS

SHORT ANSWERS TYPE QUESTIONS (4 MARKS)

1. What is impact parameter and angle of scattering ? How are they related to each other ?

Ans: Impact parameter: It is the perpendicular distance of the initial velocity vector of α - particle from centre of nucleus.



α-particle scattering

In case of head-on collision impact parameter is minimum and α - particle rebounds back $(\theta=\pi)$. For a large impact parameter α - particle goes undeviated. The chance of head on collision is very small. It in turn suggested that mass of atom is much concentrated in a small volume.

Angle of scattering 'θ' : It is defined as the angle between the direction of incidentα- particle and scattered α-particle.

Relation between impact parameter and angle ofscattering is, when Impact parameter is less then angle of scattering is high. When Impact parameter is high angle of scattering is less.

2. Derive an expression for potential and kinetic energy of an electron in any orbit of a hydrogen atom according to Bohr's atomic model.

Ans: **Kinetic Energy:** For an electron to revolve any orbit they electrostatic force is equal to centrifugal force.

$$F_e = F_c$$

$$\frac{1}{4\pi\varepsilon_0}\frac{e^2}{r^2} = \frac{mv^2}{r}$$

$$mv^2 = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{r}$$

$$KE = \frac{1}{2}mv^2 = \frac{1}{2}\frac{1}{4\pi\varepsilon_0}\frac{e^2}{r}$$

$$= \frac{1}{8\pi\varepsilon_0}\frac{e^2}{r}$$

Potential Energy:

PE of an electron $U = \int F\,dr = \int_{\infty}^{r} \frac{-e^2}{4\pi\varepsilon_0}\frac{dr}{r^2} \Rightarrow U = \frac{-e^2}{4\pi\varepsilon_0 r}$

(OR)

$$U = \frac{1}{4\pi\varepsilon_0}\frac{e(-e)}{r} = \frac{-e^2}{4\pi\varepsilon_0 r}$$

If 'n' value increases 'r' value also increases and hence P.E. (U) increases.

3. State the basic postulates of Bohr's theory of atomic spectra.

Ans: Bohr's Atomic Model Postulates:

1) Electrons revolve around the nucleus with definite velocities in circular paths of fixed radius and energy. These paths are called "orbits".

2) The energy of the electron in an orbit remains unchanged, as long as the electron remains in that orbit. It neither emits nor absorbs energy. Hence, these orbits are called as stationary orbits or states.

3) The energy of the electron changes when the electron moves from one orbit to another. The electron will move from a lower stationary orbit to a higher stationary orbit by absorbing energy. The energy is emitted when electron moves from higher stationary orbit to lower stationary orbit. The absorbed or emitted energy is equal to the energy difference between two energy levels.

$$\Delta E = E_2 - E_1 = hv$$

4) The angular momentum of electron in circular orbit is quantized,

$$mvr = \frac{nh}{2\pi}$$

$m = mass\ of\ electron.$

$v = velocity\ of\ electron,$

$r = radius\ of\ the\ orbit.$

$n = 1, 2, 3, \ldots\ldots\ldots\ldots,$

$h = Planck's\ constant$

4. What are the limitations of Bohr's theory of hydrogen atom?
Any four Limitations :

Ans: 1) Bohr's model is applicable to only single electron system (Z=1) i.e. hydrogen atom.

2) The theory fails in the case of atoms of other elements for which (z>1)

3) Bohr's model presents an elegant picture of an atom and cannot be generalised to complex atoms.

4) It does not explain the wave properties of electron.

5) This model explains only circular orbits but not elliptical orbits.

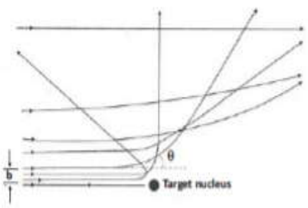
6) This model does not explain the fine structure of spectral lines.

7) This model does not explain Zeeman and Stark effects.

5. Explain the distance of closest approach and impact parameter.

Ans. **Distance of closest approach :** In α - particle scattering experiment the α - particle will move near to gold nucleus until it is just stopped. When just stopped kinetic energy of α-particle is just equal to electrostatic potential.

$$\therefore K=\frac{1}{2}mv^2 (2e)(Ze) = \frac{1}{4\pi \in_0}\frac{2Ze^2}{d}$$



α-particle scattering

Where Z is atomic number of gold, '2e' charge on α - particle distance of closest approach

$$d = \frac{2Ze^2}{4\pi \in_0 k}$$

Impact parameter : It is the perpendicular distance of the initial velocity vector of α - particle from centre of nucleus.

In case of head - on collision impact parameter is minimum and α- particle rebounds back $(\theta = \pi)$. For a large impact parameter α- particle goes undeviated. The chance of head on collision is very small. It in turn suggested that mass of atom is much concentrated in a small volume.

6. Give a brief account of Thomson model of atom. What are its limitations ?

Ans: **J.J. Thomson Model :** J.J Thomson thought that the positive charge of the atom is uniformly distributed through out the volume of the atom and the negatively charged electrons are embedded in it like seeds in a watermelon.

Limitations :

i) Rutherford α - particle scattering experiment showed that in an atom positive charge is concentrated over a small volume of atom called nucleus.

ii) In Thomson model the radiation emitted by solids and gases is due to oscillations of atoms and molecules are governed by the interactions between them.

But experiments on rarefied gases showed that hydrogen always gives rise to a set of lines with fixed wavelength.Balmer experiments and his formula for Balmer series of wavelength of a group of lines are emitted by atomic hydrogen only. Not by interaction of atoms or molecules.

7. Describe Rutherford atom model. What are the draw backs of this model?

Ans: **Rutherford's Atomic model:**

1) In Rutherford's nuclear model of the atom, the entire positive charge and most of the mass of the atom are concentrated in the nucleus.
2) The electrons would be moving in orbits about the nucleus just as the planets do around the sun.
3) Rutherford's experiments suggested the size of the nucleus to be about 10^{-15} m to 10^{-14} m.
4) Most of an atom is empty space.

Rutherford's Atomic model Drawbacks:

1. Rutherford atomic model could not explain why the electron was stable in its orbit.
2. Rutherford atomic model could not explain the emission of line spectra from hydrogen atom.

8.. Distinguish between excitation potential and ionization potential.

Ans: **Excitation potential :**

i) The amount of energy required for an electron to move from ground state to excited state is called excitation potential
ii) Excitation potential $V_e = E_1 - E_0$
iii) Hydrogen atom contains several excitation potentials.
iv) In this atom moves from ground state to excited state.

Ionisation potential:

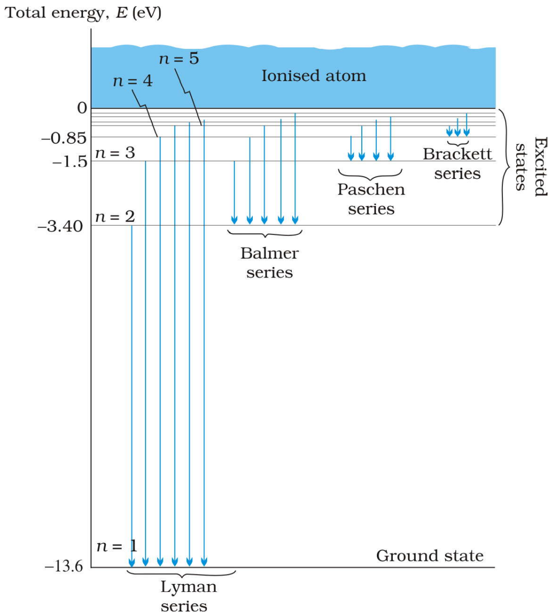
i) The amount of energy required for the electron to move from ground state is infinity is called ionisation potential
ii) Ionisation potential $V_i = E_\infty - E_0$
iii) Hydrogen atom has only one ionisation potential.
iv) In this, electron is removed and goes to infinity.

Difference: From above definitions, excitation potential will permit electrons to transit between various energy levels where as ionisation potential will liberate an electron from the influence of nucleus of that atom.

9. **Explain the different types of spectral series**

Ans: **The** atomic hydrogen emits a line spectrum consisting of various series. The frequency of any line in a series.

The following are the different types of spectral series observed in the spectrum of hydrogen atom.



a) Lyman series: the spectral lines of this series correspond to the transition of an electron from some higher energy state to the innermost orbit (n = 1)

For Lyman series, $n_1 = 1$ and $n_2 = 2, 3, 4, \ldots$

Lyman series $n = RC\left[\frac{1}{1^2} - \frac{1}{n^2}\right]$, n=2,3,4..............

This series lies in the ultraviolet region of the spectrum.

b) Balmer series: The spectal lines of this series correspond to the transition of an electron from some higher energy state to an orbit having n = 2.

For Balmer series, $n_1 = 2$ and $n_2 = 3, 4, 5, \ldots$

Balmer series $n = RC\left[\frac{1}{2^2} - \frac{1}{n^2}\right]$, n=3,4,5..............

Balmer series lies in the visible region of the spectrum.

c) Paschen series: The spectral lines of this series correspond to the transition of an electron from some higher energy state to an orbit having n = 3.

For Paschen series, $n_1 = 3$ and $n_2 = 4, 5, 6, \ldots$

Paschen series $n = RC\left[\frac{1}{3^2} - \frac{1}{n^2}\right]$, n=4,5,6..............

Paschen seiries lies in the infrared region of the spectrum.

d) Brackett series: The spectral lines of this series correspond to the transition of an electron from a higher energy state to the orbit having n = 4.

For this series, $n_1 = 4$ and $n_2 = 5, 6, 7, \ldots$

Bracket Series $n = RC\left[\frac{1}{4^2} - \frac{1}{n^2}\right]$, n=5,6,7..............

This seiries lies in the infrared region of the spectrum.

e) Pfund series: The spectral lines of this series correspond to the transition of electron from a higher energy state to the orbit having n = 5.

For this series, $n_1 = 5$ and $n_2 = 6, 7, 8, \ldots$

Pfund series $n = RC\left[\frac{1}{5^2} - \frac{1}{n^2}\right]$, n=6,7,8..............

This series lies in the far infrared region of the spectrum.

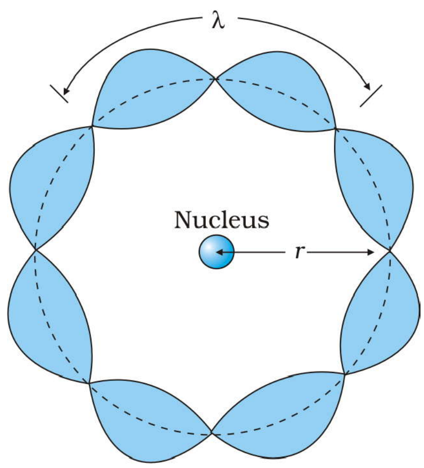
10. Write a short note on Debroglie's explanation of Bohr's second postulate of quantization?

Ans: Debroglie's explanation of Bohr's second postulate of quntization:

1) Debroglie explained that the moving electron in its circular orbit creates a stationary wave with nodes and antinodes .
2) In a stationary wave, the total distance travelled by a wave is integral number of wavelengths.
3) For an electron moving in n^{th} circular orbit of radius r_n, the total distance is the circumference of the orbit, $2\pi r_n$.

   Thus $2\pi r_n = n\lambda$ (1), where n = 1, 2, 3, ...

4) According to de-Broglie wavelength $\lambda = \frac{h}{p} \Rightarrow \lambda = \frac{h}{mV_n} \rightarrow (2)$
5) From equ (1) and (2) , we have $2\pi r_n = \frac{nh}{mV_n} \quad \therefore mV_n r_n = \frac{nh}{2\pi} = L$
6) Hence Bohr's second postulate of quantization, angular momentum of an electron is integral multiple of $\frac{h}{2\pi}$ is obtained by de Broglie.



Chapter 14

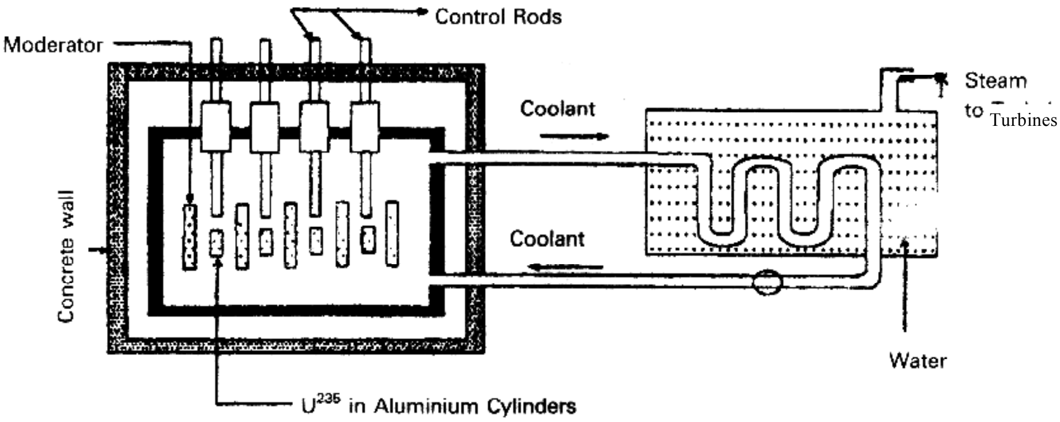
NUCLEI

LONG ANSWER QUESTIONS (8 MARKS)

1. **Explain the principle and working of a nuclear reactor with the help of a labeled diagram.**

Principle of nuclear reactor: Nuclear reactor works on the principle of achieving controlled chain reaction.

Schematic diagram of nuclear reactor:-



Nuclear Reactor

Working:-

1) **Fuel**: Fissionable material, commonly Uranium isotopes are used.
2) **Moderator**: The purpose of moderator is to slow down the fast moving neutrons.
   Eg: Heavy water, Graphite.
3) **Control rods**: To control the chain reaction.
   Eg: Cadmium (or) Boron rods
4) **Coolant**: The substance used to absorb heat generated in the reactor
5) **Radiation shielding**: Lead blocks and concrete walls of thickness 10m are used for the reactor.

Working:- Nuclear reactor works on the principle of controlled and sustain chain reaction and releases large amount of energy.

2. Explain the source of stellar energy. Explain the carbon - nitrogen cycle, proton - proton cycle occurring in stars.

A. The source of stellar energy is nuclear fusion reaction, for which hydrogen is the fuel.

Energy from Sun and Stars : Sun and Stars have been radiating huge amounts of energy by nuclear fusion reactions taking place in their core, where the temperature is of the order 10^7 K. More scientists proposed two types of cyclic processes for the source of energy in the Sun & Stars. They are :

Carbon - Nitrogen Cycle :

Carbon - Nitrogen cycle is one of the most important nuclear reactions for the production of solar energy by fusion.

$${}_1H^1 + {}_6C^{12} \rightarrow {}_7N^{13} + \gamma - \text{ray}$$

$${}_7N^{13} \rightarrow {}_6C^{13} + {}_{+1}e^0 + \upsilon \text{ (neutrino)}$$

$${}_1H^1 + {}_6C^{13} \rightarrow {}_7N^{14} + \gamma - \text{ray}$$

$${}_7N^{14} + {}_1H^1 \rightarrow {}_8O^{15} + \gamma$$

$${}_8O^{15} \rightarrow {}_7N^{15} + {}_{+1}e^0 + \upsilon$$

$${}_1H^1 + {}_7N^{15} \rightarrow {}_6C^{12} + {}_2He^4$$

The entire cycle can be summed up as,

$$4\,{}_1H^1 \rightarrow {}_2He^4 + 2\,{}_{+1}e^0 + 3\gamma + 2\upsilon + 26.70\,\text{MeV}$$

Proton - Proton Cycle :

At higher temperature the thermal energy of the protons is sufficient to form a deuteron and a positron. The deuteron then combines with another proton to form higher nuclei of helium ${}_2He^3$. Two such helium nuclei combine with another proton releasing a total amount of energy 25.71 MeV. The nuclear fusion reactions are given below.

$${}^1_1H + {}^1_1H \rightarrow {}^2_1H + e^+ + \nu + 0.42\,\text{MeV} \quad \text{(i)}$$

$$e^+ + e^- \rightarrow \gamma + \gamma + 1.02\,\text{MeV} \quad \text{(ii)}$$

$${}^2_1H + {}^1_1H \rightarrow {}^3_2He + \gamma + 5.49\,\text{MeV} \quad \text{(iii)}$$

$${}^3_2He + {}^3_2He \rightarrow {}^4_2He + {}^1_1H + {}^1_1H + 12.86\,\text{MeV} \quad \text{(iv)}$$

For this equation to takes place first three equations must occur twice. The net result of the above reactions is

$$4\,{}^1_1H + 2e^- \rightarrow {}^4_2He + 2\nu + 6\gamma + 26.7\,\text{MeV}$$

or $$(4\,{}^1_1H + 4e^-) \rightarrow ({}^4_2He + 2e^-) + 2\nu + 6\gamma + 26.7\,\text{MeV}$$

The energy released during this process is 26.70 MeV.

PROBLEMS:

1. If one microgram of $_{92}U^{235}$ is completely destroyed in an atom bomb, how, much energy will be released?

Ans: Mass m. $=1\mu g = 10^{-6}g = 10^{-9}Kg$

we have $E = Mc^2 = 10^{-9}x(3x10^8)^2$

$=10^{-9}x9x10^{16}E=9x10^7J$

2. Calculate the energy released by fission from 2g ofU^{235} in kWh. Given that the energy released per fission is 200 MeV.

Ans. Given, Mass of Uranium (m) = 2g; Energy per fission = 200 MeV

Number of atoms in 2 grams of Uranium $(n) = \frac{2\times 6.023\times 10^{23}}{236} = 5.1256\times 10^{23}$ atoms

Energy released per fission = 200 MeV = $200\times 10^6 \times 1.6\times 10^{-19}\,J = 200\times 1.6\times 10^{13}\,J$

$= 3.2\times 10^{-11}\,J$

Total Energy released 'Q' = $5.1256\times 3.2\times 10^{-11} = 1640.2\times 10^8\,J$

But, 1 kWh = $1000\times 60\times 60 = 36\times 10^5\,J$

$\therefore$ Energy in kWh 'Q' = $\frac{16402\times 10^8}{36\times 10^5} = 4.55\times 10^4\,kWh$

3. Calculate the energy equivalent of 1 g of substance.

Ans: Energy, $E = mc^2$

$E = 10^{-3} \times (3 \times 10^8)^2\,J$

$E = 10^{-3} \times 9 \times 10^{16} = 9 \times 10^{13}\,J$

Thus, if one gram of matter is converted to energy, there is a release of an enormous amount of energy.

❊ ❊ ❊ ❊ ❊

Chapter **15**

SEMICONDUCTOR ELECTRONICS : MATERIALS, DEVICES AND SIMPLE CIRCUITS

VERY SHORT ANSWER QUESTIONS (2 MARKS)

1. What is the n- type semiconductor? What are the majority and minority charge carriers in it?

Ans: i) A pure semiconductor doped with pentavalent impurity is called n-type semiconductors.

ii) Electrons are majority charge carriers and holes are minority charge carriers.

2. What are the intrinsic and extrinsic semiconductors?

Ans: i) pure semiconductors are called Intrinsic semiconductors.

ii) Semiconductors with impurities are called extrinsic semiconductors.

3. What is the p- type semiconductor? What are the majority and minority charge carriers in it?

Ans: i) A pure semiconductor doped with trivalent impurity is called p-type semiconductors.

ii) Holes are majority charge carriers and electrons are minority charge carriers.

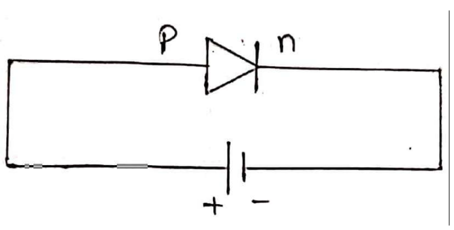
4. What is p-n junction diode ? Define depletion layer.?

Ans: **p-n Junction diode**: A semiconductor diode is basically p-n junction with metallic contacts provided at the ends for the application of an external voltage.

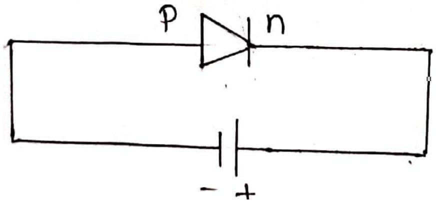
Depletion layer : The charge free region on either side of the junction together is known as depletion layer.

5. How is a battery connected to a junction diode in i) forward bias ii) reversed bias?

Ans: i) In forward bias battery positive terminal is connected to p-region and negative terminal is connected to n-region.



ii) In reverse bias battery positive terminal is connected n-region and negative terminal is connected to p-region.



6. What is the maximum percentage of rectification in half wave and full wave rectifiers?

Ans. The maximum percentage of rectification in a half wave rectifier is 40.6% and in a full wave rectifier maximum percentage of rectification is 81.2%.

7. Write the expressions for the efficiency of a half wave rectifier and a full wave rectifier.

Ans. Efficiency of half wave rectifier

$$\frac{0.406 \times R_L}{r_f + R_L}$$

Efficiency of full wave rectifier

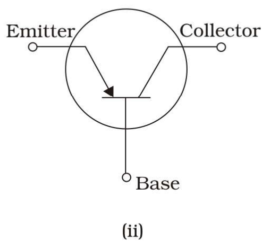
$$\frac{0.812 \times R_L}{r_f + R_L}$$

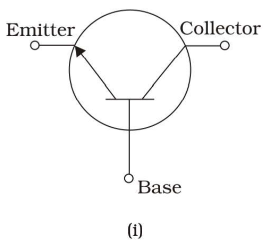
8. What happens to the width of the depletion layer in a p - n junction diode when it is i) forward biased and ii) reverse biased ?

Ans: When a p - n junction diode is forward biased thickness of depletion layer decreases and in reverse bias the thickness of depletion layer increases.

9. Draw the circuit symbols for p-n-p and n-p-n transistor?

Ans:





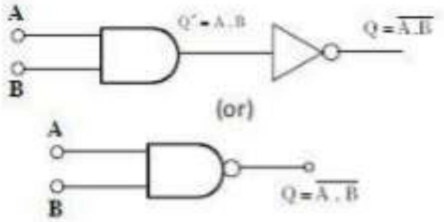
p-n-p **n-p-n**

10. Which gates are called universal gates?

Ans: NAND and NOR gates, since they can be used to make other fundamental gates.

11. Write the truth tables of NAND gate. How does it differ from AND gate ?

Ans.



Truth Table

Input		Output
A	B	Q
0	0	1
1	0	1
0	1	1
1	1	0

The output of NAND gate is opposite to output of AND gate.

SHORT ANSWER QUESTIONS (4 MARKS)

1. What are n-type and p-type semiconductors?How is a semiconductor junction formed?

Ans. n - type semiconductors : When pentavalent impurities such as phosphorous (P), arsenic (As), antimony (Sb) are added to intrinsic semiconductors then it is called n-type semiconductors.

p-type semiconductors : When trivalent impurities such as Boron (B), Aluminium (Al), Galium (Ga), Indium (In) etc. are added to intrinsic semiconductor then it is called p -type semiconductor.

p-n junction : A p-n junction is formed by adding a small quantity of pentavalent impurities in a highly controlled manner to a p-type silicon/germanium wafer.

• During the formation of p-n junction diffusion and drift of charge carriers takes place.

• In a p-n junction concentration of holes is high at p-side and concentration of electrons is high at n-side. Due to the concentration gradient between p-type and n-type region holes diffuse to n-region and electrons diffuse to p-region.

Due to diffusion of changes a charge less region is formed near junction called depleted region.

2. Discuss the behaviour of p-n junction. How does a potential barrier develop at the junction ?

Ans. A p-n junction is formed by doping a pure semiconductor by half of with trivalent impurity and other half with pentavalent impurity.

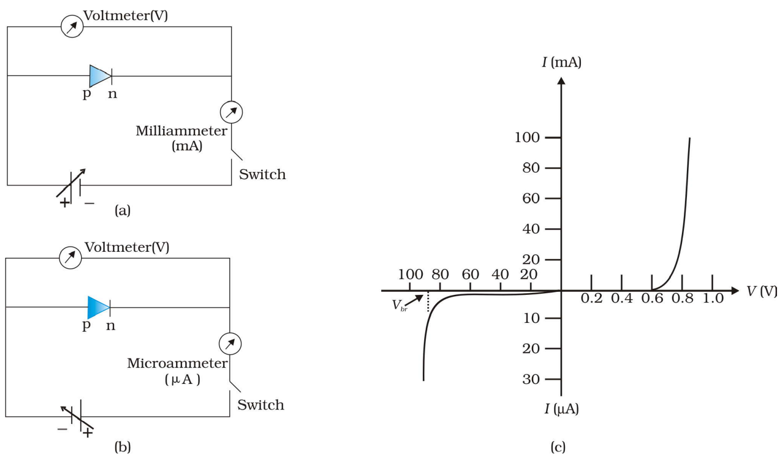
During the formation of p-n junction, electron from n-side and holes from p-side differs and neutralise at the centre. As a result a charage free region is formed across the junction and it is called defletion region.

A positively charged layer is formed on n-side and negatively charged layer is formed on p-side on either side of junction. This potential difference across the junction is called potential barrier. It prevents further neutralisation of charges.

3. Draw and explain the current voltage (1-V) characterstic curves of a junction diode in forward and reverse bias?

Ans: **I-V characterstics of junction diode :-**

Forward Bias characterstics :-



a) It is the graph between Forward voltage (V) on x-axis applied across the junction diode and the resulting Forward current (I) on y-axis through the diode.

b) The forward voltage (V) across the junction diode is increased from Zero in steps and corresponding values of forward current (I) through the diode are noted. A graph drawn between V, and I, is as shown.

c) In reverse bias, small amounts of current flows through the circuit due to minority charge carries. At a particular reverse voltage, current increase suddenly. This voltage is called breaking voltage.

d) As the forward voltage is increased from zero, the forward current increases very slowly until the forward voltage across diode reachesV (= 0.7V for silicon diode and 0.3V for germanium diode) at the knee of the curve. The forward voltage corresponding to knee of the curve is called knee voltage. If the applied forward voltage exceeds the knee voltage, the forward current increases rapidly.

ii) Reverse Bias Characterstics :

a) It is the graph between reverse voltage (VR) applied across the junction diode and the reverse current (I,) through the diode.

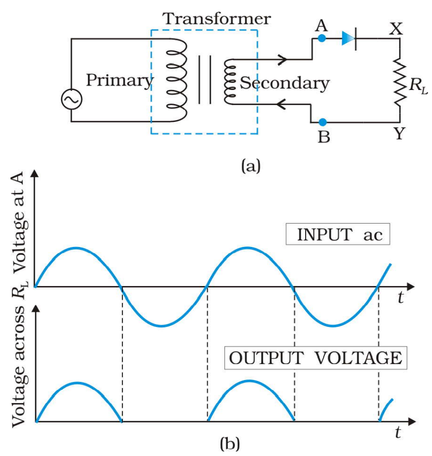
b) The reverse voltage (V,) across the diode is increased from zero and the corresponding values of reverse current (I,) are noted. A graph drawn between V, and I, is as shown.

c) As the diode is reverse biased, no current flows through it.

d) In reverse bias, small amounts of current flows through the circuit due to minority charge carries. At a particular reverse voltage current increases suddenly. This voltage is called breaking voltage.

4. Describe how a semi conductor diode is used as a half wave rectifier.

Ans: The rectified output of current is only for half of the input ac wave it is called half-wave rectifier.



During the positive half cycle, the diode is forward biased and current flows through the diode. During the negative half cycle, the diode is reverse biased and current does not flow through it. The current flows in 'R_L' only in one direction. Hence half wave rectifies only one half cycle of the ac input.

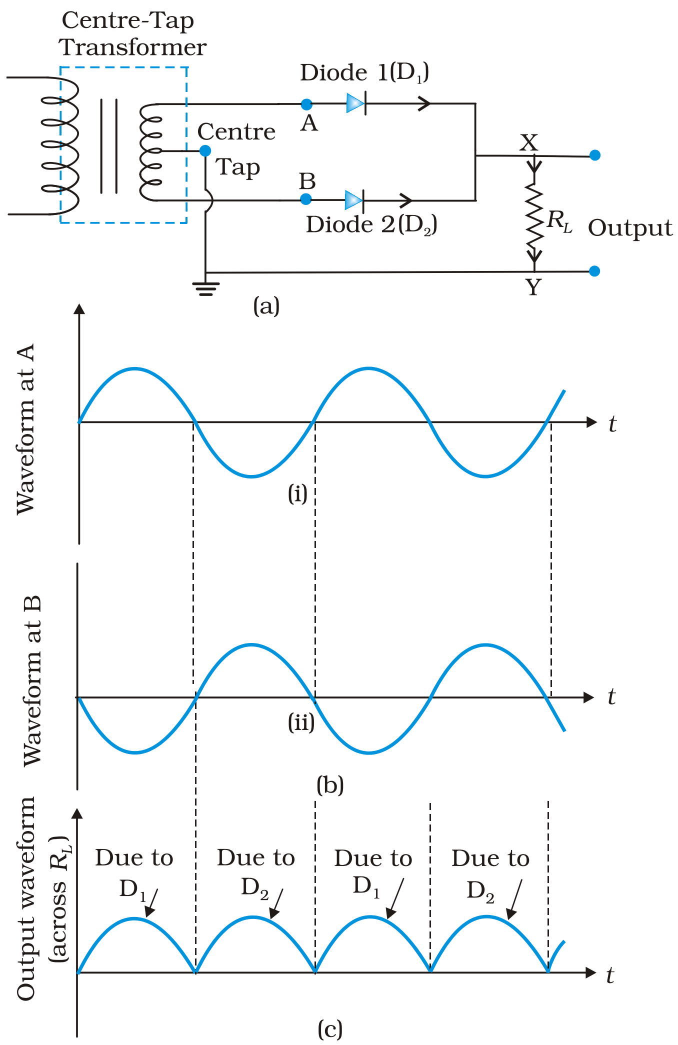
Rectifier efficiency,

$$\eta = \frac{\text{dcpoweroutput}}{\text{acpowerinput}} = \frac{0.406 \times R_L}{r_f + R_L}$$

In half wave rectification, a maximum of 40.6 % of ac power is converted into dc power.

5. What is rectification? Explain the working of a full wave rectifier.

Ans: **Rectification:** The process of converting an alternating current into direct current is called rectification.



Working:

A full wave rectifier consists of two diodes D_1 and D_2. During the positive half cycles of ac input, diode 'D_1' is forward biased and diode 'D_2' is reverse biased. The current flows through load resistance R_L due to D_1 and D_2 will not conduct. During the negative half cycle of an ac input diode D_1 is reverse biased and D_2 is forward biased and current flows through load resistance due to D_2 and D_1 will not conduct. Hence current flows through load resistance during both the half cycles and in the same direction.Its efficiency $= \dfrac{0.812 \times R_L}{r_f + R_L}$

That means the maximum efficiency of full wave rectifier is 81.2%

6. Distinguish between half -wave and full-wave rectifiers

Ans:

Half wave rectifier	Full wave rectifier
i. In half wave rectifier only one diode is used.	i. In full wave rectifier two diodes are used.
ii. Half wave rectifier converts only one half of the AC into DC.	ii. Full wave rectifier converts both the half cycles of AC into DC.
iii. Its maximum efficiency is40.6%	iii. Its maximum efficiency is 81.2%
iv. A transformer without a centre tap is used in it.	iv. A transformer with centre tap is used in it.

7. Explain hole conduction in intrinsic semiconductors.

Ans. Intrinsic semiconductors : Semiconductors with ultra high pure state are called intrinsic semiconductors. In pure germanium (Ge) or silicon(Si) crystal every germanium or Silicon atom forms four covalent bonds with neighbouring Ge/Si crystal.

Due to thermal energy some of the electrons escapes from the bonds and an empty spaces left behind in the valence band. This vacancy in the valence band is called a hole. Due to applied electric field the holes drift in opposite direction to the electrons with lesser speed and behave like positive charge carriers and current is produced due to the both electrons and holes.

Current contribution by electrons (I_e) and holes (I_h) is same.

In an intrinsic semiconductor $n_e = n_h = n_i$

Total current $I = I_e + I_h$.

8. Explain the working of LED and what are its advantages over conventional incandescent low power lamps.?

Ans: **Working of LED**: It is a heavily doped p-n junction diode which emits light in forward bias. When the diodes forward biased electrons sent from and holes sent from. Due to this the concentration of minority charge carriers increases at the junction boundary and they recombine with majority carriers as result energy is released in the form of photons. The intensity of light proportional to the forward current.

Advantages of LED: (Any Two)

1. Low operational voltage and less power
2. Fast action and no warm-up time required
3. The bandwidth of emitted light is 100Å to 500 Å.
4. Long life and ruggedness.
5. Fast on-off switching capability

9. Explain the different transistor configurations with diagrams.

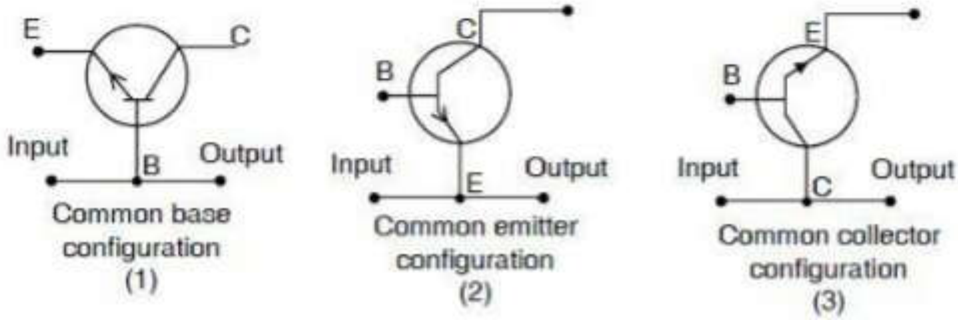
Ans. Transistor consists of three parts (1) emitter (2) base (3) collector (C).

Transistors are connected in three ways.

They are : 1) Common base configuration

2) Common emitter configuration

3) Common collector configuration



1) Common base configuration :

In this configuration base is common to both input and output. Base terminal is earthed and input is given across base emitter and output is taken across base collector.

2) Common emitter configuration :

In this configuration emitter is common to both input and output. The emitter is earthed and input is given across base emitter and output is taken across collector emitter.

3) Common collector configuration :

In this configuration collector is common to both input and output. The collector is earthed and input is given across base collector and output is taken across emitter collector.

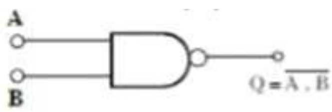
10. Define NAND and NOR gates. Give their truth tables.

NAND gate : NAND is combination of AND + NOT

The logic gate in which the output of AND gate is connected to the input of NOT gate is called NAND gate.

Truth table for NAND gate.

A	B	Y=A.B	$Y = \overline{A.B}$
0	0	0	1
0	1	0	1
1	0	0	1
1	1	1	0

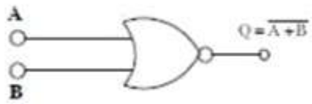


NOR-gate : NOR-gate is combination of OR + NOT

The logic gate in which the output of OR gate is connected to the input of NOT gate is called NOR gate.

Truth table for NOR gate.

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

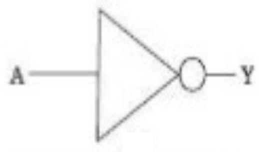


11. Explain the operation of a NOT gate and give its truth table.

Ans: **NOT gate :** It has one input terminal and one output terminal. When the input is low, the output is high and when the input is high, the output is low.

Truth tables of NOT gate : The truth tables of NOT gate interms of low and high (0 and 1) are as given below.

Input	Output
A	Y
0	1
1	0



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Chapter **16**

COMMUNICATION SYSTEM

VERY SHORT ANSWER QUESTIONS (2 MARKS)

1. What are the basic blocks of a communication system?

Ans: i) Transmitter

ii) Receiver

iii) Channel

2. What is "World Wide Web" (WWW) ?

Ans: It is an encyclopedia of knowledge accessible to everyone round the clock throughout year with the help of computer connectivity.

3. Mention the frequency range of speech signals?

Ans: 300 Hz to 3100 Hz

4. **What is sky wave propagation?**

Ans: In the frequency range from a 2 MHz upto 30 to 40 MHz long distance communication can be achieved by ionospheric reflection of radio wave back towards the earth. This mode of propagation is called sky wave propagation.

5. Mention the various parts of the ionosphere ?

Parts of ionsphere:-

1. D part of stratosphere (app. 65 km – 75 km)

2. E part of stratosphere (upto 100km)

3. F1 Part of Mesosphere (170 kms – 190 kms)

4. F2 Thermosphere (300 kms at night, 250 kms – 400 kms during day time)

6. Define modulation. Why it is necessary?

Ans: Modulation: The process of combining low frequency audio signal with high frequency signal is called modulation.

Necessity:

1. Low frequencies cannot be transmitted to long distances. Hence the modulation is necessary.
2. To reduce size of antenna
3. To increase effective radiated power by the antenna
4. To avoid mixing up of signals from different trans meters

7. Mention the basic methods of modulation?

Ans: i) Amplitude modulation(AM)

ii) Frequency modulation (FM)

iii) Phase modulation (PM)

8. **Which type of communication is employed in mobile phones?**

Ans: Space wave communication. Space waves in line of sight communication is employed in mobile phones

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