∴ Total charge,

$$q = q_1 + q_2 \quad ...(1)$$

But, $q_1 = C_1V_1$ and $q_2 = C_2V_2$

∴ From eqn. (1), we get

$$q = C_1V_1 + C_2V_2$$

We know that total capacity

$$C = C_1 + C_2$$

(i) Common potential : Let the conductors are connected by a wire so that the charges can flow from the conductor at high potential to the conductor at low potential till the potential of both the conductors become equal. Let the common potential be V.

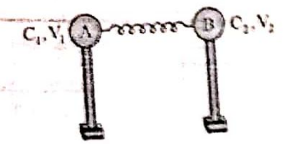


Fig.

$$V = \frac{\text{Total charge}}{\text{Total capacitance}} = \frac{q_1 + q_2}{C_1 + C_2}$$

$$\text{or } V = \frac{q_1 + q_2}{C_1 + C_2} = \frac{C_1V_1 + C_2V_2}{C_1 + C_2}$$

This is the expression for the common potential.

(ii) Loss of energy :

Energy of conductor

$$A = \frac{1}{2}C_1V_1^2$$

Energy of conductor

$$B = \frac{1}{2}C_2V_2^2$$

Total energy of the conductors before connection,

$$U = \frac{1}{2}C_1V_1^2 + \frac{1}{2}C_2V_2^2 = \frac{1}{2}(C_1V_1^2 + C_2V_2^2)$$

and total energy after connection

$$U' = \frac{1}{2}C_1V^2 + \frac{1}{2}C_2V^2 = \frac{1}{2}(C_1 + C_2)V^2$$

$$= \frac{1}{2}(C_1 + C_2)\left[\frac{C_1V_1 + C_2V_2}{C_1 + C_2}\right]^2$$

$$= \frac{1}{2}\frac{(C_1V_1 + C_2V_2)^2}{C_1 + C_2}$$

∴ Loss of energy

$$= U - U'$$

$$= \frac{1}{2}(C_1V_1^2 + C_2V_2^2) - \frac{1}{2}\frac{(C_1V_1 + C_2V_2)^2}{C_1 + C_2}$$

$$= \frac{1}{2}\left[\frac{(C_1V_1^2 + C_2V_2^2)(C_1 + C_2) - (C_1V_1 + C_2V_2)^2}{C_1 + C_2}\right]$$

$$= \frac{1}{2}\left[\frac{(C_1^2V_1^2 + C_1C_2V_1^2 + C_1C_2V_2^2 + C_2^2V_2^2) - (C_1^2V_1^2 + C_2^2V_2^2 + 2C_1C_2V_1V_2)}{C_1 + C_2}\right]$$

$$= \frac{1}{2}\left[\frac{C_1^2V_1^2 + C_1C_2V_1^2 + C_1C_2V_2^2 + C_2^2V_2^2 - C_1^2V_1^2 - C_2^2V_2^2 - 2C_1C_2V_1V_2}{C_1 + C_2}\right]$$

$$= \frac{1}{2}\left[\frac{C_1C_2V_1^2 + C_1C_2V_2^2 - 2C_1C_2V_1V_2}{C_1 + C_2}\right]$$

$$= \frac{1}{2}\frac{C_1C_2}{C_1 + C_2}(V_1 - V_2)^2$$

Since, $(V_1 - V_2)^2$ is always positive, therefore $U - U'$ will be always positive. Hence, in the distribution of charges, there is always a loss of energy proved.

$$\therefore \text{ Loss of energy } = \frac{1}{2}\frac{C_1C_2}{C_1 + C_2}(V_1 - V_2)^2$$

PRABODH MODEL PAPER SET-III

Instruction : Same as Model Paper Set-I

SECTION-A

Q. 1. What will be the nature of charges, if q_1 and q_2 are two point charges and they follow : $q_1q_2 > 0$? 1

Ans. $q_1q_2 > 0$ means both charges are either positive or negative. Hence both charges will repel each other.

Q. 2. "Transformer works on A.C. not on D.C.". Why ? 1

Ans. Transformer's working is based on principle of mutual induction. It's direction changes when direction of current flows changed and induced e.m.f. or induced current is generated in secondary coil, whereas direct current does not show the above phenomena.

Q. 3. "Intensity becomes maximum at some places, when two waves of almost same amplitude and frequency travels in a straight line". Why ? 1

Ans. Because of constructive interference.

Q. 4. What is the value of rest mass of photon. Write the formula of energy of photon of λ wavelength. 1

Ans. Zero, $E = \frac{hc}{\lambda}$.

Q. 5. Which type of semiconductor is obtained when we dopped Si with Ga ? 1

Ans. P-type semiconductor.

SECTION-B

Q. 6. Why metals cannot be used as a dielectric in any capacitor ? What is dielectric constant of metals ? 2

Ans. Metals are conductor. When metal will be used in place of a dielectric, it will conduct electricity and potential difference will become zero. So the capacitor will not act as a capacitor, therefore metal are not used as dielectric in the capacitors.

The dielectric constant of metals is infinite.

Q. 7. How will you represent a carbon r... of $14 \times 10^3\,\Omega \pm 5\%$ by colour code ?

Ans. Given : $R = 14 \times 10^3\,\Omega \pm 5\,\%$

Ring	I	II	III
Colour	Brown	Yellow	Orange
	1	4	$10^3\,\Omega$

Therefore, the resistance of $14 \times 10^3\,\Omega \pm$ ... be represented by the bands of brown, yellow ... and golden.

Q. 8. Potentiometer is superior over ... How ?

Or

"Potentiometer is an ideal voltmeter." C... statement.

Ans. When potential difference betw... points is measured by using a voltmeter, so... flows through the coil of voltmeter. Th... potential difference thus measured is slightly ... the actual value. But potential difference ... by using potentiometer is more accurate, b... current flows through the balancing length ... potentiometer. Hence, the potentiometer is ... voltmeter.

There may be some error in taking the ... pointer of voltmeter due to least count and ... factors. But as the potentiometer is bas... principle of null deflection so there is no p... such error caused by reading. So, it is ... potentiometer is superior over a voltmeter.

Q. 9. What are coherent sources ? W... the conditions for coherent sources. Ca... dent sources be coherent.

Ans. Two sources are said to be ... they emit light waves of the same freq... the same amplitude and zero or con... difference :

Conditions : (i) The frequency of ... should be equal

(ii) Phase difference should be ... should not change with time.

No, two dependent sources can...

Q. 22. A T. V. antenna is of height 'h' metre. Show that it can be used to transmit the signal up to a distance $d = \sqrt{2hR}$ on the earth surface where R is the radius of Earth. 3

Or

Prove that transmission can take place up to a distance $d = \sqrt{2hR}$. Where R is the radius of the earth and h is the height of T.V. tower.

Ans. Let PQ is a T.V. tower of height h on the surface of earth at P. Suppose a T.V. transmitter is fixed at the top of this tower which transmits the signals in all directions as shown in following figure.

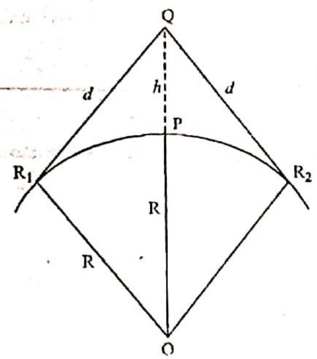


Fig. Relation between height of T.V. tower and transmision range.

Draw the tangents QR_1 and QR_2 from the point Q. It is clear from the figure, that the signals can reach directly on the surface of earth upto points R_1 and R_2. If a circle is drawn, with radius PR_1 and centre P, on the earth surface, then the transmitted signals can be received within this circle. Suppose the radius of earth is R, then $OR_1 = OR_2 = R$ (The height of T.V. tower h is negligible than R). Hence,

$$QR_1 \cong PR_1 = d$$

Now in right angle triangle OQR_1,

$$OQ^2 = OR_1^2 + QR_1^2$$

or $\quad (R+h)^2 = R^2 + d^2$

or $\quad R^2 + 2Rh + h^2 = R^2 + d^2$

or $\quad 2Rh + h^2 = d^2 \quad$ ...(1)

As $2Rh >> h^2$ hence h^2 can be neglected

$\therefore$ From eqns. (1), we get

$$d^2 = 2Rh$$

or $\quad d = \sqrt{2Rh}.$

SECTION-D

Q. 23. A group of students while coming from school noticed a box marked "Danger H.T. 440volt" on an electric pole at the side of road. They were not knowing the utility of 440 volt supply. They asked this question to their physics teacher. The teacher thought it to be an important question and hence explained to the whole class. Answer the following questions : 4

(a) Name the device which converts high a.c. voltage to low a.c. voltage. On what principle it works ?

(b) Explain the working principle of this device.

Ans. See Board Q. No. 23 (Or) of Set-I.

Or

Ghanshyam is a student of class XII in a village school. His uncle gifted him a bicycle with a dynamo fitted in it. While cycling during night he could light the bulb and see the things on the road. He however did not know how this device works. The teacher considering it and important question explained to the whole class. Answer the following questions :

(a) The working principle of dynamo is similar to law of conservation of energy. Explain.

(b) What are the other uses of dynamo ?

Ans. See Board Q. No. 23 of Set-I.

SECTION-E

Q. 24. What is a capacitor ? Derive an expression for capacity of a parallel plate capacitor. Write the factors affecting its capacity. 5

Ans. A capacitor is device by which capacity of a conductor is increased without changing its size or shape. Actually it stores electric energy.

Let A and B be two plates of a parallel plate capacitor separated by a distance d apart. Area of each plate is A and dielectric constant of the medium between them is ε_r.

Now, plate A is given $+q$ charge. Therefore, $-q$ charge will be induced on the nearer surface of the plate B and $+q$ charge on the other side. As B is connected to earth, $+q$ charge of B will go to earth.

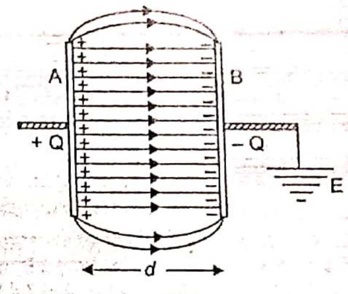


Fig.

Let the charge density of A is σ, therefore that of B will be $-\sigma$.

Now, $\quad \sigma = \dfrac{q}{A}$

$\therefore$ Intensity between the plates will be given by

$$E = \frac{\sigma}{\varepsilon_0 \varepsilon_r}.$$

$\Rightarrow \quad E = \dfrac{q}{A\varepsilon_0\varepsilon_r}, \quad [q = \text{charge}]$

But, potential difference between the plates A and B is

V = Electric field intensity × Distance between the plates

$= Ed$

or $\quad V = \dfrac{q}{A\varepsilon_0\varepsilon_r}.d$

But $\quad C = \dfrac{q}{V} = \dfrac{q}{\dfrac{q}{A\varepsilon_0\varepsilon_r}.d}$

$\therefore \quad C = \dfrac{\varepsilon_r\varepsilon_0 A}{d} \quad$ ...(1)

This is the required relation.

For air or vacuum,

$$\varepsilon_r = 1$$

$\therefore \quad C = \dfrac{\varepsilon_0 A}{d}.$

Factors affecting its capacity :

(i) Distance between its two plates (d) : With increase in distance capacity decreases $C \propto \dfrac{1}{d}$.

(ii) Surface area of plates of capacitor : Capacity increases with increase in surface area $C \propto A$.

(iii) Presence of dielectric medium between the plates : Capacity increase, $C' = kC$.

Or

Prove that there is loss of energy due to distribution of energy when two conductors are connected to each other.

Ans. Let A and B be two conductors of capacities C_1 and C_2 respectively. When charges Q_1 and Q_2 are given separately, the potential becomes V_1 and V_2 respectively.

$\therefore$ Total charge,

$$Q = Q_1 + Q_2$$

But, $\quad Q_1 = C_1V_1$ and $Q_2 = C_2V_2 \quad$ ...(1)

$\therefore$ By eqn. (1), we get

$$Q = C_1V_1 + C_2V_2$$

$\therefore$ Total capacity

$$C = C_1 + C_2$$

(i) Common potential : Let the conductors are connected by a wire and the common potential becomes V.

$\therefore \quad Q_1 + Q_2 = (C_1 + C_2)V$

or $\quad V = \dfrac{Q_1 + Q_2}{C_1 + C_2}$

or $\quad V = \dfrac{C_1V_1 + C_2V_2}{C_1 + C_2} \quad$ ...(2)

This is the expression for the common potential.

(ii) Loss of energy : Total energy of the conductors before connection :

$$U_1 = \frac{1}{2}C_1V_1^2 + \frac{1}{2}C_2V_2^2 \quad ...(3)$$

and total energy after connection,

$$U_2 = \frac{1}{2}C_1V^2 + \frac{1}{2}C_2V^2$$

$$= \frac{1}{2}(C_1 + C_2)V^2 \quad ...(4)$$

Putting the value of V from eqn. (2) in eqn. (4), we get

$$U_2 = \frac{1}{2}(C_1 + C_2)\left(\frac{C_1V_1 + C_2V_2}{C_1 + C_2}\right)^2$$

$$= \frac{1}{2}(C_1 + C_2)\frac{(C_1V_1 + C_2V_2)^2}{(C_1 + C_2)^2}$$

From fig.

In ΔPQO, $\tan\alpha = \dfrac{PQ}{OQ}$

$$= -\frac{P'Q'}{OQ}, \quad (\because PQ = -P'Q')$$

In $\Delta P'Q'O'$, $\tan\beta = \dfrac{P'Q'}{O'Q'}$

Putting these values in eqn. (1), we get

$$m = -\frac{\dfrac{P'Q'}{O'Q'}}{\dfrac{P'Q'}{OQ}} = -\frac{OQ}{O'Q'} \quad \ldots (2)$$

But $\quad OQ = f_o$

and $\quad O'Q' = -u_e \quad$ (by sign convention)

$$m = -\frac{f_o}{-u_e}$$

or $$m = \frac{f_o}{u_e} \quad \ldots(3)$$

When the image is formed at least distance of distinct vision : The image formed by the erecting lens lies within the focal length of eyepiece *i.e.*, in between O' and f_e for eyepiece $u = -u_e$ and $v_e = -D$.

Applying lens formula $\dfrac{1}{f} = \dfrac{1}{v} - \dfrac{1}{u}$, we get

$$\frac{1}{f_e} = -\frac{1}{D} - \frac{1}{-u_e}$$

$$\Rightarrow \quad \frac{1}{u_e} = \frac{1}{f_e} + \frac{1}{D}$$

Putting this value in eqn. (3), we get

$$m = f_o\left(\frac{1}{f_e} + \frac{1}{D}\right)$$

$$\Rightarrow \quad \boxed{m = \frac{f_o}{f_e}\left(1 + \frac{f_e}{D}\right)}$$

This is the required expression.

This is equation of current through the AC circuit containing pure inductance where peak value of current

$$I_0 = \frac{V_0}{\omega L} = \frac{V_0}{2\pi f L} \quad ...(3)$$

∴ Reactance of the circuit

$$X_L = \omega L = 2\pi f L \quad ...(4)$$

From eqns. (1) and (2), it is clear that phase difference between current and voltage is

$$\phi = -\frac{\pi}{2} \quad ...(5)$$

Hence, it is clear that in an inductive circuit, the current always lags behind the voltage by $\frac{\pi}{2}$.

(ii) The peak value of current $I_0 = \frac{V_0}{\omega L}$

The average power consumed in this circuit is zero.

(iii) The variant of voltage and current with time is shown in fig. (b) and phasor diagram is shown in fig. (c).

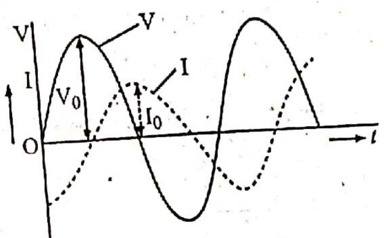


Fig. (b) : Voltage and current graph.

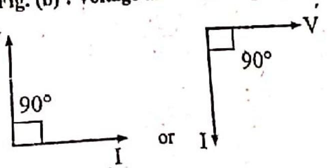


Fig. (c) : Phasor diagram.

SECTION–E

Q. 24. Obtain an expression for intensity of magnetic field due to circular coil carrying current, at its centre. 5

Ans. Let I current is flowing through a circular of coil of radius 'r'. At its centre the intensity of magnetic field is to be determined. As shown in fig. , let the number of turns in this coil are 'n'. Let us take a small element AB of length 'dl'. The line joining the small element to centre 'O' makes 90° angle with the small element.

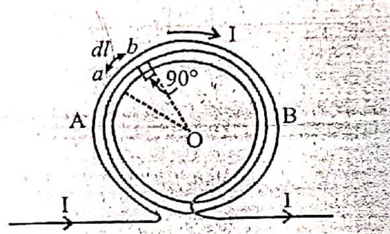


Fig. Intensity of magnetic field at the centre of circular coil carrying current.

According to Biot Savart's law, the intensity of magnetic field at O due to small element AB is

$$dB = \frac{\mu_0}{4\pi}\frac{Idl\sin 90°}{r^2}$$

or $$dB = \frac{\mu_0}{4\pi}\frac{Idl}{r^2} \quad ...(1)$$

[∵ sin 90° = 1]

By Maxwell's right hand screw rule, the direction of the magnetic field is into the plane of the paper vertically downwards. The total intensity of magnetic field due to all the line elements can be obtained by intergrating eqn. (1),

$$B = \oint dB = \oint \frac{\mu_0}{4\pi}\frac{Idl}{r^2}$$

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

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

or $$B = \frac{\mu_0}{4\pi}\frac{2\pi I}{r} \quad ...(2)$$

If n be the number of turns in the coil, then

$$B = \frac{\mu_0}{4\pi}\frac{2\pi n I}{r} \quad ...(3)$$

This is the required formula.

Or

Derive an expression for potential energy of a bar magnet placed in a uniform magnetic field making angle θ with the direction of field.

Ans. The potential energy of the magnetic dipole is equal to the amount of work done in rotating the magnet from its standard position (*i.e.*, magnet makes 90° with the direction of field) to its present position.

Let M is the magnetic moment of bar magnet, the magnet is placed in the magnetic field of intensity B making an angle θ with the direction of field.

The restoring torque on magnet will be

$$\tau = MB\sin\theta$$

Work done in deflecting the magnet through small angle $d\theta$ will be

$$dW = \tau d\theta = MB\sin\theta\, d\theta$$

∴ Work done in rotating the magnet from

$$\theta_1 = \frac{\pi}{2} \text{ to } \theta_2 = \theta$$

$$W = \int_{\pi/2}^{\theta} MB\sin\theta d\theta$$

$$= MB\left[\int_{\pi/2}^{\theta}\sin\theta d\theta\right]$$

$$= MB[-\cos\theta]_{\pi/2}^{\theta}$$

$$= -MB\left[\cos\theta - \left(\cos\frac{\pi}{2}\right)\right]$$

$$W = -MB\cos\theta$$

This work termed as potential energy of magnet

∴ Potential energy

$$U = -MB\cos\theta$$

$$= -\vec{M}.\vec{B}$$

This is the required expression.

Cases : (i) When $\theta = 0$

$$U = -MB\cos\theta = -MB\cos 0$$

$$U = -MB$$

(ii) When $\theta = 90°$

$$U = -MB\cos\theta$$

$$= -MB\cos 90°$$

$$U = 0$$

(iii) When $\theta = 180°$

$$U = -MB\cos 180°$$

$$U = -MB(-1)$$

$$U = MB.$$

Q. 25. Prove for a lens :

$$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$ **where the symbols have their usual meaning.**

Or

Draw ray diagram of the refraction through ... and derive the refraction formula.

Or

Derive the lens maker formula.

Sol. Consider a lens bounded by two ... surfaces AB and CD of radii of curvature R_1 ... respectively. A point object O is placed on the ... axis of lens. The image I_1 of the object O is fo... the first surface AB *i.e.*, if it is seen from ... lens, the image will appear at I_1.

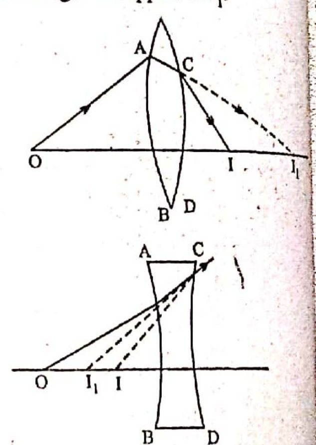


Fig. Refraction lenses.

Now, I_1 becomes an object for the surfa... the final image is formed at I by surface C...

Due to first surface AB the image of ... formed at I_1. Hence, by refraction formula

$$\frac{\mu}{v_1} - \frac{1}{u} = \frac{\mu - 1}{R_1}$$

Where μ is refractive index of mater... Since for the surface CD, I_1 acts as virtua... its image is formed at I, therefore by refract...

Q. 14. Write four equations of Maxwell. Also define the meaning of symbols ? 3

Ans. Maxwell's eqn. includes :

(a) Coulomb's law of electrostatic

(b) Gauss's law

(c) Faraday's law

(d) Ampere's circuital law.

(1) $\oint \vec{E}.ds = \frac{q}{\varepsilon_0}$

(2) $\oint \vec{B}.ds = 0$

(3) $\oint E.dl = \frac{-d\phi_B}{dt} \Rightarrow e = \frac{-d\phi}{dt}$

(4) $\oint \vec{B}.dl = \mu_0 \left(I_C + \varepsilon_0 \frac{d\phi_E}{dt} \right)$

Where : I_d (Displacement current) $= E_0 \frac{d\phi_E}{dt}$.

Q. 15. The angle of polarization of a transparent medium is 60°, then find the following : 3

(i) Refractive index of medium.

(ii) Angle of refraction.

Sol. (i) Formula : $\mu = \tan i_p$

Given : $i_p = 60°$

$\mu = \tan 60° \Rightarrow \mu = \sqrt{3}$. **Ans.**

(ii) $i_p + r = 90°$.

$r = 90° - i_p$

$= 90° - 60° \Rightarrow r = 30°$. **Ans.**

Q. 16. Establish relation between *u*, *v* and *f* for convex lens also draw graph for $\frac{1}{u}$ and $\frac{1}{v}$. 3

Ans. Let C is the optical centre of a convex lens. An object AB is placed in front of the lens. The real and inverted image A′B′ is formed by the lens.

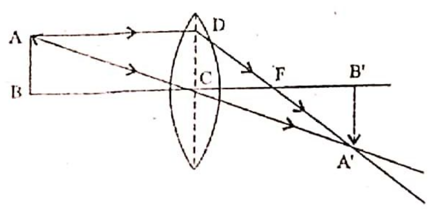


Fig.

According to sign convention,

CB $= -u$, CB′ $= v$ and CF $= f$

As Δ ABC ~ Δ A′B′C

$\therefore \frac{AB}{CB} = \frac{A'B'}{CB'}$

or $\frac{AB}{A'B'} = \frac{CB}{CB'}$ ...(1)

Similarly, Δ DCF ~ Δ A′B′F

$\therefore \frac{DC}{CF} = \frac{A'B'}{FB'}$

or $\frac{DC}{A'B'} = \frac{CF}{FB'}$

But DC = AB

$\therefore \frac{AB}{A'B'} = \frac{CF}{FB'}$ ...(2)

From eqn. (1) and eqn. (2),

$\frac{CB}{CB'} = \frac{CF}{FB'}$

or $\frac{CB}{CB'} = \frac{CF}{CB' - CF}$

Substituting the values,

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

or $-u(v - f) = vf$

or $-uv + uf = vf$

Divided both sides by *uvf*,

$\frac{-uv}{uvf} + \frac{uf}{uvf} = \frac{vf}{uvf}$

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

or $\boxed{\frac{1}{f} = \frac{1}{v} - \frac{1}{u}}$ This is the required formula.

Graph :

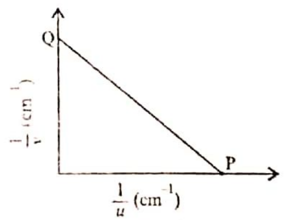


Fig.

Q. 17. A proton and α-particle accelerated with same velocity. Find the ratio of their de-Broglie wave-length. 3

Sol. For proton :

$$\lambda_p = \frac{h}{m_p v_p},$$

and for α-particle

$$\lambda_\alpha = \frac{h}{m_\alpha v_\alpha}$$

$$\frac{\lambda_p}{\lambda_\alpha} = \frac{\frac{h}{m_p v_p}}{\frac{h}{m_\alpha v_\alpha}} = \frac{m_\alpha v_\alpha}{m_p v_p}$$

Here, $v_p = v_\alpha$, $m_\alpha = 4m_p$

$$\frac{\lambda_p}{\lambda_\alpha} = \frac{v_p (4m_p)}{v_p (m_p)}$$

$$\frac{\lambda_p}{\lambda_\alpha} = \frac{4}{1}.$$

Hence, $\lambda_p : \lambda_\alpha = 4 : 1$ **Ans.**

Q. 18. Explain the Balmer series of spectrum series. Also write the value of wavelength of Balmer series. 3

Ans. In the spectrum of hydrogen atom the spacing between the lines with in certain set of the hydrogen spectrum decreases in a regular way. Each of these sets is called a spectral series.

In 1885 the 1st such series was observed by a Swedish school teacher Johanan Jakob Balmer in the visible region of the hydrogen spectrum. The series is called Balmer series.

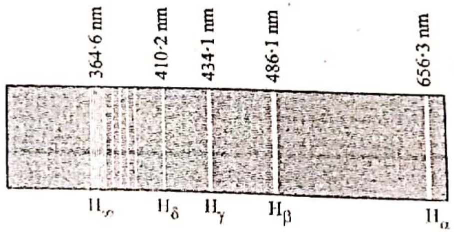


Fig. L

$$\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{n^2}\right) \quad ...(1)$$

where λ is the wavelength, R is a cons[...] the Rydberg constant, and *n* may have inte[...] 3, 4, 5, etc. The value of R is $1{\cdot}097 \times 10^{[...]}$ equation is also called Balmer formula.

Taking $n = 3$ in eqn. (1), one obtains the [...] of the H_α line :

$$\frac{1}{\lambda} = 1{\cdot}097 \times 10^7 \left(\frac{1}{2^2} - \frac{1}{3^2}\right) m^{-1}$$

$$= 1{\cdot}522 \times 10^6 \, m^{-1}$$

i.e., $\lambda = 656{\cdot}3$ nm.

Q. 19. The sequence of step-wise deca[...] dioactive nucleus is :

$$D \xrightarrow{\beta-} D_1 \xrightarrow{\alpha} D_2$$

If the mass number and atomic n[...] D_2 are 176 and 71 respectively. Answer [...] wing :

(i) Mass number of D.

(ii) Atomic number of D.

Ans. $D \xrightarrow{\beta-} D_1 \xrightarrow{\alpha\text{-particle}}$

$^{180}_{72}D \longrightarrow {}^{180}_{73}D_1 \longrightarrow$

(i) Mass number of D = 180.

(ii) Atomic number of D = 72.

Q. 20. Define amplifier. Draw the la[...] gram of N-P-N transistor in CE mode a[...] fier. Write the formula of current gain.

Ans. Amplifier : The amplifier is a de[...] amplifies the power of alternating current[...]

Use of N-P-N transistor as an ampl[...] mode : The circuit diagram of a transistor [...] CE mode is shown in fig. The input signal [...] be amplified is applied across the base an[...] transistor. A high resistance is conn[...] collector circuit.

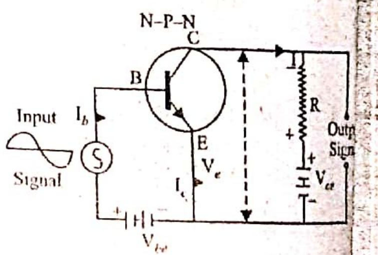


Fig. N-P-N transistor as an ampli[...] C.E. mode.

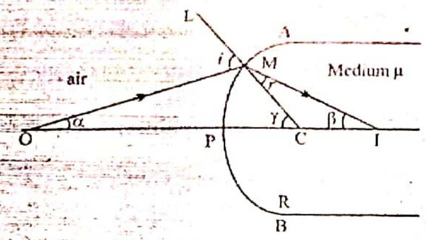


Fig. Refraction at convex refracting surface.

or $\left(\frac{1}{OP}+\frac{1}{PC}\right)=\mu\left(\frac{1}{PC}-\frac{1}{PI}\right)$ ...(3)

$\because$ OP $=-u$, PC $=+R$, PI $=+v$

putting these values in (3)

$$-\frac{1}{u}+\frac{1}{R}=\mu\left(\frac{1}{R}-\frac{1}{v}\right)$$

or $$-\frac{1}{u}+\frac{1}{R}=\frac{\mu}{R}-\frac{\mu}{v}$$

or $$\frac{\mu}{v}-\frac{1}{u}=\frac{\mu}{R}-\frac{1}{R}$$

or $$\frac{\mu}{v}-\frac{1}{u}=\frac{\mu-1}{R}$$

This is the required refraction formula.

Or

Describe terrestrial telescope under the follo-wing heads :

1. Ray diagram of image formation.

2. Magnifying power and length of tube when (i) Final image is formed at least distance of distinct vision. (ii) Final image is formed at infinity.

Ans. 1. Ray diagram of image formation : In fig. the ray diagram of terrestrial telescope is shown.

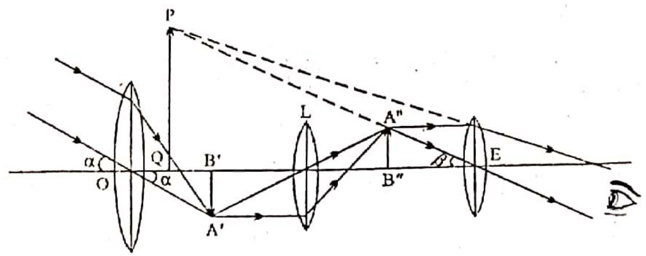


Fig. (a) When final image is formed at least distance of distinct vision

Since A"B" is inverted w.r.t. A'B' hence it is erected w.r.t. actual object. The distance between A'B' and A"B" is equal to $4f$. The eye piece is so adjusted that image A"B" is formed between its optical centre and focus. In this situation final image PQ is formed at least distance of distinct vision (fig. [a]).

But if the image A"B" is formed at focus of eye piece, then final image is formed at infinity (fig. [b]).

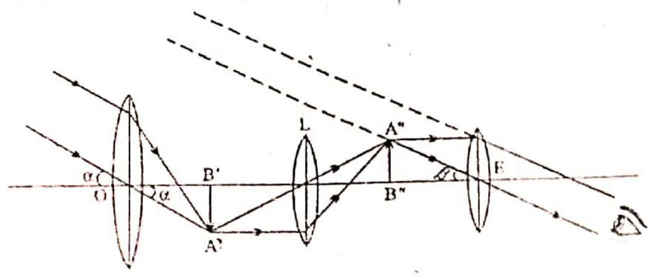


Fig. (b) When final image is formed at infinity

Expression for magnifying power : It is defined as the ratio of visual angle of final image to that of the visual angle of object.

$\therefore$ $$m=\frac{\text{Visual angle of final image}}{\text{Visual angle of object}}$$

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

As the object is situated very far, hence visual angle formed on the objective is equal to the visual angle formed on the eyepiece.

As, the angles α and β are very less, hence $\alpha\approx\tan\alpha$ and $\beta\approx\tan\beta$.

$\therefore$ $$m=\frac{\beta}{\alpha}=\frac{\tan\beta}{\tan\alpha} \quad ...(1)$$

By the figure,

$$\tan\alpha=\frac{A'B'}{OB'}=\frac{-A''B''}{OB'},$$

[$\because$ A'B' = −A"B"]

And $$\tan\beta=\frac{A''B''}{EB''}$$

Putting the values in eqn. (1), we get

$$m=\frac{A''B''/EB''}{-A''B''/OB'}$$

or $$m=\frac{-A''B''}{EB''}\times\frac{OB'}{A''B''}$$

or $$m=\frac{-OB'}{EB''} \quad ...(2)$$

But OB' $=f_0$ and EB" $=-u_e$

Putting the value in eqn. (2), we get

$$m=\frac{-f_o}{-u_e}$$

or $$m=\frac{f_o}{u_e} \quad ...(3)$$

Case I : When final image is formed at least distance of distinct vision : Let focal length of eye piece is f_e, then for eye piece $u=-u_e$ or $v=-D$.

By lens formula $\frac{1}{f}=\frac{1}{v}-\frac{1}{u}$,

or $$\frac{1}{f_e}=\frac{1}{-D}-\frac{1}{-u_e}$$

or $$\frac{1}{f_e}=-\frac{1}{D}+\frac{1}{u_e} \text{ or } \frac{1}{u_e}=\frac{1}{f_e}+\frac{1}{D}$$

Putting the value in eqn. (3), we get

$$m=f_o\left(\frac{1}{f_e}+\frac{1}{D}\right)$$

or $$m=\frac{f_o}{f_e}\left(1+\frac{f_e}{D}\right)$$

In this condition, the length of telesco[pe]

L $=f_o+4f+|u_e|$.

Case II : When final image is formed at [infinity :] When the image A"B" is formed at the focal [length of] eye piece, then $u_e=f_e$. In this condition, [final image is] formed at infinity.

$\therefore$ $$m=\frac{f_o}{f_e}$$

In this condition, the length of telesc[ope]

L $=f_o+4f+f_e$.

Q. 26. Derive an expression for inten[sity of] electric field at a point on equatorial line o[f elec]tric dipole.

Ans. Let AB be an electric dipole whic[h consists] of $+q$ and $-q$ charges separated by a d[istance] '$2l$' intensity of field at P, due to $+q$ charg[e]

$$E_1=\frac{1}{4\pi\varepsilon_0}\frac{q}{AP^2} \quad \text{(along AP)}$$

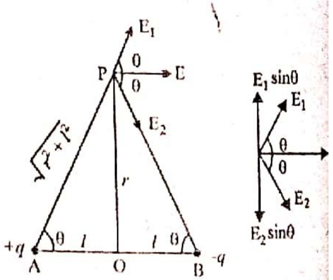


Fig.

But, $AP^2=OP^2+OA^2$

or $AP^2=r^2+l^2$

$$E_1=\frac{1}{4\pi\varepsilon_0}\frac{q}{(r^2+l^2)}$$

Q. 17. Threshold frequency in photoelectric effect gives more importance to photon theory than wave theory. Explain. 3

Ans. According to wave theory, the photoelectric should be possible for any frequency, if the light of higher intensity is used. But according to Einstein's photoelectric equation, the kinetic energy of emitted electron is :

$$\frac{1}{2}mv^2 = h\upsilon - h\upsilon_0$$

If threshold frequency υ_0 is greater than frequency of incident rays, then kinetic energy will be negative which is not possible. Hence, the threshold frequency has importance in photoelectric effect.

Q. 18. Lyman, Balmer and Paschen series of hydrogen spectrum lies in which range ? Write the formula of wavelength. 3

Ans. (i) Lyman Series : It is the series in which the spectral lines correspond to the transition of electron from some higher energy states to the lower energy state $n_f = 1$.

$$\therefore \quad \bar{v} = \frac{1}{\lambda} = R_H\left(\frac{1}{1^2} - \frac{1}{n_i^2}\right)$$

where $n_i = 2, 3, 4, \ldots\ldots$

They lie in UV region of the spectra.
Longest wavelength = 1216Å
Shorter wavelength = 912 Å

(ii) Balmer series : It is the series in which spectral lines correspond to the transition of electron from some higher energy states to the lower energy state $n_f = 2$.

$$i.e., \quad \bar{v} = \frac{1}{\lambda} = R_H\left(\frac{1}{Z^2} - \frac{1}{n_i^2}\right)$$

Where $n_i = 3, 4, 5 \ldots$

These lie in the visible region of spectra.
Longest wavelength = 6563Å
Shorter wavelength = 3646Å

(iii) Paschen series : It is the series in which spectral lines correspond to the transition of electron from some higher energy states to the lower energy state $n_f = 3$.

$$i.e., \quad \bar{v} = \frac{1}{\lambda} = R_H\left(\frac{1}{3^2} - \frac{1}{n_i^2}\right)$$

where $n_i = 4, 5, 6, \ldots\ldots$

These lie in the IR region of spectra.

Q. 19. Plot the graph of the binding energy per nucleon E_{bn} as a function of mass number. Give reason for loss of energy of nuclei having large mass number. 3

Ans. Nuclei having large mass number is heavy and unstable. Therefore value of binding energy per nucleon starts decreasing.

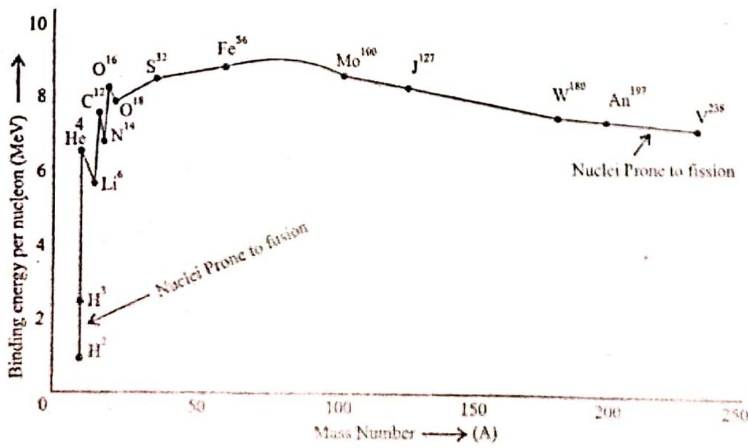
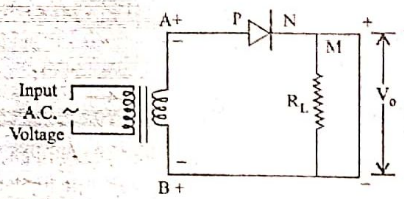


Fig.

Q. 20. What do you mean by rectification ? draw the labelled diagram of P-N junction diode as a half wave rectifier. 3

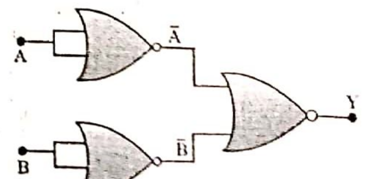
Ans. Rectification— The process of conversion of alternating current to direct current is called rectification.



T– Step up transformer
PN –Junction diode
R_L–load resistor
V_o output voltage.

Q. 21. Which gates are known as universal gates ? How can we obtain AND gate from NOR gates ? 3

Ans. NOR and NAND gates are called universal getes.



$\boxed{Y = A.B}$

Q. 22. What do you understand by ground wave propagation ? What are the factors that affect it ? Write suitable frequency range ? 3

Ans. In ground wave propagation radio waves move near and along with the surface of earth.

Frequency range : Below 1.5 MHz

Factors— (i) Length of antenna.
(ii) Frequency of waves
(iii) Power of waves.

SECTION-D

Q. 23. In the field of Amit a tower of maximum power is established and this tower covered a large portion of field. Amit wants to remove that tower, and field so many applications. Amit's elder sister who is a teacher explained the Amit the impo of this tower. After the conversation with his sister, Amit conviced.

On the basis of above paragraph answer following question.

(i) Why is it necessary for transfer of th ergy ?

(ii) "Low power ratio implies high loss". Explain.

(iii) What are the values displayed by An his sister ?

Ans. (i) Transfer of power at high voltage the economic loss.

(ii) P = VIcosθ, *i.e.* cosθ will be less fo potential V, then I increases. Hence power P also increases.

(iii) Amit's sister explained the importance tower and power transmission to Amit.

Or

Seema is student of class X in a village her uncle gifted her a cycle with a dynam while cycling during night she light the bulb the things on the road. She however did not kn this device works. He asked her class teach her teacher explained to the whole class. An following questions :

(i) On which principle dynamo works

(ii) What are the values displayed Seema teacher ?

Ans. (i) Dynamo is based on the principle tromagnetic induction. When magnetic flux lin the coil changes an emf is induced in the bulb starts glowing.

(ii) Scientific attitude. Curiosity towards

SECTION-E

Q. 24. Draw the diagram of Weston galvanometer and explain its construc working. How it can be made more sens

Ans. Construction : It is a moving-coi meter. The coil consists of insulated cop wound on an aluminium frame. This coil res the pole pieces of a strong horseshoe mag pivots. The pole pieces of magnet are cut in shape to make the field radial. Two sp connected to the two pivots in opposite which apply restoring couple.

$$\therefore \quad U_2 = \frac{1}{2}\cdot\frac{(C_1V_1 + C_2V_2)^2}{C_1 + C_2}$$

Hence, difference of energy,

$$U_1 - U_2 = \frac{1}{2}C_1V_1^2 + \frac{1}{2}C_2V_2^2 - \frac{1}{2}\frac{(C_1V_1 + C_2V_2)^2}{C_1 + C_2}$$

$$= \frac{1}{2}\left[\frac{(C_1V_1^2 + C_2V_2^2)(C_1 + C_2) - (C_1V_1 + C_2V_2)^2}{C_1 + C_2}\right]$$

$$= \frac{1}{2}\left[\frac{C_1^2V_1^2 + C_1C_2V_1^2 + C_1C_2V_2^2 + C_2^2V_2^2 - C_1^2V_1^2 - C_2^2V_2^2 - 2C_1C_2V_1V_2}{C_1 + C_2}\right]$$

$$= \frac{1}{2}\left[\frac{C_1C_2V_1^2 + C_1C_2V_2^2 - 2C_1C_2V_1V_2}{C_1 + C_2}\right]$$

$$= \frac{1}{2}C_1C_2\left[\frac{V_1^2 + V_2^2 - 2V_1V_2}{C_1 + C_2}\right]$$

$$= \frac{1}{2}\left[\frac{C_1C_2(V_1 - V_2)^2}{C_1 + C_2}\right]$$

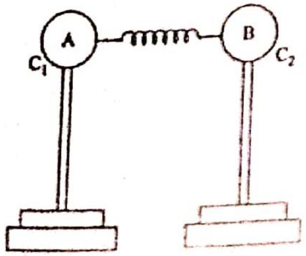


Fig.

$\because (V_1 - V_2)^2$ is positive, hence $(V_1 - V_2)$ is positive. Hence, during redistribution there will be always difference of energy.

i.e., $U_1 - U_2 > 0 \Rightarrow U_1 > U_2$

i.e., energy before joining is greater than energy after joining.

$\therefore$ The loss in energy,

$$\Delta U = \frac{C_1C_2}{2(C_1 + C_2)}(V_1 - V_2)^2.$$

Q. 25. What do you mean by magnetic field intensity ? Derive an expression for magnetic field intensity at a point lying on the axis of current carrying solenoid. **5**

Sol. Magnetic field intensity : It is the force experienced by unit north pole at any point in the magnetic field.

Consider a very long solenoid having n turns per unit length carrying current I. The magnetic field inside the solenoid is uniform and directed along the axis of solenoid.

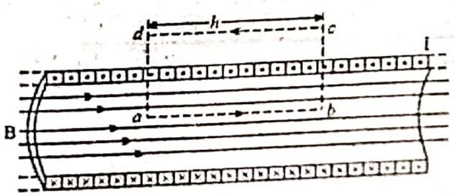


Fig. An application of ampere's law to a section of a long ideal solenoid carrying current I. The amperian loop is the rectangle *abcd*.

Consider a rectangular amperian loop *abcd* in a solenoid. Magnetic field B is uniform within the solenoid. Let the length of the amperian loop be h.

$\therefore$ Total number of turns in amperian loop $= nh$.

The integral $\oint \vec{B}.\vec{dl}$ is basically equal to the sum of four integrals

i.e., $$\oint \vec{B}.\vec{dl} = \int_a^b \vec{B}.\vec{dl} + \int_b^c \vec{B}.\vec{dl} + \int_c^d \vec{B}.\vec{dl} + \int_d^a \vec{B}.\vec{dl} \quad ...(1)$$

Now, $$\int_a^b \vec{B}.\vec{dl} = \int_a^b Bdl\cos 0^\circ,$$

($\because \vec{B}$ is parallel to $\vec{dl}$ along ab)

$$= \int_a^b Bdl = B\int_a^b dl$$

$$= B(l)_a^b = B(b - a) = Bh$$

Again, $$\int_b^c \vec{B}.\vec{dl} = \int_b^c B.dl\cos 90^\circ = 0$$

and $$\int_d^a \vec{B}.\vec{dl} = 0,$$

($\because bc$ and da are perpendicular to the direction of magnetic field $\vec{B}$)

Now, $$\int_c^d \vec{B}.\vec{dl} = 0,$$

($\because$ Magnetic field outside the solenoid is zero)

$\therefore$ Putting the values in eqn. (1), we get

$$\int_c^d \vec{B}.\vec{dl} = Bh + 0 + 0 + 0 = Bh \quad ...(2)$$

According to ampere's circuital law,

$$\oint \vec{B}.\vec{dl} = \mu_0 \times \text{net current enclosed by the amperian loop } abcd.$$

$$= \mu_0 \times \text{number of terms in loop} \times I$$

$$= \mu_0\, nhI \quad ...(3)$$

Comparing eqns. (2) and (3),

$$Bh = \mu_0\, nhI$$

$$B = \mu_0\, nI.$$

This is the required expression. **Ans.**

Or

What is cyclotron ? Write its construction and working ?

Ans. Cyclotron : Cyclotron is a device which is used to accelerate positively charged particles like α-paricle and protons.

It is based on the principle that when a positively charged particle is made to move again and again in a high frequency electric field and using strong magnetic field, then it gets accelerated and acquires sufficiently large amount of energy.

Construction : It consist of two hollow D-shaped metallic chambers D_1 and D_2, called dees. These dees are separated by a small gap where a source of positively charged particle is placed. Dees are connected to a high frequency oscillator, which provide high frequency electric field across the gap of the dees. This arrangement is placed between two poles of strong electromagnet. The magnetic field due to this electromagnet is perpendicular to the plane of the dees.

Principle : When a positively charged particle is made to move again and again under the influence of magnetic field and high frequency electric field, then gain large amount of energy.

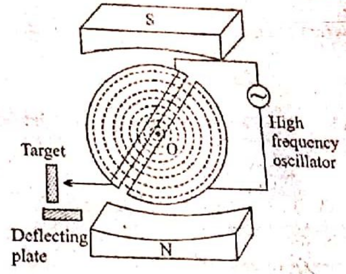


Fig.

Working : If a positively charged particle (proton) is emitted from O, when D_2 is negatively charged and the dee D_1 is positively charged, it will accelerate towards D_2. As soon as it enters D_2, it is shielded from the electric field by metallic chamber (enclosed space). Inside D_2, it moves at right angles to the magnetic field and hence describe a semi-circle inside it. After completing the semicircle, it enters the gap between the dees at the time when the polarities of the dees have been reversed. Now, the proton is further accelerated towards D_1. Then it enters D_1 and again describes the semicircle due to the magnetic field which is perpendicular to the motion of the proton. This motion continues till the proton reaches the periphery of the dee system. At this stage, the proton is deflected by the deflecting plate which then comes out through the window and hits the target.

Q. 26. Describe compound microscope under the following points :

(i) Construction,

(ii) Ray diagram for formation of image,

(iii) Expression for magnifying power when image is formed at least distance of distinct vision. **5**

Ans. (i) Construction : It has two co-axial cylindrical pipes. There is convex lens fitted at external end of each pipe. The lens towards object is called objective lens and convex lens towards eye is called eyepiece. The aperture of objective lens is small. With the help of rack and pinion arrangement the pipe containing eyepiece can be move inside the pipe which contains objective lens.

The total value of magnetic field will be obtained by integrating eqn. (2).

$$\therefore \quad \oint dB = B = \oint \frac{\mu_0}{4\pi}\frac{I dl}{r^2}$$

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

But $\oint dl = l =$ sum of all line elements. This is equal to the circumference of the circle.

i.e., $\oint dl = l = 2\pi r$

$$\therefore \quad B = \frac{\mu_0}{4\pi}\frac{I}{r^2}2\pi r$$

or $$B = \frac{\mu_0}{2}\frac{I}{r}\ \text{Wb/m}^2$$

If the coil has n turns, then

$$\vec{B} = \frac{\mu_0}{2}\frac{nI}{r}$$

By Maxwell's right hand screw rule, the direction of the magnetic field will be, into the plane of paper vertically downwards. If current flows in clockwise direction.

Or

Define magnetic moment of a magnet. Find out magnitude and direction of restoring torque (couple) acting on a bar magnet, kept in uniform magnetic field at "θ" angle, also derive an expression for potential energy of the bar magnet.

Ans. Magnetic moment — The magnetic moment of a magnet is defined as " it is numerically equal to moment of restoring couple, which acts on a magnet kept perpendicular to uniform magnetic field of unit intensity."

Let NS be a bar magnet, placed in a uniform magnetic field of intensity B, making an angle θ with the field.

Suppose m be the pole strength and $2l$ be the effective length. Now, mB force will be act on each pole, parallel and in opposite direction, therefore a couple will act, which tends to bring the magnet in the direction of B.

Hence, this couple is called "Restoring couple or Restoring torque".

Fig. Torque acting on a bar magnet

Restoring torque is defined as the product of magnitude of any one of the forces, and the perpendicular distance between them.

$$\tau = \text{Force} \times \text{Perpendicular distance}$$

or Torque, $\tau = mB \times SP$ ...(1)

Also, in ΔNPS, we get

$$\sin\theta = \frac{SP}{NS}$$

or $$SP = NS\sin\theta = 2l\sin\theta$$

∴ Putting the value of SP in eqn. (1),

$$\tau = mB \times 2l\sin\theta$$

But $m \times 2l = M$ (magnetic moment)

$$\therefore \quad \tau = MB\sin\theta$$

In vector form :

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

and the direction of $\vec{\tau}$ will be perpendicular to the plane containing $\vec{M}$ and $\vec{B}$.

Definition of magnetic moment :

As $\tau = MB\sin\theta$

If the magnet is held perpendicular to the field, then $\theta = 90°$ or $\sin\theta = 1$ then the torque acting on the magnet will be maximum, if the strength of the applied field is 1 *i.e.*, B = 1, then

$$\tau_{max} = M$$

Hence, magnetic moment is numerically equal to the maximum torque acting on the bar magnet when it is held perpendicular in a uniform magnetic field of unit intensity.

Potential energy — The potential energy of the magnetic dipole is equal to the amount of work done in rotating the magnet from its standard position (i.e. magnet makes 90° with the direction of field) to its present position.

Let M is the magnetic moment of bar magnet, the magnet is placed in the magnetic field of intensity B making an angle θ with the direction of field.

The restoring torque on magnet will be

$$\tau = MB\sin\theta$$

Work done in deflecting the magnet through small angle $d\theta$ will be

$$dW = \tau d\theta = MB\sin\theta\, d\theta$$

∴ Work done in rotating the magnet from

$$\theta_1 = \frac{\pi}{2} \text{ to } \theta_2 = \theta$$

$$W = \int_{\pi/2}^{\theta} MB\sin\theta\, d\theta$$

$$= MB\left[\int_{\pi/2}^{\theta}\sin\theta\, d\theta\right]$$

$$= MB[-\cos\theta]_{\pi/2}^{\theta}$$

$$= -MB\left[\cos\theta - \left(\cos\frac{\pi}{2}\right)\right]$$

$$W = -MB\cos\theta$$

This work termed as potential energy of magnet

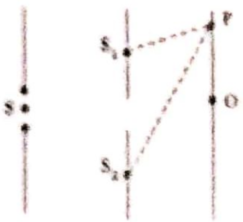
∴ Potential energy

$$U = -MB\cos\theta$$

In vector form $= -\vec{M}.\vec{B}$

This is the required expression.

Q. 26. The experimental set-up of young's double slit experiment is given below :



On the basis of path difference $\Delta = S_2P - S_1P$ find out conditions for constructive and destructive interference of light and derive an expression for fringe width. 5

Ans. Let S is a source which is illuminated with monochromatic light S_1 and S_2 are the two slits placed close to each other which are parallel and equidistant from S. Therefore, S_1 and S_2 behave as coherent sources.

Suppose that $S_1S_2 = d$

Screen is placed at distance D from S_1, S_2 on which interference fringes are formed.

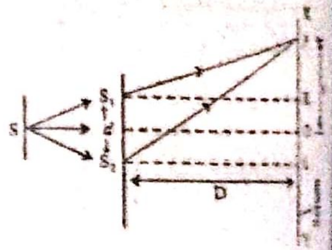
Path difference at point O on screen is

$$S_1O - S_2O = 0$$

∴ Intensity at point O will be maximum, it will be central fringe.

Let a point P on the screen XY at distance x from the centre.

From S_1, drop perpendicular S_1K on screen and from S_2, drop perpendicular S_2L on screen.



In right angled ΔS_1KP,

$$S_1P^2 = KP^2 + S_1K^2$$

$$= (OP - OK)^2 + S_1K^2$$

$$= \left(x - \frac{d}{2}\right)^2 + D^2$$

Or $$S_1P^2 = D^2 + \left(x - \frac{d}{2}\right)^2$$

Similarly in right angled ΔS_2PL,

$$S_2P^2 = S_2L^2 + LP^2$$

$$= S_2L^2 + (OP + OL)^2$$

$$= D^2 + \left(x + \frac{d}{2}\right)^2$$

$$S_2P^2 - S_1P^2 = D^2 + \left(x + \frac{d}{2}\right)^2 - D^2 - \left(x - \frac{d}{2}\right)^2$$

or $(S_2P + S_1P)(S_2P - S_1P)$

$$= \left(x^2 + \frac{d^2}{4} + xd\right) - \left(x^2 + \frac{d^2}{4} - xd\right)$$

or $(S_2P + S_1P)(S_2P - S_1P) = 2xd$

or $$S_2P - S_1P = \frac{2xd}{(S_2P + S_1P)}$$

Now, from eqns. (1) and (2), we get

$$mc^2 = h\upsilon \Rightarrow m = \frac{h\upsilon}{c^2}$$

But $\quad \upsilon = \frac{c}{\lambda}, \quad \therefore m = \frac{hc}{\lambda c^2}$

or $\quad m = \frac{h}{\lambda c}$ ...(3)

If the momentum of photon be p, then

$$p = mc$$

or $\quad p = \frac{h}{c\lambda} \times c, \quad$ [from eqn. (3)]

or $\quad p = \frac{h}{\lambda} \Rightarrow \lambda = \frac{h}{p}$

Which is called de-Broglie wave equation.

Again, if the velocity of mass "m" is v, then

$$p = mv$$

and $\quad \lambda = \frac{h}{mv}$

Which is de-Broglie equation.

Q. 18. Explain α-decay and β-decay by giving one example of each. 3

Ans. 1. α-decay— An α-particle is a helium nucleus. Thus, a nucleus emitting an α-particle losses two protons and two neutrons.

Hence, atomic number decreases by 2 and mass number decreases by 4.

The α-decay can be written as

$${}^{A}_{Z}X \longrightarrow {}^{A-4}_{Z-2}Y + \alpha - \text{particle} + Q$$

X : Parent nucleus, Y : Daughter nucleus and Q is energy released.

Example : ${}^{238}_{92}U \longrightarrow {}^{234}_{90}Th + {}^{4}_{2}He$

2. β-Decay—Beta decay involves the emission of an electron of positron. A positron carries + e charge and its mass is equal to that of electron.

There are mainly two types of β-decay.

(i) β^+–decay : In this decay positron emission takes place when a nuclear proton changes into neutron and a neutrino is emitted.

β^+–decay can be written as

$${}^{A}_{Z}X \longrightarrow {}^{A}_{Z-1}Y + {}^{0}_{+1}e + \upsilon$$
(Positron) (Neutrino)

Example : ${}^{13}_{7}N \longrightarrow {}^{13}_{6}C + {}^{0}_{+1}e + \upsilon.$

(ii) β^--decay : In this decay a neutron in the nucleus transformed into a proton, an electron and antineutrino.

$${}^{A}_{Z}X \longrightarrow {}^{A}_{Z+1}Y + {}^{0}_{-1}e + \bar{\upsilon}$$

Example : ${}^{14}_{6}C \longrightarrow {}^{14}_{7}N + e^- + \bar{\upsilon}.$

Q. 19. What is nuclear force ? Write its four characteristics. 3

Ans. Nuclear force : Nuclear force is a force of attraction among the nucleons present in the nucleus of an atom.

Characteristics : (i) Nuclear force is always an attractive force.

(ii) It is a short range force.

(iii) It is strongest force in nature.

(iv) It is not a central force.

Q. 20. Describe the working of a *P-N* junction diode as a half wave rectifier under the following heads : 3

(i) Rectification,

(ii) Labelled circuit diagram and

(iii) Working.

Ans. (i) Rectification : A device which converts alternating current or voltage to direct current or voltage is known as rectifier and the process is called rectification.

(ii) Labelled diagram :

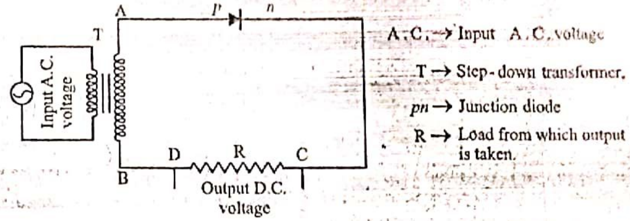


Fig. P. N. Junction

(iii) Working : When an alternating voltage is applied to the primary coil of transformer T, then an alternating voltage is induced in the secondary coil.

During the positive half of the input signal, A is at high potential w.r.t. that of B. Then P-N junction diode is in forward biased. Thus, the current flows through it and conventional current flows through R, from C to D. As the input voltage increase or decrease the current I also increase or decrease and so the output voltage (= IR) across the load. Output voltage across R of same shape as the positive half wave of the input.

During the negative half of the input signal, A is at negative potential w.r.t. B. The junction diode is reverse-biased and current flow is only of the order of μA which can be neglected. In other words, we can say that no current flows through R, hence no potential difference is obtained across R.

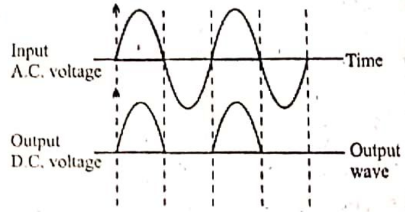
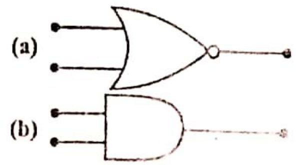


Fig. Half wave rectifier

The same phenomenon is repeated in the next cycle. Therefore, only half cycle of the input alternating wave is converted into d.c.

This process is called half wave rectification.

Q. 21. Identify the following gates and write their truth table : 3



Ans. (a) NOR Gate

(b) AND Gate.

Truth table : (a) NOR Gate :

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

(b) AND Gate :

A	B	Y = AB
0	0	0
0	1	0
1	0	0
1	1	1

Q. 10. Write the name of X and Y in diagram ? 2

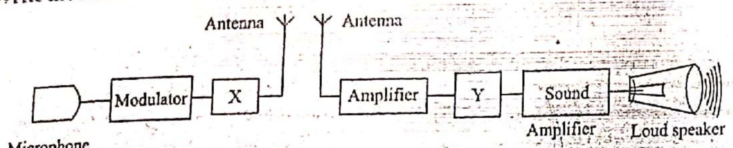


Fig. (a) Transmitter

Fig. (b) Receiver

Ans. X—Amplifier
Y—Demodulator.

SECTION-C

Q. 11. If a length of wire of 5 Ω resistance is made double. What will be its new resistance ? 3

Ans. Given, $R_1 = 5\Omega$

$l_2 = 2l_1$

Formula: $\frac{R_1}{R_2} = \left(\frac{l_1}{l_2}\right)^2$

$\frac{5}{R_2} = \left(\frac{l_1}{2l_1}\right)^2$

$R_2 = 4\times5$

$R_2 = 20\Omega.$ **Ans.**

Q. 12. What is Lorent'z force ? Write the formula for Lorent'z force obtain the different values of Lorent'z force for different conditions. Show that work done by the Lorent'z force is zero. 3

Ans. The force acting on a moving charge in a magnetic field is called Lorent'z force. The Lorent'z force is given by the following formula.

$$\vec{F} = q(\vec{v}\times\vec{B})$$

The value of Lorent'z force depends on the following factors :

(i) Charge on particle.
(ii) Velocity of particle.
(iii) Magnitude of magnetic field.
(iv) Direction of motion.

Magnitude of Lorentz force : If a particle of charge q moves with uniform velocity v in magnetic field B, then the magnitude of Lorentz force is given by :

$$F = qvB\sin\theta \quad ...(1)$$

Special cases :

(i) If $\boxed{v=0}$ *i.e.* the charged particle is at rest then,

$F = q(0)\,B\sin\theta$

$F = 0$

(ii) If $\boxed{\theta=0^\circ}$

Then, $F = qvB\sin 0^\circ$

$F = 0$

i.e. Magnitude of force is zero, when charged particle moves parallel to magnetic field.

(iii) If $\boxed{\theta=90^\circ}$

Then, $F = qvB\sin 90^\circ$

$F = qvB$ (Maximum)

i.e. magnitude of force is maximum, when charged particle moves perpendicular to magnetic field.

Work done by the Lorentz force : Since Lorentz force is always applied perpendicular to motion of charged particle ($\theta = 90^\circ$) so, the work done by this force will be

$W = Fd\cos\theta$

$= Fd\cos 90^\circ$

$W = 0$

and kinetic energy and speed of the particle will be constant but direction changes.

Q. 13. What will be the value of "g" if a bar magnet falled inside the coil. What happens if coil break at any point. 3

Ans. The value of "g" decreases, because induced current opposes the motion of bar magnet.

The value of "g" remains unchanged, if coil break at any point, because there will be no induced current.

Q. 14. A transmitting antenna at the top of tower has height of 32 m and that of receiving antenna 50 m. What is the maximum distance between them for satisfactory communication in line of sight mode ? (R = 6400 km) 3

Ans. Given, $h_T = 32$ m, $h_R = 50$ m,

$R = 6400$ km

$= 6400\times10^3$ cm

Formula : $d_m = \sqrt{2Rh_T} + \sqrt{2Rh_R}$

$= \sqrt{2\times6400\times10^3}\,(\sqrt{32}+\sqrt{50})$

$= \sqrt{2\times640\times10^2}\,(4\sqrt{2}+5\sqrt{2})$

$= 35\cdot78\times10^2\times\sqrt{2}\times9$

$= 45\cdot5$ km **Ans.**

Q. 15. The ratio of the intensities of two waves is 1 : 9. What will be their of maximum and minimum intensities ? 3

Sol. Formula :

$$\frac{I_{max}}{I_{min}} = \frac{(a_1+a_2)^2}{(a_1-a_2)^2}$$

Given, $\frac{I_1}{I_2} = \frac{1}{9}$

Since, $I \propto a^2$

$\therefore$ $\left(\frac{a_1}{a_2^2}\right)^2 = \frac{1}{9}$, Or $\frac{a_1}{a_2^2} = \frac{1}{3}$

Let $a_1 = x$ and $a_2 = 3x$

$$\frac{I_{max}}{I_{min}} = \frac{(x+3x)^2}{(x-3x)^2} = \frac{(4x)^2}{(-2x)^2}$$

Or $\frac{I_{max}}{I_{min}} = \frac{4}{1}$

$\therefore$ $I_{max} : I_{min} = 4 : 1.$ **Ans.**

Q. 16. The focal lengths of two lenses are f_1 and f_2. If the focal length of the combination is F, then prove that : 3

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}.$$

Ans. Let L_1 and L_2 be two thin lenses which are kept in contact. The focal length of the lenses are f_1 and f_2 respectively.

An object O is situated at a distance u from the optical centre O_1 of lens L_1 (*i.e.*, $OO_1 = u$).

A beam of light from O falls on lens L_1 as OA. It undergoes refraction and would have moved as AI_1, (if lens L_2 is not present). Hence, virtual image I_1 of object is formed. If the distance of image I_1 from lens L_1 is v_1, then by lens formula,

$$\frac{1}{f_1} = \frac{1}{v_1} - \frac{1}{u}, \text{ (where } v_1 = O_1I_1) \quad ...(1)$$

But due to the presence of lens L_2, the refracted beam AB, undergoes refraction at L_2 and form the final image at I. Hence, the image of lens L_1 *i.e.*, I_1 serves as the object for lens L_2.

If v be the image distance of the second lens L_2, then by lens formula

$$\frac{1}{v} - \frac{1}{v_1} = \frac{1}{f_2} \quad ...(2)$$

Where, v is the image distance for L_2 *i.e.* $O_2I = v$ and $O_2I_1 = v_1$.

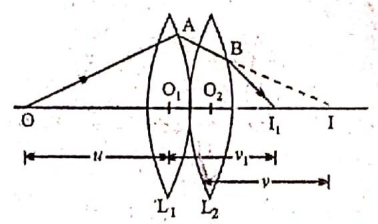


Fig.

Adding eqns. (1) and (2), we have

$$\frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{v} - \frac{1}{u} \quad ...(3)$$

But the image of O is formed at I, by the combination. If the focal length of combination be F, then

$$\frac{1}{F} = \frac{1}{v} - \frac{1}{u} \quad ...(4)$$

Hence, from eqns. (3) and (4), we get

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} \quad ...(5)$$

This is required expression.

PRABODH MODEL PAPER SET-II

Instruction : Same as Model Paper Set-I

SECTION–A

Q. 1. Define electric field intensity, write its S.I. unit also. 1

Ans. The electric field intensity at a point due to a force charge is defined as the force experienced by a unit positive test charge placed at that point.

S.I. unit : N/C.

Q. 2. Write difference between resistance and reactance ? 1

Ans. The opposition offered by a conductor to the flow of AC or DC is called resistance.

The opposition offered by an inductor or a capacitor in the flow of an AC is called reactance resistance does not depends on the frequency but the reactance depends upon the frequency.

Q. 3. What will happen if a convex lens of refractive index μ_1 is immersed into a liquid of refractive index μ_2. (If : $\mu_2 > \mu_1$) 1

Ans. Focal length of lens increases and it's nature become like concave.

Q. 4. What is the effect on width of depletion layer when diode is in forward bias or in reverse bias ? 1

Ans. In forward bias width of depletion layer increases, whereas in reverse bias width of depletion layer decreases.

Q. 5. What factor affects the value of stopping potential ? 1

Ans. On frequency of incident light.

SECTION–B

Q. 6. "The two equipotential surface never intersect each other". Why ? 2

Ans. Two equipotential surfaces can never intersect each other because the equipotential surface is normal to the electric field. If two equipotential surfaces intersect each other, then at the point of intersection there will be two directions of electric field which is never possible.

Q. 7. Write the name of two substances which resistance decreases on increasing the temperature ? 2

Ans. Silicon and Germanium.

Q. 8. A carbon resistor had red green and violet colour in order. What is it's resistance ? 2

Ans.	Red	green	violet	No colour
	2	5	7	20%

$$R = 25\times10^7 \pm 20\ \%\ \Omega$$

$$R = 2{\cdot}5\times10^6 \pm 20\ \%\ \Omega.$$

Q. 9. What will be the effect on fringe width in Young's double slit experiment if water is used instead of air and source is white light source ? 2

Ans. If in place of air, water is used in Young's double slit experiment, then as the wavelength of light is decreased in water, so by the formula $\beta = \frac{\lambda D}{d}$, the fringe width will decrease and coloured fringes obtained if we use white light source.

Q. 10. What do you mean by modulation depth ? What should be it's value ? 2

Ans. The ratio of change in amplitude of carrier wave from it's initial amplitude to the initial amplitude of carrier wave is called depth of modulation.

It's value should be unity.

SECTION–C

Q. 11. How resistance of resistances 2, 3 and 6 Ω be arranged so that R_{eq} becomes 4 Ω. Show by diagram ? 3

Sol. On joining 3 and 6 Ω in parallel combination :

$$\frac{1}{R_1} = \frac{1}{3} + \frac{1}{6} \Rightarrow \frac{2+1}{6} = \frac{3}{6}$$

or $\quad R_1 = 2\ \Omega$

Now, $R_1 = 2\ \Omega$ and $2\ \Omega$ are connected in series combination :

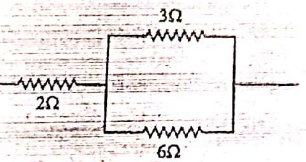


Fig.

$$R = R_1 + R_2$$
$$R = 2 + 2 = 4\ \Omega$$ **Ans.**

Q. 12. Compare the magnetic properties of paramagnetic, diamagnetic and ferromagnetic substances on any four points. 3

Ans. Comparison of magnetic properties of paramagnetic, diamagnetic and ferromagnetic :

S. No.	Paramagnetic substance	Diamagnetic substance	Ferromagnetic substance
1.	They are attracted towards strong magnets.	They are repelled by strong magnet.	They are attracted towards weak magnet.
2.	When suspended in a magnetic field they aligned parallel to the field.	When suspended in a magnetic field they aligned perpendicular to the field.	They also aligned parallel to the field.
3.	They move from weaker region to stronger region in magnetizing field.	They move from stronger region to weaker region in a magnetic field.	They also move from weaker region of magnetizing field.
4.	The relative permeability of these substances are slightly greater than one.	The relative permeability of these substances are slightly less than one.	The relative permeability is very high.
5.	The susceptibility is inversely proportional to absolute temperature.	The susceptibility does not depend upon temperature.	The susceptibility decreases with the rise of temperature.
6.	The susceptibility of these substances are small and positive.	The susceptibility of these substances are small and negative.	The susceptibility of these substances are very high and positive.
7.	They cannot be made strong magnet.	They cannot be made strong magnet.	They can be made strong magnet.

Q. 13. State Lenz's law and explain that Lenz's law is in accordance with the law of conservation of energy. 3

Ans. According to Lenz's law : In every condition of electromagnetic induction the direction of induced current is such that it opposes the cause by which it is produced.

Lenz's law and law of conservation of energy : When N-pole of bar magnet is brought near the one end of a coil, then the face of coil towards the magnet becomes N-pole and a force of repulsion acts between the coil and magnet. To bring the magnet towards coil work has to be done against the repulsion force. This mechanical work (*i.e.*, mechanical energy) is transformed into electrical energy and induced current is obtained in the circuit. Similarly, when N-pole of magnet is taken away from the coil, then that face of coil becomes S-pole which will oppose the motion of N-pole of magnet. Thus, the work is done against the force of attraction and hence mechanical energy changes into electrical energy. By the above discussion it is clear that Lenz's law is in accordance with the law of conservation of energy.

$\therefore$ Net flux linked with Gaussian surface,

$$\phi = \oint_S \vec{E}.\vec{ds} = \int_{S_1} \vec{E}.\vec{ds} + \int_{S_2} \vec{E}.\vec{ds} + \int_{S_3} \vec{E}.\vec{ds}$$

$$\phi = \int_{S_1} E\,ds\cos 90° + \int_{S_2} E\,ds\cos 90° + \int_{S_3} E\,ds\cos 0°$$

$$= 0 + 0 + \int_{S_3} E\,ds = \int_{S_3} E ds$$

or $\phi = E.2\pi rl$ ...(1)

But by Gauss's theorem

$$\phi = \frac{\text{Charge present inside the Gaussian Surface}}{\varepsilon_0}$$

$$= \frac{q}{\varepsilon_0} = \frac{\lambda l}{\varepsilon_0} \quad ...(2)$$

From eqn. (1) and (2)

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

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

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

This is the required expression.

Or

What is capacitor ? Derive an expression for capacity of a parallel plate capacitor if space between its plates is partially filled with a dielectric medium ?

Ans. Capacitor—A device which is used to store electrical energy (charge) without changing its shape or size is called as capacitor or condenser.

Let M and N be parallel plates of a capacitor. The distance between the plates is d and plate of thickness t of dielectric constant ε_r is introduced.

Now, plate A is given charge $+q$.

Let the charge density be σ, then

$$\sigma = \frac{q}{A}$$

$\therefore$ Intensity of field in air,

$$E_1 = \frac{\sigma}{\varepsilon_0}$$

or $$E_1 = \frac{q}{\varepsilon_0 A} \quad ...(1)$$

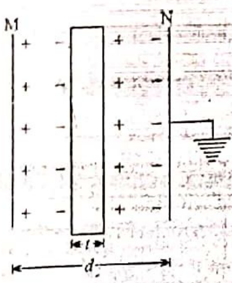


Fig.

If the intensity of field inside the dielectric medium be E_2, then

$$E_2 = \frac{\sigma}{\varepsilon_0\varepsilon_r} = \frac{q}{\varepsilon_0\varepsilon_r A}$$

Where, $\varepsilon_r = K$ = dielectric constant.

Now, potential difference between M and N is

$$V_M - V_N = E_1(d-t) + E_2 t$$

$$= \frac{q}{\varepsilon_0 A}(d-t) + \frac{q}{\varepsilon_0\varepsilon_r A}t$$

$$= \frac{q}{\varepsilon_0 A}\left[d - t + \frac{t}{\varepsilon_r}\right]$$

or $$V_M - V_N = \frac{q}{\varepsilon_0 A}\left[d - t\left(1 - \frac{1}{\varepsilon_r}\right)\right] \quad ...(2)$$

But, capacitance of capacitor is

$$C = \frac{q}{V_M - V_N}, \left(\because C = \frac{q}{V}\right) \quad ...(3)$$

$$C = \frac{q}{\frac{q}{\varepsilon_0 A}\left[d - t\left(1 - \frac{1}{\varepsilon_r}\right)\right]}$$ [from eqn. (2)]

$$C = \frac{\varepsilon_0 A}{d - t\left(1 - \frac{1}{\varepsilon_r}\right)}$$

This is the required expression.

Q. 25. State Biot-Savart's law. By using this law find out magnetic field intensity at centre of current carrying circular coil of radius "r" and having "n" turns. Also find out direction of this field. 5

Ans. As shown in Given figure. I current is flowing through a conductor MN.

The length of small element of the conductor is $\vec{dl}$ and the position vector of point P with respect to

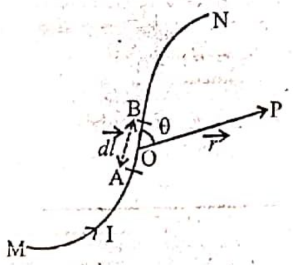


Fig. Biot Savart's law.

small, element is $\vec{r}$, then according to Biot Savart's law, the intensity of magnetic field at point P due to small element is :

(i) Directly proportional to the current flowing through it *i.e.*,

$$dB \propto I.$$

(ii) Directly proportional to the length of small element dl *i.e.*,

$$dB \propto dl.$$

(iii) Directly proportional to the sine of angle between length of small element and OP *i.e.*,

$$dB \propto \sin\theta.$$

(iv) Inversely proportional to the square of distance of point of observation and small element *i.e.*,

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

Combining the above four conditions,

$$dB \propto \frac{Idl\sin\theta}{r^2}$$

or $$dB = K\frac{Idl\sin\theta}{r^2} \quad ...(1)$$

Where, K is a proportionality constant. In S.I. system its value is equal to $\frac{\mu_0}{4\pi}$.

$\therefore$ From eqn (1),

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

Where, μ_0 is permeability of free space its value is $\mu_0 = 4\pi \times 10^{-7}$ tesla metre/ampere.

Hence, eqn. (2) can be written as

$$dB = 10^{-7}\frac{Idl\sin\theta}{r^2}\text{ tesla} \quad ...(3)$$

This is Biot Savart's law.

In eqn. (3), if $dl = 1$ m, $\theta = 90°$, $r = 1$ m and $dB = 10^{-7}$ Wb/m^2, then the current

$$I = 1A$$

Thus, one ampere of current is that current which produces magnetic field of 10^{-7} Wb/m^2 at the centre of a conductor of length 1 m placed in the form of an arc of a circle of radius 1 m.

Let I current is flowing through a circular of coil of radius 'r'. At its centre the intensity of magnetic field is to be determined. As shown in fig. , let the number of turns in this coil are 'n'. Let us take a small element AB of length 'dl'. The line joining the small element to centre 'O' makes 90° angle with the small element.

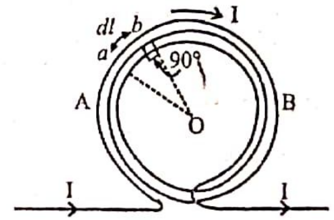


Fig. Intensity of magnetic field at the centre of circular coil carrying current.

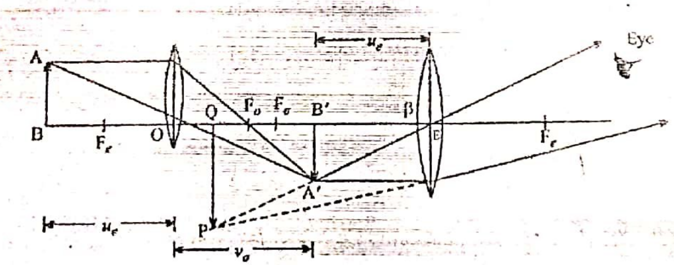
According to Biot Savart's law, the intensity of magnetic field at O due to small element AB is

$$dB = \frac{\mu_0}{4\pi}\frac{Idl\sin 90°}{r^2}$$

or $$dB = \frac{\mu_0}{4\pi}\frac{Idl}{r^2} \quad ...(1)$$

$[\because \sin 90° = 1]$

(ii) Ray diagram :



Where, $O \rightarrow$ Objective lens, $E \rightarrow$ Eye lens, $AB \rightarrow$ object, $PQ \rightarrow$ Image.

(iii) Expression for magnifying power : Ratio of angle subtended by an image to the angle subtended by an object placed at least distance of distinct vision is called magnifying power of microscope.

If angle subtended by an image is β and angle by an object placed at D is given by α. Therefore, magnifying power

$$m = \frac{\beta}{\alpha} \quad \text{...(1)}$$

$$\therefore \quad \alpha = \frac{AB}{D}.$$

Where, D → Least distance of distinct vision.

As eye is close to the eye lens, we can take the angle subtended at lens for human eye also.

∴ Angle made by an image PQ

$$\beta = \frac{PQ}{EQ} = \frac{A'B'}{EB}$$

or $$\beta = \frac{A'B'}{u_e}$$

Where, $u_e \rightarrow EB' \rightarrow$ Distance of image from eye lens.

Substituting above values in eqn. (1),

$$m = \frac{\frac{A'B'}{u_e}}{\frac{AB}{D}} = \frac{A'B'}{AB} \times \frac{D}{u_e} \quad \text{.... (2)}$$

Now, in similar triangles ΔA'OB' and ΔAOB,

$$\frac{A'B'}{AB} = \frac{OB'}{OB}$$

∴ From eqn. (2),

$$m = \frac{OB'}{OB} \times \frac{D}{u_e}$$

or $$m = \frac{v'_o}{-u_o} \times \frac{-D}{-u_e},$$

(by sign convention)

Where, $u_o \rightarrow OB \rightarrow$ Distance of object from objective lens, $v_o \rightarrow OB' \rightarrow$ Distance between objective to the image A'B'.

or $$m = \frac{-v_o D}{u_o u_e} \quad \text{...(3)}$$

When image is formed at least distance of distinct vision :

From formula : $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$

For eye lens, $\frac{1}{f_e} = \frac{1}{-v_e} - \frac{1}{-u_e}$

or $\frac{1}{f_e} = \frac{1}{-v_e} + \frac{1}{u_e}$

But, $v_e = D$

$$\therefore \quad \frac{1}{f_e} = -\frac{1}{D} + \frac{1}{u_e}$$

or $$\frac{1}{u_e} = \frac{1}{f_e} + \frac{1}{D}$$

or $$\frac{D}{u_e} = \frac{D}{f_e} + 1$$

Substituting this value in eqn. (3), we get

$$m = \frac{-v_o}{u_o}\left(1 + \frac{D}{f_e}\right) \quad \text{...(4)}$$

Formula for magnification when image is formed at D magnification.

Or

Describe terrestrial telescope under the following points :

(i) Construction, (ii) Ray diagram for formation of image, (iii) Expression for magnifying power when image is formed at least distance of distinct vision.

Ans. (i) Construction : The construction of terrestrial telescope is similar to astronomical telescope. The only difference is that in terrestrial telescope there is third convex lens provided between objective and eye lens, which is called erecting or inverting lens. The focal length and aperture of objective lens is much greater than that of eye lens.

(ii) Ray diagram :

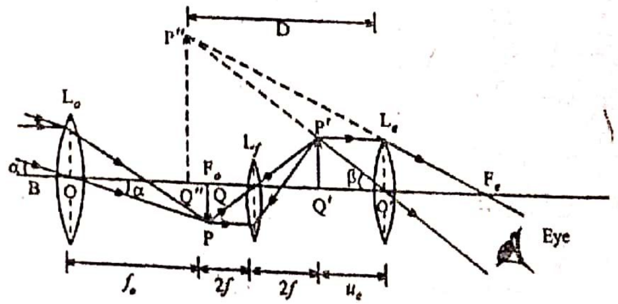


Fig. When image is formed at least distance of distinct vision.

(iii) Expression for magnifying power : Magnification is defined as the ratio of the visual angle of final image to that of the visual angle of object.

$$\therefore \quad m = \frac{\text{Visual angle of final image}}{\text{Visual angle of object}} = \frac{\beta}{\alpha}$$

As the angles α and β are very less, hence $\tan\alpha \approx \alpha$ and $\tan\beta \approx \beta$.

$$\therefore \quad m = \frac{\beta}{\alpha} = \frac{\tan\beta}{\tan\alpha}$$

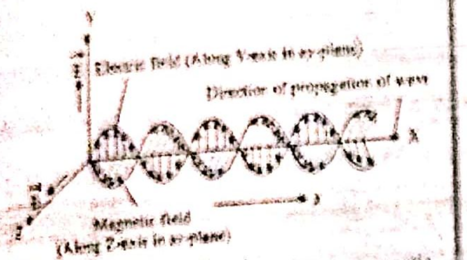


Fig. graphical representation of electromagnetic waves.

Q. 15. Describe compound microscope under following points : **3**

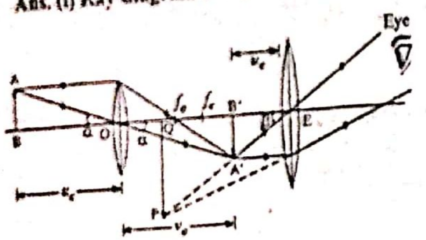
(i) Ray diagram when final image is formed at least distance of distinct vision.

(ii) Write only expression for magnifying power when :

(a) Final image is formed at least distance of distinct vision.

(ii) Final image is formed at infinity.

Ans. (i) Ray diagram :



Where, O → objective lens, E → Eye lens, AB → object, PQ → Image.

(ii) Magnifying power :

(a) $m = \frac{-v_o}{u_o}\left(1 + \frac{D}{f_e}\right)$

(b) $m = \frac{-v_o}{u_o} \cdot \frac{D}{f_e}$

Q. 16. State Brewster's law. Prove that at angle of polarization, reflected rays and refracted rays are mutually perpendicular. **3**

Ans. Brewster's law : The refractive index of a medium is equal to the tangent of angle of polarization, *i.e.*,

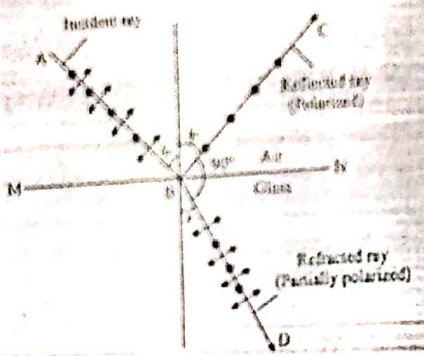
$$\mu = \tan i_p$$

Let a light ray is incident at the angle of polarization i_p to the medium of refractive index μ.

By Snell's law $\mu = \frac{\sin i_p}{\sin r}$ ...(1)

Where, r is the angle of refraction.

But, $\mu = \tan i_p$ ...(2)



From equation (1) and (2), we get

$$\tan i_p = \frac{\sin i_p}{\sin r}$$

or $\frac{\sin i_p}{\cos i_p} = \frac{\sin i_p}{\sin r}$

∴ $\cos i_p = \sin r$

or $\sin(90 - i_p) = \sin r$

or $90° - i_p = r$

or $i_p + r = 90°$

But we have $i_p + r + \angle CBD = 180°$

or $90° + \angle CBD = 180°$

or $\angle CBD = 90°$

Thus, reflected ray and refracted ray are mutually perpendicular.

Q. 17. Calculate de-Broglie wavelength associated with an electron. **3**

Ans. Suppose an electron carrying 'e' charge and of mass 'm' is accelerated through a potential difference of 'V' volt.

The energy gained by electron $= eV$ ... (1)

This energy is in the form of kinetic energy of electron,

$$= \frac{1}{2}mv^2 \quad \text{... (2)}$$

∴ $\frac{1}{2}mv^2 = eV$

or $mv^2 = 2eV$

or $m^2v^2 = 2meV$

∴ Momentum

$$p = mv = \sqrt{2meV}$$

Hence, de-Broglie wavelength associated with electron

$$\lambda = \frac{h}{p}$$

or $$\lambda = \frac{h}{\sqrt{2meV}}$$

∵ $h = 6{\cdot}6 \times 10^{-34}$ J.s, $e = 1{\cdot}6 \times 10^{-19}$ C and, $m = 9{\cdot}1 \times 10^{-31}$ kg.

∴ $$\lambda = \frac{6{\cdot}6 \times 10^{-34}}{\sqrt{2 \times 9{\cdot}1 \times 10^{-31} \times 1{\cdot}6 \times 10^{-19} V}}$$

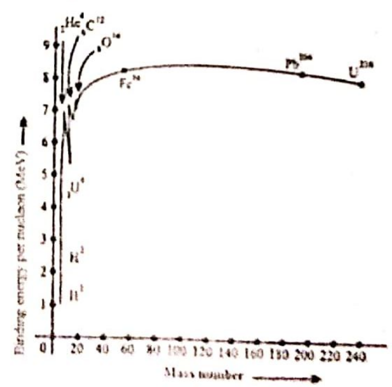
$$= \sqrt{\frac{150}{V}} \times 10^{-10} \text{ m.}$$

$$= \sqrt{\frac{150}{V}} \text{Å} = \frac{12{\cdot}247}{\sqrt{V}} \text{Å}.$$

Q. 18. Draw the graph showing the variation of binding energy per nucleon with the mass number. Write any two important conclusions drawn from it. **3**

Ans. From the binding energy curve, it follows that :

(i) The maximum value of binding energy per nucleon is 8·79MeV and it is for $^{56}_{26}$Fe. This explains the large abundance of Fe in nature.



(ii) Since for ... of intermediate mass numbers, the value of the binding energy per nucleon is around the maximum value, these nuclei are the most stable.

Q. 19. Write any three difference between nuclear fusion and nuclear fission. **3**

Ans. Difference between nuclear fission and nuclear fusion :

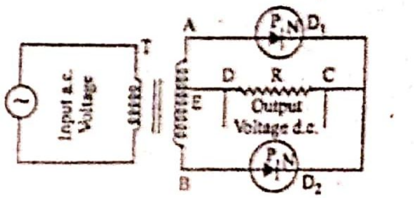
S.N.	Nuclear fission	Nuclear fusion
1.	Nuclear fission is the process of breaking up of a heavy nucleus into lighter nuclei.	In fusion reaction, two lighter nuclei combine to form a heavy nucleus.
2.	It is chain reaction.	It is not a chain reaction.
3.	This process is induced by bombardment of a heavy nucleus by neutrons.	This process is induced by very high temperature.
4.	A large amount of energy is produced.	The energy produced in nuclear fusion much more.

Q. 20. Describe use of P-N juction as full wave rectifier under following points : **3**

(a) Labelled circuit diagram and

(b) Working.

Ans. (a) Labelled diagram : T → Step-down transformer, D_1, D_2 → Diodes, R → Load resistance.



(b) Working function : When a.c. voltage is applied on primary coil of step-down transformer T, a.c. voltage induces in secondary coils.

In first half cycle, A is at positive and B is at negative potential with respect of E. Therefore, diode D_1 becomes forward-biased and current flows in load resistance R from C to D. This time point B is at lower potential relative to E, therefore D_2 is at reverse biased.

Latest Blue Print of Question Paper For This Year's Exam Issued by CG Board of Secondary Education Raipur

PHYSICS

Class XII

Time : 3·00 Hours MM : 70

S.N.	Unit Name	Alloted Numbers	VSA 1	SA-I 2	SA-II 3	LA-I 4	LA-II 5	Total Marks
1.	Electric Charges and Fields, Electrostatic Potential and Capacitance	08	1(1)	2(1)	–	–	5(1)	08(3)
2.	Current Electricity	07	–	4(2)	3(1)	–	–	07(3)
3.	Magnetic Effects of Current Magnetism and matter	08	–	–	3(1)	–	5(1)	08(2)
4.	Electromagnetic Induction and Alternating Currents	08	1(1)	–	3(1)	4(1)	–	08(3)
5.	Electromagnetic Waves	03	–	–	3(1)	–	–	03(1)
6.	Ray Optics and Optical Instruments, Wave Optics	14	1(1)	2(1)	6(2)	–	5(1)	14(5)
7.	Dual Nature of Radiation and Matter	04	1(1)	–	3(1)	–	–	04(2)
8.	Atoms and Nuclei	06	–	–	6(2)	–	–	06(2)
9.	Semiconductor Electronics: Materials Devices and Simple Circuits	07	1(1)	–	6(2)	–	–	07(3)
10.	Communication Systems	05	–	2(1)	3(1)	–	–	05(2)
	Total	70	5(5)	10(5)	36(12)	4(1)	15(3)	70(26)

Note : Inside the bracket shows the number of questions and outside the bracket shows the number of marks.

Physics (187 – 242) .... 187 – 197

PRABODH MODEL PAPER SET-I

Physics (C.G.) : Class XII

Time : 3 Hrs. M.M. : 70

Instruction :

1. All questions are compulsory. There are 26 questions in all.
2. There are five sections in this question paper. Each question in Section 'A' carries 1 mark, in Section 'B' 2marks, Section 'C' 3 marks, Section 'D' 4 marks and in Section 'E' each question is of 5 marks.
3. Q. No. 1 to 5 carries 1 mark each.
4. Q. No. 6 to 10 are very short answer type questions and carries 2 marks each.
5. Q. No. 11 to 22 are short answer type questions and carries 3 marks each.
6. Q. No. 23 is long answer type questions and carries 4 marks each.
7. Q. No. 24 to 26 are very long answer type questions and carries 5 marks each.

SECTION–A

Q. 1. What will be the value of electric field intensity and electric potential of spherical conductor of radius R at a distance of r (If $r<R$). 1

Ans. Intensity of electric field $E = 0$

Electric potential $V = \frac{1}{4\pi\varepsilon_0}\frac{q}{R}$.

Q. 2. RMS value of an alternating current is 220 volt. Find it's peak value. Find the average value of one cycle ? 1

Sol. $V_{rms} = 220$ volt

$V_0 = ?$

$$V_{rms} = \frac{V_0}{\sqrt{2}}$$

$$220 = \frac{V_0}{\sqrt{2}}$$

$$V_0 = 220\sqrt{2} \text{ volt.}$$

Average value of voltage = Zero. Ans.

Q. 3. For which colour of light refractive index and angle of deviation is maximum ? 1

Ans. For violet colour the refractive index and angle of deviation is maximum.

Q. 4. What do you mean by threshold energy or work function ? 1

Ans. The minimum amount of energy required to eject out an electron. Just out of surface without giving any velocity to, is called work function.

Q. 5. Why do prefer to use a transistor as common emitter amplifier rather than a common base amplifier ? 1

Ans. We prefer to use a transistor as common emitter amplifier than a common base amplifier because in C-E mode the voltage gain and power gain is more.

SECTION–B

Q. 6. Three capacitors, each of capacitance 3μF are connected in series. What is the effective capacitance of the combination ?

Sol. Given :

$C_1 = 3\mu F, \ C_2 = 3\mu F, \ C_3 = 3\mu F$

If the intensity of field inside the dielectric medium be E_2, then

$$E_2 = \frac{\sigma}{\varepsilon_0 \varepsilon_r} = \frac{q}{\varepsilon_0 \varepsilon_r A}$$

Where, $\varepsilon_r = K$ = dielectric constant.
Now, potential difference between M and N is

$$V_M - V_N = E_1(d-t) + E_2 t$$

$$= \frac{q}{\varepsilon_0 A}(d-t) + \frac{q}{\varepsilon_0 \varepsilon_r A} t$$

$$= \frac{q}{\varepsilon_0 A}\left[d - t + \frac{t}{\varepsilon_r}\right]$$

or $$V_M - V_N = \frac{q}{\varepsilon_0 A}\left[d - t\left(1 - \frac{1}{\varepsilon_r}\right)\right] \quad ...(2)$$

But, capacitance of capacitor is

$$C = \frac{q}{V_M - V_N}, \quad \left(\because C = \frac{q}{V}\right) \quad ...(3)$$

$$C = \frac{q}{\frac{q}{\varepsilon_0 A}\left[d - t\left(1 - \frac{1}{\varepsilon_r}\right)\right]}$$ [from eqn. (2)]

$$C = \frac{\varepsilon_0 A}{d - t\left(1 - \frac{1}{\varepsilon_r}\right)}$$

This is the required expression.

Q. 25. Derive an expression for force acting between the two parallel wires carrying current in the same direction. **5**

Ans. Let AB and CD are two parallel conductors kept at a distance d and having current i_1 and i_2 respectively.

A magnetic field due to current i_1 is produced around AB.

$\therefore$ Intensity of magnetic field due to AB at a distance d is

$$\therefore B = \frac{\mu_0}{4\pi} \cdot \frac{2i_1}{d}$$

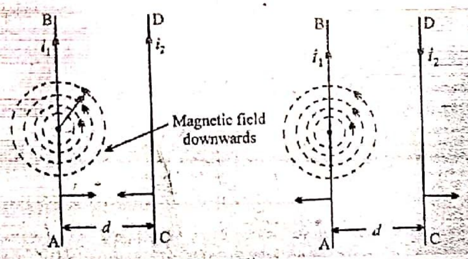


Fig.

By Maxwell's right-hand grip rule, the direction of this field is downwards perpendicular to the plane of the paper.

Now, the conductor CD is in this field.

$\therefore$ Force acting on the conductor of length l,

$$F = i_2 l B$$

or $$F = i_2 l \cdot \frac{\mu_0}{4\pi} \cdot \frac{2i_1}{d}$$

or $$F = \frac{\mu_0}{4\pi} \cdot \frac{2i_1 i_2 l}{d}$$

$\therefore$ Force acting on CD, per unit length will be

$$F = \frac{\mu_0}{4\pi} \cdot \frac{2i_1 i_2}{d}$$

If the current are flowing in the same direction, then by Flemming's left-hand rule, forces will be towards CD and AB. Hence, they will attract each other and when the currents are flowing in opposite directions, they will repel each other.

Or

Determine the force on a unit north pole, kept on the broad-side-on position of a smaller bar magnet.

Ans. Broad side-on-position : When the point where the intensity of the magnetic field has to be found lies on the perpendicular bisector of magnetic axis, *i.e.*, on the neutral axis, then it is called broad-side-on position.

Magnetic field is the force experienced by unit north pole placed at that point.

Hence, $\quad B = \frac{F}{m}$

If $\quad m = 1$, then B = T

Let NS be a bar magnet of pole strength m and effective length $2l$ and magnetic moment $M = m2l$.

Consider a point P at a distance d from the centre O of a magnet on it's neutral axis. Let unit north pole be placed at P.

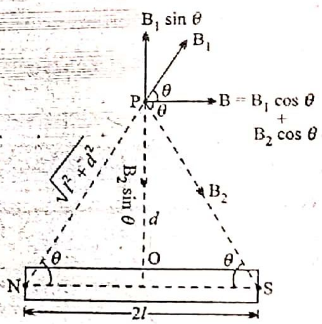


Fig. Magnetic field on equator line.

Now, the intensity of field at P, due to N-pole will be :

$$B_1 = \frac{\mu_0}{4\pi} \cdot \frac{m}{NP^2}, \text{ (along } \overrightarrow{NP}) \quad ...(1)$$

Again, the intensity of field at P, due to S-pole will be :

$$B_2 = \frac{\mu_0}{4\pi} \cdot \frac{m}{SP^2}, \text{ (along } \overrightarrow{PS}) \quad ...(2)$$

But $NP^2 = NO^2 + OP^2 = l^2 + d^2$

or $NP = \sqrt{l^2 + d^2}$

Similarly, $SP = \sqrt{l^2 + d^2}$, $\quad (\because NP = SP)$

Let $\angle PNS = \theta$

$\therefore \angle PSN = \angle BPB_1 = \angle BPS = \theta$

Resolving B_1 and B_2 into it's components, we have $B_1 \cos\theta$ along NS and $B_1 \sin\theta \perp$ NS along OP. Also $\cos\theta$ along NS and $B_2 \sin\theta \perp$ NS along PO.

But $B_1 = B_2$

$\Rightarrow B_1 \sin\theta = B_2 \sin\theta$

Since, their direction are opposite and their magnitudes are equal, hence they cancel each other.

The resultant field is therefore

$$B = B_1 \cos\theta + B_2 \cos\theta$$
$$= B_1 \cos\theta + B_1 \cos\theta \quad (\because B_1 = B_2)$$
$$= 2B_1 \cos\theta$$
$$= 2\frac{\mu_0}{4\pi} \frac{m}{NP^2} \cos\theta \quad ...(3)$$

In ΔONP,

$$\cos\theta = \frac{ON}{PN} = \frac{l}{\sqrt{l^2 + d^2}}$$

$$\therefore \quad B = 2\frac{\mu_0}{4\pi} \frac{m}{l^2 + d^2} \times \frac{l}{\sqrt{l^2 + d^2}}$$

$$\therefore \quad B = \frac{\mu_0}{4\pi} \cdot \frac{M}{(l^2 + d^2)^{3/2}}$$

($\because M = 2ml$ *i.e.*, magnetic moment)

This is the required formula.

Again, if the magnet is small *i.e.*, $l << d$

$$B = \frac{\mu_0}{4\pi} \cdot \frac{M}{(d^2)^{3/2}}$$

or $$B = \frac{\mu_0}{4\pi} \cdot \frac{M}{d^3}$$

The direction of the magnetic field is from N pole to S pole parallel to the axis.

Q. 26. Prove that $_a\mu_g = \dfrac{\sin\left(\dfrac{A + \delta_m}{2}\right)}{\sin\dfrac{A}{2}}$.

Or

Derive an expression for refractive index of material of prism. **5**

Ans. Let ABC be a prism, AB and AC are refracting surfaces. A is the angle of prism, PQ is incident ray, QR is refracted ray, RS is emergent ray, MO and NO are normals, i is angle of incidence, r_1 is angle of refraction, e is angle of emergence, r_2 is angle of incidence of AC.

Now, from figure,

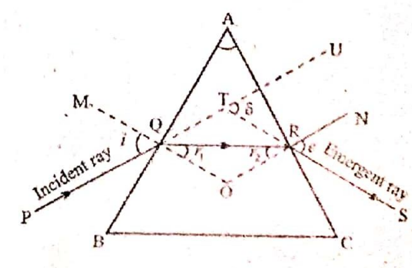


Fig.

Q. 22. *What are analog and digital signals ?* 3

Ans. Analog signal : The analog signals are those signals which are continuous and can have any value in a limited range which are described by the sinusoidal function. The analog signal can be represented by the following equation :

$$F(t) = a \sin \omega t.$$

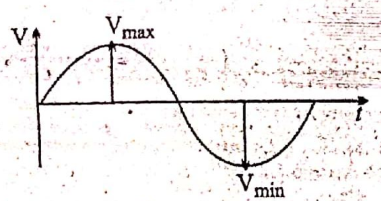


Fig. : Analog signal.

Digital signal : A digital signal is that which can have either a high level or low level. The digital signals are not continuous, these are discrete signals.

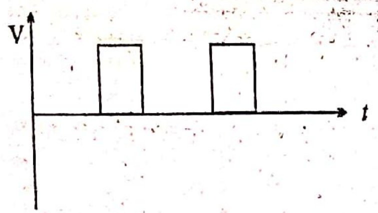


Fig. Digital signal.

SECTION-D

Q. 23. Mohan and his friends went for a walk. There they saw a truck on the road carrying some inflammable materials. They also noticed metallic chains hanging from body of truck and touching the ground. Mohan explained his friends that the axle of wheels of moving truck cuts the magnetic line of earth's magnetic field and due to this some charge will be induced across it's ends. This induced charge discharge to the earth through metallic chains and inflammable materials are safe. Answer the following questions : 4

(i) What are the values displayed by mohan ?

(ii) When is induced emf produced ?

(iii) Name and state the law used to find out direction of induced current ?

Ans. (i) Presence of mind, scientific attitude, awareness etc.

(ii) E.m.f. is induced in conductor due to change in magnetic flux linked with it.

(iii) Lenz's law : As per this law the direction of induced current is such that it opposes the cause of it's own birth.

Or

Current and magnetism are interrelated with each other. Oerested and amperes state that magnetic field induces near the current carrying conductor. After some years Faradey's states that moving charged particle causes an induced current.

Answer the following questions :

(i) Ammeter shows deflection, when magnet is moved near or away from the coil. Why ?

(ii) A square and rectangular loop is moving outside the magnetic field perpendicularly. In which loop an induced e.m.f. remains constant ?

(iii) Give one example of Faradey's contribution ?

Ans. (i) Due to change of magnetic flux in coil.

(ii) In rectangular loop.

(iii) Dynamo.

SECTION-E

Q. 24. Determine the intensity of electric field by Gauss's law, due to a uniformly charged spherical shell at a point— 5

(i) Outside the shell.

(ii) On the surface of shell.

(iii) Inside the shell.

Ans. Intensity of electric field due to uniformly charged spherical shell :

Suppose that a sphere of radius R is uniformly charged with $+q$ charge. Intensity at any point due to this charged sphere depends on it's position relative to the sphere.

(i) When point P lies outside the spherical shell : Consider a point P which lies outside the spherical shell of radius R. Now, imagine a sphere of radius r which passes through P. This closed surface behaves as Gaussian surface.

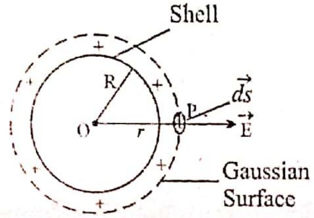


Fig.

Since, sphere is uniformly charged, so that electric field at each point on the surface is equal and points radially outward.

$\therefore$ Net flux through the Gaussian sphere of radius r will be

$$\phi_E = \oint_s \vec{E}.\vec{ds} = \oint E\, ds \cos\theta$$

$$= E\oint ds \cos\theta,$$

$$= E\oint ds$$

$$\therefore \quad \phi_E = E.4\pi r^2, \qquad (\because \oint ds = 4\pi r^2) \quad ...(1)$$

But, charge enclosed the Gaussian surface is q. Therefore, from Gauss's law.

$$\phi_E = \frac{q}{\varepsilon_0}. \qquad ...(2)$$

Equating eqns. (1) and (2), we have

$$\therefore \; E.4\pi r^2 = \frac{q}{\varepsilon_0}$$

$$\text{or} \quad E = \frac{1}{4\pi\varepsilon_0}.\frac{q}{r^2} \qquad ...(3)$$

It is clear from above equation that, the electric field outside any uniformly charged spherical shell is exactly to that electric field when we take the same charge at the centre of sphere.

(ii) Point P lies on the surface of spherical shell : In this case,

$$r = R$$

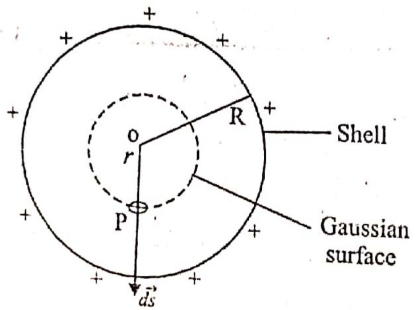


Fig.

$\therefore$ From eqn. (3),

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

(iii) When point P lies inside the spherical shell : As we know, the charge given to spherical shell spreads equally all over the surface, there is no charge present inside the sphere. Hence, by Gauss's law,

$$\phi_E = \frac{1}{\varepsilon_0}(0) = 0$$

$$\text{But,} \quad \phi_E = \oint_s \vec{E}.\vec{ds} = \oint E\, ds \cos 0$$

$$\therefore \quad \phi_E = E\oint ds = E.4\pi r^2$$

From eqns. (4) and (5),

$E.4\pi r^2 = 0 \Rightarrow E = 0$

Therefore, electric field inside a spherical shell is always zero. The given figure shows the variation of electric field with distance.

Or

Derive the expression for the capacity of parallel-plate capacitor when the medium between the plates is partially filled by a dielectric medium.

Ans. Let M and N be parallel plates of a capacitor. The distance between the plates is d and plate thickness t of dielectric constant ε_r is introduced.

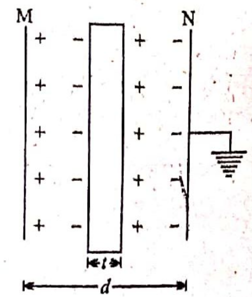


Fig.

Now, plate A is given charge $+q$. Let the charge density be σ, then

$$\sigma = \frac{q}{A}$$

$\therefore$ Intensity of field in air,

$$E_1 = \frac{\sigma}{\varepsilon_0}$$

$$\text{or} \quad E_1 = \frac{q}{\varepsilon_0 A}$$

Angle of deviation,

$\delta = \angle UTS$

In ΔTQR, $\delta = \angle TQR + \angle TRQ$,

(In a triangle, exterior angle is sum of interior opposite angles)

$= (i - r_1) + (e - r_2)$ ...(1)

In the position of minimum deviation,

$i = e$ (say)

and $r_1 = r_2 = r$ also $\delta = \delta_m$ (say)

$\therefore \delta_m = (i - r) + (i - r)$

$\delta_m = 2i - 2r$ ...(2)

In quadrilateral AQOR,

$\angle AQO + \angle ARO = 180°$

(each angle is equal to 90°)

$\therefore$ Remaining angles

$\angle A + \angle QOR = 180°$ ...(3)

In ΔQOR,

$\angle QOR + r_1 + r_2 = 180°$ ...(4)

From eqn. (3) and (4),

$\angle A + \angle QOR = \angle QOR + r_1 + r_2$

or $\angle A = r_1 + r_2$

By condition of minimum deviation,

$\angle A = r + r = 2r$, $[\because r_1 = r_2 = r]$

or $r = \dfrac{A}{2}$

Putting it in eqn. (2),

$\delta_m = 2i - A$

or $2i = A + \delta_m$

or $i = \dfrac{A + \delta_m}{2}$

By Snell's law,

$$\mu = \frac{\sin i}{\sin r}$$

$$\therefore \quad \mu = \frac{\sin\left(\dfrac{A + \delta_m}{2}\right)}{\sin\dfrac{A}{2}}$$

This is the required formula. **Proved.**

Or

Describe the astronomical telescope under the following heads :

(i) Rays diagram for the formation of image.

(ii) Formula for the magnification when the final image is formed : (a) At infinity and (b) At least distance of distinct vision.

Or

Draw ray diagram for astronomical telescope and derive formula for magnifying power.

Ans. (i) Ray diagram for the formation of image :

(a) When image is formed at infinity.

(b) When image is formed at least distance of distinct vision telescope.

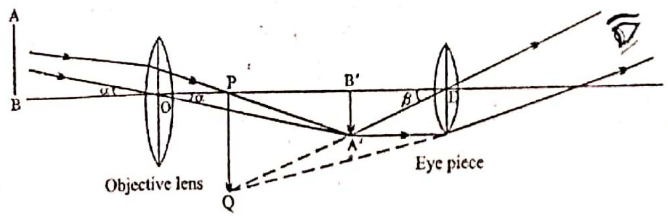


Fig. (a) When final image is formed at least distance of distinct vision

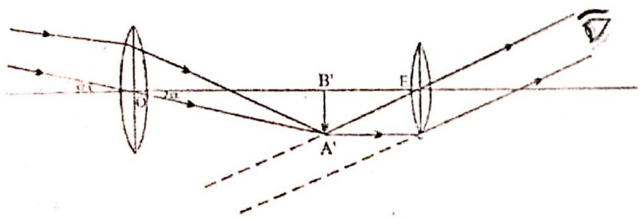


Fig. (b) When final image is formed at infinity

Expression for magnifying power : Magnifying power of a telescope in normal adjustment is defined as the ratio of the angle subtended by the image at the eye as seen through the telescope to the angle subtended by the object seen directly when both the object and the image be at infinity. It is also called angular magnification (m).

i.e., $m = \dfrac{\text{Visual angle of final image}}{\text{Visual angle of object}}$

or $m = \dfrac{\beta}{\alpha}$

Since α and β are very small therefore $\alpha = \tan\alpha$ and $\beta = \tan\beta$.

$\therefore \quad m = \dfrac{\tan\beta}{\tan\alpha}$ ...(1)

From fig. (a) and (b),

$\tan\beta = \dfrac{A'B'}{EB'}$ and $\tan\alpha = \dfrac{A'B'}{OB'}$

Putting the values in the eqn. (1), we get

$$m = \frac{A'B'/EB'}{A'B'/OB'}$$

or $m = \dfrac{A'B'}{EB'} \times \dfrac{OB'}{A'B'}$ or $m = \dfrac{OB'}{EB'}$

But $OB' = f_o$ = Focal length of objective lens

$EB' = -u_e$ = Distance of A'B' from eye piece

$m = \dfrac{f_o}{-u_e}$ or $m = -\dfrac{f_o}{u_e}$ ...(2)

Case I : When final image is formed at least distance of distinct vision : Let focal length of eye piece is f_e, then for eye piece $u = -u_e$ and $v = -D$.

$\therefore$ By lens formula $\dfrac{1}{f} = \dfrac{1}{v} - \dfrac{1}{u}$,

$$\frac{1}{f_e} = \frac{1}{-D} - \frac{1}{-u_e}$$

or $\dfrac{1}{f_e} = -\dfrac{1}{D} + \dfrac{1}{u_e}$

or $\dfrac{1}{u_e} = \dfrac{1}{f_e} + \dfrac{1}{D}$

Putting the value in eqn. (2), we get

$$m = -f_o\left(\frac{1}{f_e} + \frac{1}{D}\right)$$

or $m = \dfrac{-f_o}{f_e}\left(1 + \dfrac{f_e}{D}\right)$

In this condition, the length of telescop[e]

$= f_o + |u_e|$.

Case II : When final image is formed a[t]

If the image A'B' is formed at focus of eye p[iece] final image will form at infinity.

In this condition, $u_e = f_e$.

Putting the value in eqn. (2), we get

$$m = \frac{-f_o}{f_e}$$

In this condition, the length of telescop[e]

$L = f_o + f_e$.

Conditions for better magnification : [...] magnification of telescope, following are t[he condi]tions:

(i) The focal length (f_o) of the objectiv[e ...] more,

(ii) The focal length (f_e) of the eye le[ns ...] less,

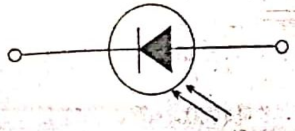
(iii) The eye lens must be formed at lea[st distance] of distinct vision,

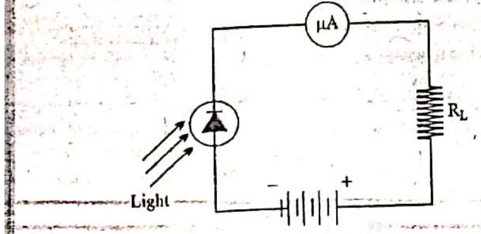
(iv) The eye must be kept near to the [...]

Q. 21. What do you mean by photo diode ? Draw the symbol of it and characteristics curve ? 3

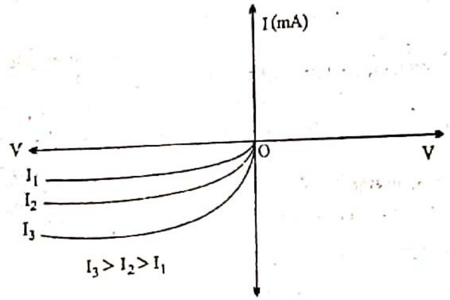
Ans. Photo diode is a P–N junction diode which is made up of light sensitive semiconductor devices. Photo diode is at reverse bias.

Symbol :





Characteristics curve :



Q. 22. Compare the amplitude modulation and frequency modulation ? 3

Ans. Comparison of amplitude modulation and frequency modulation :

S. No.	Amplitude modulation	Frequency modulation
1.	In AM the amplitude of carrier waves change in accordance with amplitude of modulating wave.	In FM the amplitude remains constant.
2.	It is noisy.	There is less noise level in frequency modulation.
3.	AM receiver and transmitter are cheaper and simple.	FM receivers and transmitters are complex and costly.
4.	In amplitude modulation LW, MW and SW transmission is possible.	In FM, VHF and UHF transmission is possible.

SECTION–D

Q. 23. Obtain an expression of mutual inductance of two long coaxial solenoids. Also write the factors which affects the mutual inductance. 4

Ans. Let us consider about two long solenoids S_1 and S_2. The solenoid S_1 is completely enclosed by S_2. The two solenoids are coaxial having equal length l. The number of turns per unit length in S_1 and S_2 are n_1 and n_2 respectively.

Let I_1 current is flowing through solenoids S_1; then the intensity of magnetic field at a point inside it be

$$B_1 = \mu_0 n_1 I_1$$

∴ The flux linked with solenoid S_2 due to magnetic field of S_1 be :

$$\phi_{21} = N_2 B_1 A$$
$$= n_2 l . \mu_0 n_1 I_1 A, \qquad [\because N_2 = n_2 l]$$
$$\phi_{21} = \mu_0 n_1 n_2 l I_1 A \qquad ...(1)$$

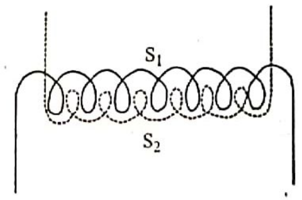


Fig. Mutual inductance of two long solenoid.

If the mutual inductance of second coil with respect to first coil is M_{21}, then

$$M_{21} = \frac{\phi_{21}}{I_1} \qquad ...(2)$$

From eqn (1) and (2),

$$M_{21} = \mu_0 n_1 n_2 A l \qquad ...(3)$$

Now, if I_2 current is flowing through secondary solenoid S_2, then magnetic field inside it be :

$$B_2 = \mu_0 n_2 I_2 \qquad ...(4)$$

∴ The flux linked with solenoid S_1 due to magnetic field of S_2 be :

$$\phi_{12} = N_1 B_2 A$$
$$= n_1 l \mu_0 n_2 I_2 A$$
$$\text{or} \quad \phi_{12} = \mu_0 n_1 n_2 I_2 l A \qquad ...(5)$$

If the mutual inductance of first coil with respect to second coil is M_{12}, then

$$M_{12} = \frac{\phi_{12}}{I_2}$$

$$\text{or} \quad M_{12} = \frac{\mu_0 n_1 n_2 I_2 l A}{I_2}$$

$$\text{or} \quad M_{12} = \mu_0 n_1 n_2 l A \qquad ...(6)$$

From eqn. (3) and (6), it is clear that

$$M_{12} = M_{21} = M \text{ (Say)}$$

Hence, the mutual inductance of two long coaxial solenoids are

$$M = \mu_0 n_1 n_2 l A \qquad ...(7)$$

Obviously, "In case of long solenoids the mutual inductance remains same whether the current flows through either of the coil."

Now, if the total number of turns is S_1 and S_2 are $N_1 = n_1 l$ and $N_2 = n_2 l$ respectively,then

$$n_1 = \frac{N_1}{l} \text{ and } n_2 = \frac{N_2}{l}$$

∴ From eqn. (7),

$$M = \frac{\mu_0 N_1 N_2 A}{l} \qquad ...(8)$$

This is the formula of mutual inductance of two long solenoids.

Factors affecting the mutual inductance :

(i) On no. of turns of solenoid :

$$M \propto N_1 N_2$$

(ii) On the area of secondary solenoid :

$$M \propto A$$

(iii) On the length of solenoids :

$$M \propto \frac{1}{l}$$

(iv) On the medium between the solenoid :

$$M \propto \mu.$$

Or

The alternating voltage is applied with the help of an alternating e.m.f. source, across the ends of pure inductive coil :

(i) Obtain phase difference between current and voltage.

(ii) Obtain current and average power consumed in the circuit.

(iii) Draw the voltage-time graph and current-time graph for the circuit.

Ans.

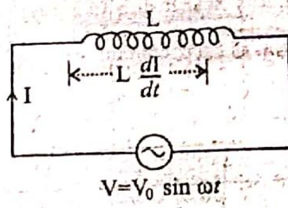


Fig. (a) AC circuit containing 'I'

(i) Let us consider about an AC circuit containing pure inductance only. Let an alternating e.m.f.

$$V = V_0 \sin \omega t \qquad ...(1)$$

is applied across the ends of inductor, as shown in fig. (a), where V is instantaneous voltage, V_0 is peak value of voltage and ω is angular frequency. If the current through this circuit at an instant 't' is 'I', then

$$V = L\frac{dI}{dt} \text{ or } dI = \frac{V}{L} dt$$

$$\text{or} \quad dI = \frac{V_0}{L} \sin \omega t \, dt \qquad ...(1)$$

Integrating eqn. (1),

$$I = \int \frac{V_0}{L} \sin \omega t \, dt = \frac{V_0}{L} \int \sin \omega t \, dt$$

$$= \frac{V_0}{L}\left[-\frac{\cos \omega t}{\omega}\right] = \frac{V_0}{\omega L}(-\cos \omega t)$$

$$\frac{V_0}{\omega L} \sin\left(\omega t - \frac{\pi}{2}\right)$$

$$= I_0 \sin\left(\omega t - \frac{\pi}{2}\right) \qquad ...(2)$$

$$\frac{\frac{1}{\mu}}{v}-\frac{1}{v_1}=\frac{\left(\frac{1}{\mu}-1\right)}{R_2} \quad ...(2)$$

Where $\frac{1}{\mu}$ = Refractive index of air w.r.t. glass.

Multiply by μ both the sides, we get

$$\frac{1}{v}-\frac{\mu}{v_1}=\frac{1-\mu}{R_2} \quad ...(3)$$

Adding eqns. (1) and (3), we get

$$\frac{1}{v}-\frac{1}{u}=(\mu-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right) \quad ...(4)$$

Now, if $u=\infty$, then $v=f$

[∵ If object is at infinity then image formed at focus]

$$\therefore \quad \frac{1}{f}-\frac{1}{\infty}=(\mu-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

$$\therefore \quad \frac{1}{f}=(\mu-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right) \quad ...(5)$$

This formula is also called Lens Maker's Formula.

Or

Explain laws of reflection on the basis of Huygen's wave theory.

Ans. Laws of reflection on the basis of huygen's wave theory

Let XY be a reflecting surface, on which a plane wavefront AB strikes with a velocity c. PA is an incident ray.

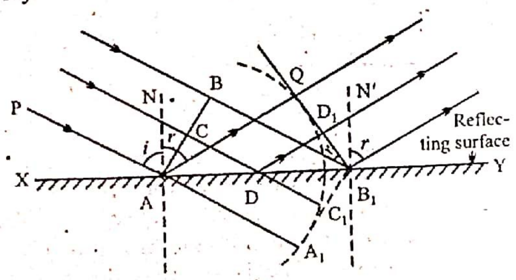


Fig. Reflection on the basis of Huygens' theory.

At $t=0$, the wavefront AB touches the reflecting face XY at A. Draw a normal AN on the surface XY at A. Then $\angle PAN = i$ = angle of incidence.

All the points of the wavefront AB will touch the reflecting face XY. At last the point B will touch the face at B_1. Let the time taken by B to reach B_1 is t. Then $BB_1 = ct$ (∵ distance = velocity × time). Had there been no reflecting face XY in the path of wavefront, then by Huygen's principle, the position of AB would have been at A_1B_1. Then $AA_1 = ct$. But due to the presence of face XY, when the wavefront just strikes, the point A starts sending the secondary wavelets. These wavelets reach a distance of $AQ = ct$ in time t.

Taking A as centre, draw a sphere of radius ct and from the point B draw a tangential plane B_1Q touching this sphere at Q. B_1Q acts as reflected wavefront.

Test of reflected wavefront : Take a point C on the incident wavefront AB. Draw a line CC_1 parallel to BB_1 which intersects the plane XY at D. From the point D, draw a perpendicular DD_1 on B_1Q.

Hence, $\Delta B_1AQ \sim \Delta B_1DD_1$

$$\therefore \quad \frac{AQ}{DD_1}=\frac{AB_1}{DB_1} \quad ...(1)$$

Similarly, $\Delta B_1AA_1 \sim \Delta B_1DC_1$

$$\therefore \quad \frac{AB_1}{DB_1}=\frac{AA_1}{DC_1} \quad ...(2)$$

From eqns. (1) and (2), we have

$$\frac{AQ}{DD_1}=\frac{AA_1}{DC_1} \text{ or } \frac{ct}{DD_1}=\frac{ct}{DC_1}, \quad (\because AQ = AA_1 = ct)$$

$\therefore$ $DD_1 = DC_1$ = radius of secondary wavelets coming out of point D.

Hence, the secondary wavelets coming out of point D touches B_1Q. It is true for all the points situated in between A and B_1. Hence, B_1Q is the reflected wavefront.

Proof of the laws : AQ is perpendicular to the reflected wavefront B_1Q. Hence AQ will be the reflected ray.

$\therefore \quad \angle QAN = r$ = angle of reflection

Now, angle of incidence,

$$i = \angle PAN = 90° - \angle BAN = \angle BAB_1$$

and angle of reflection,

$$r = \angle QAN = 90° - \angle QAB_1 = \angle AB_1Q$$

In right angled ΔABB_1,

$$\sin i = \sin BAB_1 = \frac{BB_1}{AB_1}=\frac{ct}{AB_1}, \quad (\because BB_1 = ct)$$

Hence, $\quad ct = AB_1 \sin i \quad ...(3)$

Similarly in ΔAQB_1,

$$\sin r = \sin AB_1Q = \frac{AQ}{AB_1}=\frac{ct}{AB_1}, \quad (\because AQ = ct)$$

Hence, $\quad ct = AB_1 \sin r \quad ...(4)$

From eqns. (3) and (4), $AB_1 \sin i = AB_1 \sin r$

or $\quad \sin i = \sin r$

or $\quad i = r$

Hence, angle of incidence is equal to the angle of reflection.

Q. 26. Calculate the intensity of electric field due to a linear charge with the help of Gauss's theorem. **5**

Ans. Let MN is a linear conductor, at r distance apart from it at point P the intensity of electric field is to be obtained. Let $+q$ charge is given to its length 'l', then linear charge density

$$\lambda = \frac{q}{l}$$

$$q = \lambda l \quad ...(1)$$

Draw a cylinder of radius 'r' (With axis MN) of length 'l'. The surface of this cylinder will be a Gaussian surface. Let us rate a small surface ds containing the point 'P'.

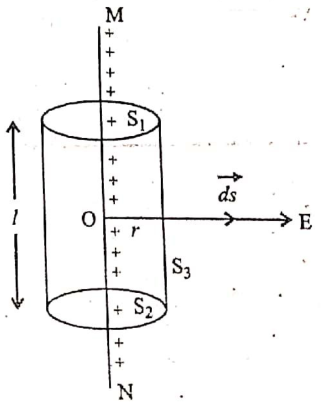


Fig. Intensity of electric field due to a linear charge.

$\therefore$ Flux linked with ds

$$d\phi = \vec{E}.\vec{ds}$$

The cylindrical Gaussian surface has three surfaces :

(i) Plane circular surface S_1

(ii) Plane circular surface S_2

(iii) Curved surface S_3

∴ Net flux linked with Gaussian surface,

$$\phi = \oint_S \vec{E}.\vec{ds} = \int_{S_1}\vec{E}.\vec{ds}+\int_{S_2}\vec{E}.\vec{ds}+\int_{S_3}\vec{E}.\vec{ds}$$

$$\phi = \int_{S_1} E\,ds\cos 90° + \int_{S_2} E\,ds\cos 90° + \int_{S_3} E\,ds\cos 0°$$

$$= 0+0+\int_{S_3} E\,ds = \int_{S_3} E ds$$

or $\quad \phi = E.2\pi rl \quad ...(2)$

But by Gauss's theorem

$$\phi = \frac{\text{Charge present inside the Gaussian Surface}}{\varepsilon_0}$$

[From eqn. (1)]

$$= \frac{q}{\varepsilon_0}=\frac{\lambda l}{\varepsilon_0} \quad ...(3)$$

From eqn. (2) and (3)

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

or $\quad E = \dfrac{\lambda l}{2\pi r\varepsilon_0 l}$

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

This is the required expression.

Or

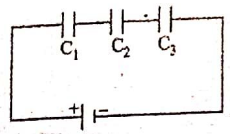
The capacities of two conductors are C_1 and C_2 respectively. q_1 and q_2 charges are given so that their potentials become V_1 and V_2 respectively. If they are connected by a wire, calculate the following :

(i) Common potential and (ii) Loss of energy.

Or

Prove that when two charged conductors a[re] connected, there will be a loss of energy.

Ans. Let A and B are two conductors of capacit[ies] C_1 and C_2 respectively. When charges q_1 and q_2 given separately, the potential becomes V_1 and respectively.



Effective capacitance :

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

$$=\frac{1}{3}+\frac{1}{3}+\frac{1}{3}$$

$$\frac{1}{C}=\frac{3}{3} \Rightarrow C=1\mu F$$

Hence, effective capacitance = $1\mu F$ **Ans.**

Q. 7. Why the potentiometer must have longer wire ? 2

Ans. The longer wire is used in potentiometer so that the potential gradient reduces and the balance point is obtained away from higher potential point. Hence, the accuracy will be more and the sensitivity of potentiometer is increased.

Q. 8. Write three differences between specific resistance and resistance. 2

Ans. The differences between specific resistance and resistance are :

Specific resistance	Resistance
1. It's value depends on nature of material of the conductor.	1. It's values depends on material of conductor, it's length and it's cross section area of conductor.
2. Specific resistance remains unchanged, on changing conductor's length or cross section area.	2. Value of resistance changes on changing length or radius of conductor.
3. It's unit is Ω - m (ohm-meter)	3. It's unit is Ω (ohm).

Q. 9. Write demerits of amplitude modulation. 2

Ans. The demerits of disadvantages of amplitude modulation are given below :

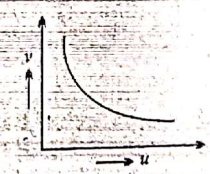
(i) Noise reception : The amplitude modulated signals are affected by external noise (Unwanted signals) and so the reception is noisy.

(ii) It has low frequency.

(iii) It has small operating range.

Q. 10. Plot a graph of 'u' versus 'v' for concave mirror. 2

Ans.



SECTION-C

Q. 11. What do you understand by internal resistance of a cell ? On what factors does it depend and also derive it's expression ? 3

Ans. The resistance offered by the electrolyte of the cell (placed between two electrode) during the flow of current inside the cell is called internal resistance of the cell.

The following factors affect the internal resistance of the cell :

(a) Distance between the electrodes.

(b) Area of immersed electrodes.

(c) Concentration of the electrolyte.

(d) Temperature.

Let e.m.f. of a cell be E and it's internal resistance is r.

If current I is flowing through a resistance R, then by Ohm's law,

$$I=\frac{V}{R} \quad ...(1)$$

Where, V is the potential difference across the resistance.

Now, total e.m.f. of the circuit = E and total resistance of the circuit = R + r

$$I=\frac{E}{R+r} \quad ...(2)$$

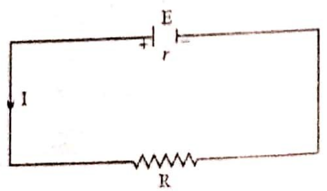


Fig.

By eqn. (1) and (2) we get

$$\frac{V}{R}=\frac{E}{R+r}$$

or $VR+Vr=ER$

or $Vr=ER-VR$

or $$r=\frac{R(E-V)}{V}$$

$\therefore$ $$r=R\left(\frac{E}{V}-1\right)$$

This is the required relationship.

Q. 12. Obtain an expression for work done in deflecting a bar magnet in a uniform magnetic field. 3

Ans. Let a bar magnet of magnetic moment M is placed in a uniform magnetic field of intensity B such that it makes an angle θ with the direction of field.

The torque acting on bar magnet is

$$\tau = MB\sin\theta.$$

If small amount of work done in relating the magnet is dW then.

$$dW=\tau.d\theta$$
$$=MB\sin\theta d\theta$$

$\therefore$ Net work done in deflecting the magnet through angle θ.

$$\int_0^W dW=\int_0^\theta MB\sin\theta d\theta$$

or $$W = MB.\int_0^\theta \sin\theta d\theta$$

$$=MB[-\cos\theta]_0^\theta$$

$$=MB[-\cos\theta+\cos 0°]$$

$$W=MB[1-\cos\theta]$$

This is the required expression.

Q. 13. The magnetic flux through a coil is varying according to the relation $\phi=(6t^2-5t+1)$ wb calculate the induced current through the coil at t= 0·25sec if the resistance of the coil is 10 Ω. 3

Sol. Formula, $e=-\frac{d\phi}{dt}$

and $I=\frac{E}{R}$

Given : $\phi=6t^2-5t+1$

$\therefore$ $$e=-\frac{d\phi}{dt}=\frac{-d}{dt}(6t^2-5t+1)$$

$$=-12t+5$$

Put $t=0{\cdot}25$ sec

$$e=-12\times0{\cdot}25+5$$

$$e=2 \text{ Volt.}$$

Induced current $I=\frac{e}{R}=\frac{2}{10}=0{\cdot}2$ Amp. **Ans.**

Q. 14. What are electromagnetic waves ? How can these waves be produced ? 3

Ans. The electromagnetic waves are those waves in which there are sinusoidal variation of electric and magnetic field vectors which are mutually perpendicular and also perpendicular to the direction of propagation of wave.

(a) Experimental arrangement : The experi-mental arrangement of Hertz experiment is shown in fig. X_1 and X_2 are two metallic plates which are connected to two small metallic spheres by thick metallic rods R_1 and R_2. There is an air gap between the spheres. The metallic plates are connected with an induction coil. With the help of induction a high potential difference can be applied between the plates. A detector made of thick circular wire is used to detect the electromagnetic waves as shown in fig.

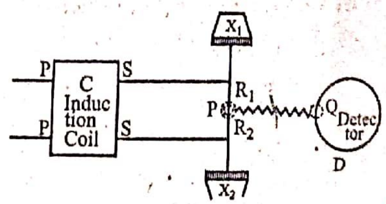


Fig. Hertz experiment.

Conclusion : When a very high potential of the order of thousands volts, then the particles of air gap are ionized and the electromagnetic waves of high frequency are generated. When detector is adjusted such that it's air gap Q is parallel to air gap P, then the oscillatory electric field is perpendicular to the plane of detector. So, an electric field is produced in the gap of detector which causes a spark.

If the gap Q is perpendicular to gap P, then no spark is obtained. So, it can be concluded that the electromagnetic waves produced in gap P are polarized. In the Hertz experiment the wavelength of wave produced in nearly 6 m.

Q. 7. Calculate the number of free electrons flown per second through a conductor carrying 1A of current ? 2

Ans. Given,

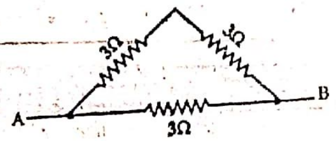
$$I = 1A,$$
$$t = 1 \text{ sec.}$$

No. of free electrons $n = \frac{It}{e}$

$$n = \frac{1 \times 1}{1{\cdot}6 \times 10^{-19}}$$

$$n = 0{\cdot}625 \times 10^{19},$$

Q. 8. Find out effective resistance between points A and B : 2



Ans. Two resistances each of 3 Ω are in series, hence their effective resistance is 6 Ω. This effective resistance is in parallel combination with third resistance of 3Ω.

$$\frac{1}{R} = \frac{1}{6} + \frac{1}{3} \Rightarrow \frac{1}{R} = \frac{1+2}{6} \Rightarrow \frac{1}{R} = \frac{3}{6}$$

$\therefore$ R = 2Ω.

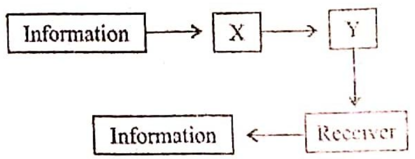
Q. 9. What is polaroid ? State its any two applications. 2

Ans. Polaroids are large sized manufactured polarizing films capable of producing plane polarized beam of light.

Applications : (i) They are used in sun glasses to reduce intensity of light.

(ii) They are used for viewing three-dimensional pictures.

Q. 10. Name 'X' and 'Y' in the given communication system : 2

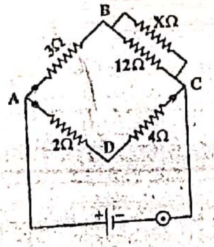


Ans. X → Transmitter

Y → Communication channel (Medium).

SECTION–C

Q. 11.



In the electric network given above points B and D are at same potential. Find out value of X. 3

Sol. The given circuit diagram is similar to balanced wheatstone bridge. Hence

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

i.e. $$\frac{3}{\frac{12x}{x+12}} = \frac{2}{4}$$

or $$\frac{3(x+12)}{12x} = \frac{1}{2}$$

or $$6(x+12) = 12x$$

or $$6x + 72 = 12x$$

or $$12x - 6x = 72$$

$$6x = 72$$

or $$x = \frac{72}{6} = 12\Omega.$$ **Ans.**

Q. 12. What is self induction ? define self inductance and write its unit. 3

Ans. Whenever there is a change in current passing through a coil or circuit the magnetic flux linked with it will also change. As a result of this in accordance with Faraday's law of electromagnetic induction an e.m.f. is induced in the coil or the circuit which opposses the changes that causes it. This phenomenon is called self induction.

$$e = -L\frac{dI}{dt}$$

If $\frac{dI}{dt} = 1$ then

$$\boxed{e = -L}$$

Self inductance of coil is numerically equal to e.m.f. induced in the coil when rate of change of c[...] the coil is unity.

SI unit = "Henry".

Q. 13. Write any three differences between diamagnetic and paramagnetic substances.

Ans. Three differences between diamagnetic and paramagnetic substances :

S. N.	Paramagnetic substance	Diamagnetic substance
1.	They are attracted towards strong magnets.	They are repelled by strong magnet.
2.	When suspended in a magnetic field they aligned parallel to the field.	When suspended in a magnetic field they align perpendicular to the field.
3.	They move from weaker region to stronger region in magnetizing field.	They move from stronger region to weaker re[...] in a magnetic field.

Q. 14. What is microwave oven ? How does it work ? 3

Ans. A device that uses microwaves for cooking and warming food is known as microwave oven.

The magnetron in microwave oven produces microwaves of higher frequency.

These waves penetrate food and excite the molecules of water and that of food contents to vibrates at large amplitudes to produce heat.

This heat produced is used for cooking food.

Q. 15. The focal length of a plano-convex lens (μ = 1·5) is 0·3m. Find out radius of curvature of its convex surface. 3

Sol. Given : $f = 0{\cdot}3 \text{ m} = 30 \text{ cm}$ and $\mu = 1{\cdot}5$

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

or $$\frac{1}{f} = (1{\cdot}5 - 1)\left[\frac{1}{R_1} - \frac{1}{\infty}\right]$$

$\Rightarrow$ $$\frac{1}{30} = (1{\cdot}5 - 1)\left(\frac{1}{R_1} - 0\right)$$

or $$\frac{1}{30} = \frac{0{\cdot}5}{R_1}, \qquad \left(\because \frac{1}{\infty} = 0\right)$$

$\Rightarrow$ $R_1 = 30 \times 0{\cdot}5 = 15$ cm. **Ans.**

Q. 16. The soap bubble appears to be coloured when white light is incident on its surface. Name the phenomena involved in this process and explain it. 3

Ans. The name of the phenomena is interference of light. When white light is made to fall from an extented source on a thin film of soap bubble [...] some part of it is reflected and remaining pa[...] transmited.

The transmitted part again undergoes reflec[...] bottom surface. The interference occurs betwe[...] light reflected from top and bottom surface of [...] film and at time of constructive interfere[...] particular colour can be seen in white light and [...] feflected part at some points the bubble ap[...] coloured.

Actually interference is redistribution of e[...] due to superposition of light waves coming fro[...] coherent sources of light.

Q. 17. Explain dual nature of light and fi[...] wave equation.

Sol. For few phenomena light shows wave [...] and for few phenomena it shows particle nature [...] is called dual nature of light. For example interf[...] of light is explained on the basis of wave na[...] light while to explain photoelectric effect ligh[...] are treated to be made up of particles.

A wave associated with a moving par[...] known as matter wave or de-Broglie wave.

Wave equation— According to quantum [...] the energy of a photon is given by the form[...]

$$E = h\nu$$

where, h = Planck constant and ν = fr[...] of light.

Suppose the mass of photon is m.

$\therefore$ By Einstein's mass energy relatio[...]

$$E = mc^2$$

Where, c = Velocity of light

Similarly, the intensity of field due to $(-q)$ charge will be :

$$E_2 = \frac{1}{4\pi\varepsilon_0} \cdot \frac{(-q)}{(r^2+l^2)} \quad ...(2)$$

(along PB direction)

$\therefore$ Resultant, $E = E_1 \cos\theta + E_2 \cos\theta$

or $E = 2E_1 \cos\theta$

[From eqn. (1) and eqn. (2), $|E_1| = |E_2|$] ...(3)

The components $E_1 \sin\theta$ and $E_2 \sin\theta$ cancel each other because their magnitudes are equal and their direction are opposite

But, in right angled ΔAOP,

$$\cos\theta = \frac{AO}{AP} = \frac{l}{\sqrt{r^2+l^2}}$$

$$E = \frac{1}{4\pi\varepsilon_0} \cdot \frac{2q}{r^2+l^2} \cdot \frac{l}{\sqrt{r^2+l^2}},$$

[from eqn. (3)]

or $$E = \frac{1}{4\pi\varepsilon_0} \cdot \frac{p}{(r^2+l^2)^{\frac{3}{2}}},$$

$[\because p = q \times 2l]$

If $l << r$, then

$$E = \frac{1}{4\pi\varepsilon_0} \cdot \frac{p}{(r^2)^{\frac{3}{2}}} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{p}{r^3}$$

or $$E = \frac{1}{4\pi\varepsilon_0} \cdot \frac{p}{r^3}.$$

Or

Establish the formula of intensity of electric field at a point on axial position due to an electric dipole.

Ans. Let AB is an electric dipole whose length is $2l$ and charge is q. Due to this dipole intensity of electric field at point P on the axis is to be obtained. Distance of point P from the centre of dipole is 'r'.

Along $\overrightarrow{PA}$,

Intensity due to $+q$ charge at P is

$$E_1 = \frac{1}{4\pi\varepsilon_0} \frac{q}{BP^2} = \frac{1}{4\pi\varepsilon_0} \frac{q}{(r-l)^2} \quad ...(1)$$

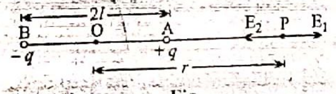


Fig.

Along $\overrightarrow{BP}$

Intensity at P due to $-q$ charge is

$$E_2 = \frac{1}{4\pi\varepsilon_0} \frac{-q}{(AP)^2} = \frac{1}{4\pi\varepsilon_0} \frac{-q}{(r+l)^2} \quad ...(2)$$

The intensity of electric at P due to electric dipole

$$\vec{E} = \vec{E}_1 + \vec{E}_2$$

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

$$= \frac{q}{4\pi\varepsilon_0}\left[\frac{1}{(r-l)^2} - \frac{1}{(r+l)^2}\right]$$

$$= \frac{q}{4\pi\varepsilon_0}\left[\frac{4rl}{(r^2-l^2)^2}\right]$$

$$= \frac{2r(2ql)}{4\pi\varepsilon_0(r^2-l^2)^2}$$

$\because$ $2ql = p$

$\therefore$ $$E = \frac{2pr}{4\pi\varepsilon_0(r^2-l^2)^2}$$

If $r >> l$, then l can be neglected, so

$$E = \frac{1}{4\pi\varepsilon_0} \cdot \frac{2p}{r^3}$$

This is the required expression.

C.G. BOARD SAMPLE PAPER SET-I

Physics (C.G.) : Class XII

Time : 3 Hrs. M. M. : 70

Instruction :

1. All questions are compulsory. Total No. of questions are 26.
2. There are five sections in this question paper. Each question in Section 'A' carries 1 mark, in Section 'B' 2 marks, Section 'C' 3 marks, Section 'D' 4 marks and in Section 'E' each question is of 5 marks.
3. Q. No. 1 to 5 carries 1 mark each.
4. Q. No. 6 to 10 are very short answer type questions and carries 2 mark each.
5. Q. No. 11 to 22 are short answer type questions and carries 3 mark each.
6. Q. No. 23 is long answer type questions and carries 4 mark each.
7. Q. No. 24 to 26 are very long answer type questions and carries 5 mark each.

SECTION–A

Q. 1. Name the physical quantities whose SI unit is Newton/ Coulomb. Is it vector of scaler ? 1

Ans. Electric field intensity. It is a vector quantity.

Q. 2. An A.C. current flowing through a circuit is $I = 5\sin\frac{2\pi t}{T}$. Find out the rms value of current. **1**

Ans. Given,

A.C. current $\Rightarrow I = 5\sin\frac{2\pi t}{T}$

On comparing

$I = I_0 \sin\omega t$

We get, $I_0 = 5$

$$I_{rms} = \frac{I_0}{\sqrt{2}} = \frac{5}{\sqrt{2}} A.$$ **Ans.**

Q. 3. Define Snell's law for refraction of light ? **1**

Ans. According to Snell's law :

"When a ray of light travels from one medium to another medium then ratio of sine of angle of incidence to the sine of the angle of refraction is always constant and constant is called refractive index of medium".

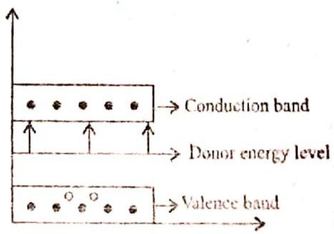
i.e. $$\boxed{{}_1\mu_2 = \frac{\sin i}{\sin r}}.$$

Q. 4. Alkali metals are more suitable for photo electric emission, why ? **1**

Ans. Work function of alkali metals are less, that is the reason, alkali metals are more suitable for photoelectric emission.

Q. 5. Show the donor energy level in energy band diagram of N-Type semiconductor. **1**

Ans.



An aluminium pointer is fixed with the coil, which moves on a graduated scale. It is kept inside a non-magnetic box, to protect it from air and dust.

The front portion of box is made up of glass in order to see the pointer and scale.

In the given figure.

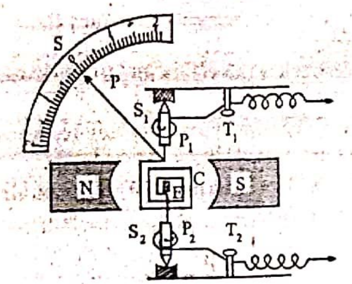


Fig. Weston (pivoted) galvanometer

N, S → Pole pieces of horseshoe magnet, C → Coil, E → Core, P_1, P_2 → Pivots, S_1, S_2 → Springs, T_1, T_2 → Terminals and P → Pointer.

Working : When the current is passed through the coil, a deflecting couple acts on it hence the coil is deflected. At the same time the springs produce restoring couple. In equilibrium, both the moment of couple are equal and opposite.

Let θ be the deflection in the galvanometer when I current is passed through its coil, then $I \propto \theta \Rightarrow I = k\theta$,

where $k = \dfrac{C}{NBA}$.

In this way, deflection in a galvanometer is directly proportional to current flowing through its coil.

In order to make it more sensitive,

(i) The number of turns in the coil should be increased.

(ii) Use strong magnet as horseshoe magnet.

(iii) Increase the area of the coil.

Or

Explain construction, principle and working of a cyclotron. Derive an expression for maximum K.E. of charged particle.

Or

Explain the cyclotron under follwoing points :

(i) Construction, (ii) Principle and working process.

Ans. Construction : It consist of two hollow D-shaped metallic chambers D_1 and D_2, called dees. These dees are separated by a small gap where a source of positively charged particle is placed. Dees are connected to a high frequency oscillator, which provide high frequency electric field across the gap of the dees. This arrangement is placed between two poles of strong electromagnet. The magnetic field due to this electromagnet is perpendicular to the plane of the dees.

Principle : When a positively charged particle is made to move again and again under the influence of magnetic field and high frequency electric field, then gain large amount of energy.

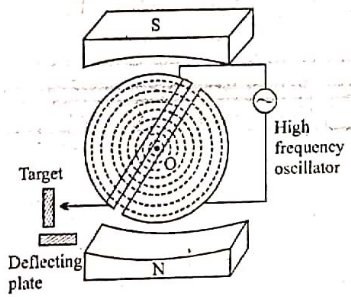


Fig.

Working : If a positively charged particle (proton) is emitted from O, when D_2 is negatively charged and the dee D_1 is positively charged, it will accelerate towards D_2. As soon as it enters D_2, it is shielded from the electric field by metallic chamber (enclosed space). Inside D_2, it moves at right angles to the magnetic field and hence describe a semi-circle inside it. After completing the semicircle, it enters the gap between the dees at the time when the polarities of the dees have been reversed. Now, the proton is further accelerated towards D_1. Then it enters D_1 and again describes the semicircle due to the magnetic field which is perpendicular to the motion of the proton. This motion continues till the proton reaches the periphery of the dee system. At this stage, the proton is deflected by the deflecting plate which then comes out through the window and hits the target.

Theory : When a proton (or any other positively charged particle) moves at right angle to the magnetic field $\vec{B}$ inside the dees, Lorentz force acts on it.

i.e., $F = qvB \sin 90° = qvB$

Where, q = Charge of particle

and v = Velocity of particle

The force provides the necessary centripetal force $\dfrac{mv^2}{r}$, to the charged particle to move in a circular path of radius r.

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

$$\text{or} \quad r = \frac{mv}{qB} \quad \text{...(1)}$$

Time taken to complete one semicircle inside a dees,

$$t = \frac{\text{Distance}}{\text{Speed}} = \frac{\pi r}{v}$$

$$\text{or} \quad t = \frac{\pi}{v} \times \frac{mv}{qB}, \quad \text{[from equ. (1)]}$$

$$\therefore \quad t = \frac{\pi m}{qB} \quad \text{...(2)}$$

Thus, time taken to complete one semi-circle does not depend upon radius of path.

If T is the time-period of the alternate electric field, then the polarities of the dees changes in time T/2.

$$\frac{T}{2} = \frac{\pi m}{qB}$$

$$\text{or} \quad T = \frac{2\pi m}{qB} \quad \text{...(3)}$$

cyclotron frequency

$$\upsilon = \frac{1}{T}$$

$$i.e., \quad \upsilon = \frac{qB}{2\pi m}$$

Expression of K.E.

$$K.E. = \frac{1}{2} mv^2$$

$$K.E. = \frac{1}{2} m \left(\frac{qBr}{m}\right)^2, \quad \left(\because v = \frac{qBr}{m}\right)$$

K.E. of charged particle

$$= \frac{1}{2} \frac{q^2B^2r^2}{m}$$

$$\text{or} \quad K.E. \propto r^2, \quad \left(\because \frac{q^2B^2}{2m} = \text{constant}\right)$$

i.e. K.E. becomes maximum at circumference of dees.

Q.25. Derive the formula for refraction at convex spherical surface. 5

$$\frac{\mu}{v} - \frac{1}{u} = \frac{\mu - 1}{R},$$

where symbols have their usual meanings.

Ans. Let APB be main cross-section of convex refracting surface. There is an air on its left side and a medium of refractive index μ on its right side. O is object and its real image is formed at I. As per diagram

$\angle OML = i$ = angle of incidence

$\angle IMC = r$ = angle of refraction

Let $\angle MOC = \alpha$, $\angle MCP = \gamma$ and $\angle MIP = \beta$

As per Snell's law

$$\mu = \frac{\sin i}{\sin r} \Rightarrow \mu = \frac{i}{r},$$

($\because$ for smaller values of i and r, $\sin i \approx i$ and $\sin r \approx r$)

$$\text{or} \quad i = \mu r \quad \text{...(1)}$$

In ΔOMC, $i = \alpha + \gamma$ and in ΔIMC, $\gamma = r + \beta$

or $r = \gamma - \beta$

From equation (1)

$$(\alpha + \gamma) = \mu(\gamma - \beta) \quad \text{...(2)}$$

$$\because \quad \text{angle} = \frac{\text{arc}}{\text{radius}}$$

$$\therefore \quad \alpha = \frac{PM}{OP}, \beta = \frac{PM}{PI}, \gamma = \frac{PM}{PC}$$

Putting these values in equation (2)

$$\left(\frac{PM}{OP} + \frac{PM}{PC}\right) = \mu\left(\frac{PM}{PC} - \frac{PM}{PI}\right)$$