MODEL SET-1

SECTION-II (NON-OBJECTIVE TYPE QUESTIONS)

Question Nos. 1 to 11 are of short answer type. Each question carries 2 marks. 11 × 2 = 22

SHORT QUESTIONS

1. What do you mean by surface charge density and write its SI unit ?

Ans.—Surface charge density—It is defined as charge per unit area. It is denoted by σ.

It can be expressed as, $\boxed{\sigma = \frac{Q}{A}}$

The S.I. unit of σ coulomb / metre^2 (cm^{-2}).

2. The vertical component of earth's magnetic field at a place is $\sqrt{3}$ times the horizontal component. What is the angle of dip at this place ?

Ans.—We know that,

$$\tan\theta = \frac{V}{H}$$

Where 'θ' is the angel of dip, According of question it is given

that, $V = \sqrt{3}H$

$$\therefore \quad \tan\theta = \frac{V}{H} = \sqrt{3}$$

$$\therefore \quad \tan\theta = \sqrt{3}$$

So, $\boxed{\theta = 60^\circ}$

3. Give two applications of ultra-violet waves.

Ans.—Two applications of ultra-violet waves are as follow—

(i) They are used to preserve food stuff and make drinking water free from bacteria, as these rays can kill bacteria, germs etc.

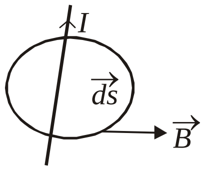
(ii) They are used for stirlizing the surgical instruments.

4. State Ampere's circuital law. Express it mathematically.

Ans.—It states that—"Line integral of magnetic field 'B' around any closed path is free space is equal to absolute permeability 'μ_0' times the net current 'I' enclosed by the path.

Mathematically, it can be expressed as—

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



5. A wire of resistance 10 Ω is stretched to double its length. What will be its new resistance ?

Ans.— $R = p\frac{l}{A} = p\frac{ll}{Al} = \frac{p}{V}l^2$

V is volume which does not change in stretching.

$$\therefore \quad \frac{R_2}{R_1} = \frac{l_2^{\,2}}{l_1^{\,2}} = \frac{(2l_1)}{l_1} = 4$$

$$\therefore \quad R_2 = 4R_1 = 4 \times 10 = 40\ \Omega$$

6. State Brewster's law. Express it mathematically.

Ans.—Brewster's law—It status that, the refractive index of the refractive medium (n) is numerically equal to the tangent of the angle of incident (i_B) for which reflected ray is polarised.

Mathematically, it can be expressed as—

$$\boxed{n = \tan i_B}$$

7. Derive the expression for de-Broglie wavelength ?

Ans.—According to quantum theory, the energy of a photon is given by, E = hν …(i)

According to Einstein is relation between Energy (E) & momentum p.

$$E = \sqrt{p^2c^2 + m^2c^4}$$

Photon is mass less ($m_0 = 0$)

$$\therefore \quad E = pc$$

we have $h\nu = pc$

$$p\frac{h}{\left(\frac{c}{\nu}\right)} = \frac{h}{\lambda} \quad \ldots(ii)$$

Relation (ii) in for wave (photon)

According to di Broglie if a wave behave like a particle, then a particle (matter) must behave like wave of wavelength.

$$\lambda = \frac{h}{p} \quad \ldots(iii)$$

8. The powers of two lenses are +12D and –2D. They are placed in contact coaxially. What will be the focal length of the combination ?

Ans.—We know that,

Power of combination, $P = P_1 + P_2$

Here according to question $P_1 = +12$, $P_2 = -2D$

∴ Focal length of the combination is given by,

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

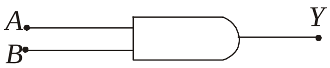
$$= \frac{1}{10}\,\text{m}$$

$$= \frac{1}{10} \times 100 = 10\ \text{cm}$$

$$\boxed{f = 10\text{cm}}$$

9. Write logic symbol (Boolean expression) and truth table of ‘AND’ gate ?

Ans.—Logic symbol of two input AND gate is given by :



Truth Table of AND gate is given by :

Truth table of AND gate is given by :

Input		Output
A	*B*	*Y*
0	0	0
0	1	0
1	0	0
1	1	1

Boolean expression
A · B = Y

10. Write full form of 'LASER' and 'MASER' ?

Ans.—'LASER' stands for light Amplication by stimulated emission of radiation.
'MASER' stands for microwave Amplication by stimulated emission of radiation.

11. If the maximum amplitude of the AM wave is 12V and the minimum amplitude of this wave is 4V, find the modulation index is percentage.

Ans.—Given that,

E_{max} = 12V,
E_{min} = 4V,

$$\therefore \quad m_a = \frac{E_{max} - E_{min}}{E_{max} + E_{min}}$$

$$= \frac{12-4}{12+4}$$

$$= \frac{8}{16}$$

$$m_a = \frac{1}{2}$$

So, $$m_a = \frac{1}{2} \times 100 = 50\%$$

$$\boxed{m_a = 50\%}$$

SECTION-II (NON-OBJECTIVE TYPE QUESTIONS)

Question Nos. 12 to 15 are of long answer type. Answer must be explantory and in your own language. Each question carries 5 marks. **4 × 5 = 20**

LONG QUESTIONS

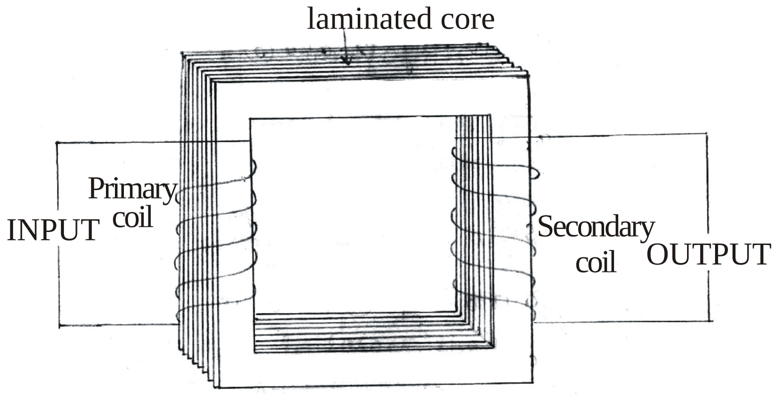
12. With the help of mean and labelled diagram explain the working principle of a transformer. Mention different types of losses in a transformer ?

Ans.—Transformer—Transformer is a device which converts low alternating voltage at high alternating current into high alternating voltage at low alternating current and vice versa.

It does not work on D.C.

Principle—It works on the principle of "mutual induction". It states that if magnetic changes in primary coil then *EMF* is induced in secondary coil and vice versa.

Construction



Transformer

Working

In a transformer these are two types of coil : Primary and Secondary.

Primary coil is attached with input whereas secondary coil is connected to output.

Through induction alternating voltage may be increased or decreased. It works on the "Coupling Method".

Theory

According to law of Faraday

$$\frac{d\phi}{dt} = -E \qquad \ldots(i)$$

Flux changes in the coil is directly proportional to the no. of turns in the coil

$$\phi s \ \alpha \ N_s \qquad \ldots(ii)$$

$$\phi p \ \alpha \ N_P \qquad \ldots(iii)$$

Dividing (ii) and (iii)

$$\frac{\phi s}{\phi p} = \frac{N_s}{N_P}$$

$$\phi s = \frac{N_s}{N_P}\phi p \qquad \ldots(iv)$$

Differentiating eq (iv) w.r.t.

$$\frac{d\phi s}{dt} = \frac{N_s}{N_P} \cdot \frac{d\phi p}{dt} \qquad \ldots(v)$$

Using eqn (i) in (v)

$$-E_s = \frac{N_S}{N_p}\left(-\varepsilon_p\right)$$

$$\boxed{E_s = \frac{N_S}{N_p}\varepsilon_p}$$

eq^n is called working theory of a Transformer upto here only

$\frac{N_s}{N_p}$ is called Transformation Ratio

It is represented by k

$$K = \frac{N_s}{N_p} \qquad \ldots(vi)$$

If K > 1, then transformer is step-up Transformer.
If k < 1, then transformer is step-down Transformer.

Types of Transformer

Step-up Transformer—A transformer is said to be step-up if low alternating voltage at high alternating current is converted into high alternating voltage at low alternating current.

In a step-up transformer, no. of turns in secondary coil is larger than no. of turns is primary coil.

i.e. $\boxed{N_s > N_p}$ …(A)

Step-Down Transformer—Transformer is said to be step-down transformer if it converts high alternating voltage at low alternating current into low alternating voltage at high alternating current.

Number of turns in a primary coil is larger than no. of turns in a secondary coil.

i.e. $\boxed{N_p > N_s}$ …(B)

Uses of Transformer

(i) A step-down transformer is used for the purpose of obtaining large electric current for electrical welding.
(ii) A step-down transformer is used in the Induction-furnace for melting the metals.
(iii) A step-up transformer is used for the production of X-ray.
(iv) Transformer are used in voltage-regulator and stabilizer.
(v) Small transformer are used in radio-sets, television,telephones and loud speakers.

Different Types of loses in transformer

Flux loss—The linkage of primary to secondary coil is neither ideal nor perfect. Hence, whole of the magnetic flux produced in primary coil never gets linked up with the secondary coil. Hence some of the energy is lost in the form of flux, known as flux loss.

Copper loss—Due to resistance of the windings in primary and secondary coil, it opposes the current to pass through it when current passes through the coil heat is produced. Due to heat, energy is lost which is called 'copper loss'.

Iron loss—Due to the variation in magnetic flux, eddy current is produced in the core of a transformer. When current passes through resistance, small heat is produced due to Eddy current. Hence small amount of energy is lost due to heat, known as Iron loss.

Hysteresis loss—The alternating current passed through the coil which is magnetic in behaviour. During each cycle of AC, magnelisation and demagnetisation is the result. Due to this hysteresis loop, energy is lost which is called Hysteresis loss.

Humming loss—When alternating current is passed through the core of wise, it starts vibrating. Due to vibration, sound is produced, hence same amount of energy is lost in the form of sound, which is called 'Humming loss'.

Efficiency

Efficiecny the ratio of output powr to the input power

Mathematically it can be written as :

$$\eta = \frac{\text{P output}}{\text{P input}} \qquad \ldots(1)$$

$$\eta = \frac{\varepsilon_s I_s}{\varepsilon_p I_p} \qquad \ldots(2)$$

Due to different types of losses, such as flux loss, copper loss, Iron loss, hysteresis loss and humming loss, output power is always less than input power.

$$\varepsilon_s I_s < \varepsilon_p I_p \qquad \ldots(3)$$

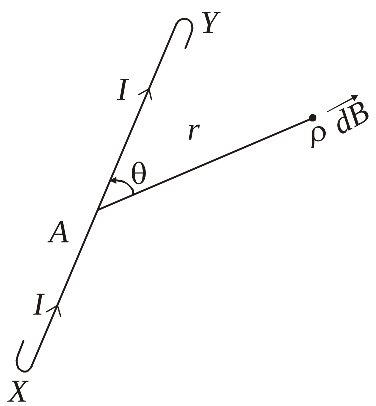
$$\eta < 1$$

η is never equal to 100%

Conclusion : Efficiency of a transformer is always less than 100%

13. Explain Biot-Savart law. With its help derive an expression for the magnetic field at any print on the axis of a current carrying circula loop ?

Ans.—Bio-Savart's Law



Bio-Savart's Law is the basis law of electricity and magnetism it is used to find the small magnetic field due to current carrying wire.

It states that small magnetic field (dB) due to current carrying element is

I. directly proportional to the electric current passed through the wire

i.e. $\boxed{dB \propto I}$ …(i)

II. directly proportional to the small length (dl)

i.e. $\boxed{dB \propto dl}$ …(ii)

III. directly proportional to the sine of angle between current carrying wire and given point.

i.e. $\boxed{dB \propto \sin\theta}$

IV. inversly proportional to the square of distance between current carrying wire and given point.

i.e. $\boxed{dB \propto \frac{1}{r^2}}$ …(iv)

Combining eq^n (i), (ii), (iii) and (iv)

$$dB \propto \frac{Idl \sin\theta}{r^2} \qquad \ldots(v)$$

$$\boxed{dB = \frac{\mu_0}{4\pi} \cdot \frac{Idl \sin\theta}{r^2}} \qquad \ldots(vi)$$

Eq^{11}(vi) is scalar form of Biot-Savart's Law.

Where, $\frac{\mu_0}{4\pi}$ is a proportionality constant.

$$\frac{\mu_0}{4\pi} = 10^{-7}\ TmA^{-1} \qquad \ldots(vii)$$

$$\therefore \quad \mu_0 = 4\pi \times 10^{-7}\ TmA^{-1} \qquad \ldots(viii)$$

In vector form eq^n (vi) can be written as,

$$\boxed{\overrightarrow{dB} = \frac{\mu_0}{4\pi} \cdot \frac{I}{r^2}\left(\overrightarrow{dB} \times \hat{r}\right)} \qquad \ldots(ix)$$

Direction of $\overrightarrow{dB}$ is perpendicular to the plane of $\overrightarrow{dl}$ and $\hat{r}$.

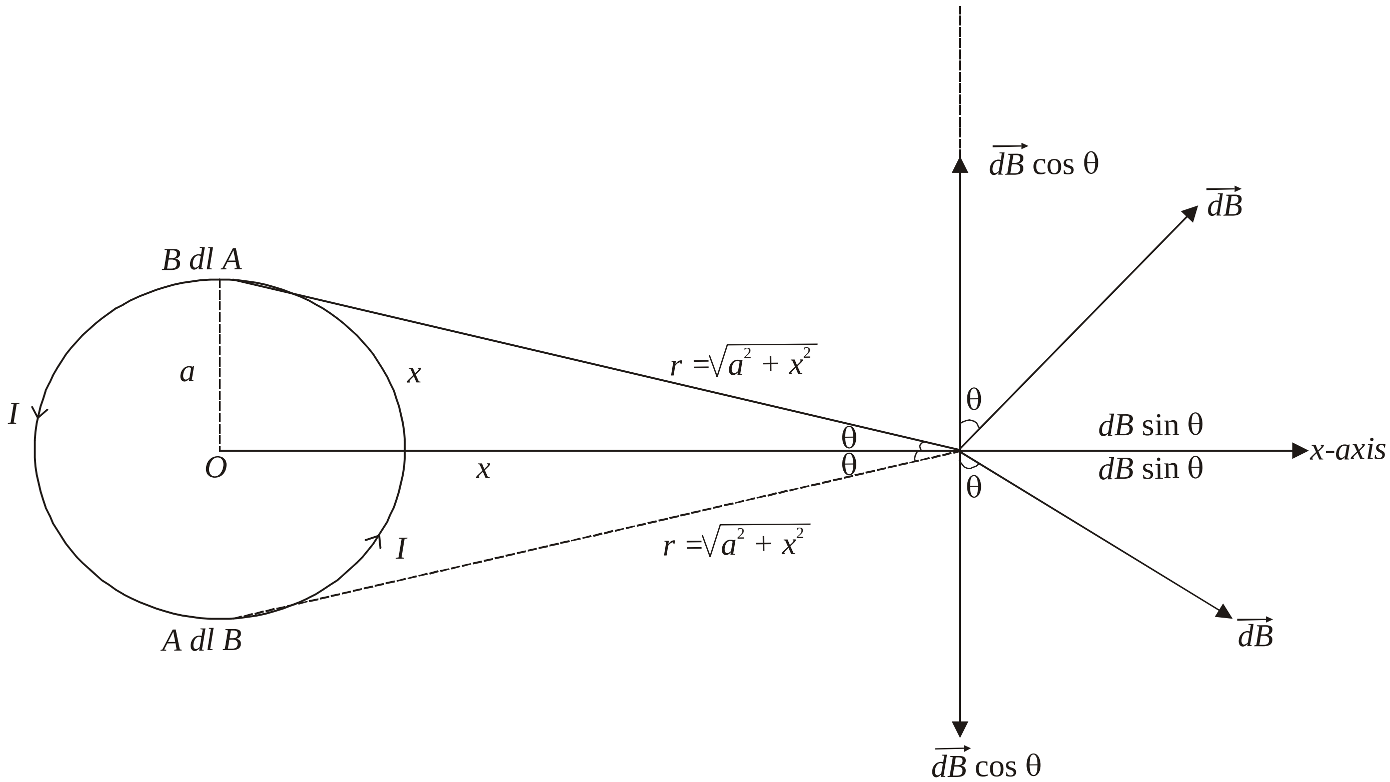
Total magnetic field due to current carrying wire,

$$\overrightarrow{B} = \int \overrightarrow{dB} \qquad \ldots(x)$$

$$\boxed{\overrightarrow{B} = \frac{\mu_0}{4\pi} \cdot \frac{I}{r^2} \int \overrightarrow{dl} \times \hat{r}}$$

Application of Biot-Savart's Law

Magnetic field on the axial line of circular current carrying loop.



Let us consider a circular current carrying verticle circle as shown in the figure. The radius of circular current carrying loop is we want to calculate total magnetic field at point P which is x distance away from at centre.

There are two components of Magnetic field $\overrightarrow{dB}$. Each and Every $\overrightarrow{dB}\cos\theta$ component cancelled by each other. Due to its counter part.

$$B = \overrightarrow{dB} \cdot \sin\theta \quad \ldots(1)$$

$$\ldots(2)$$

But, $\theta = 90^o$ …(3)

$$\therefore \quad dB = \frac{\mu_0}{4\pi} \cdot \frac{Idl \sin 90^o}{r^2}$$

$$\therefore \quad dB = \frac{\mu_0}{4\pi} \cdot \frac{Idl \sin 9}{r^2} \quad \ldots(4)$$

Using in eq^n (1)

$$B = \int \frac{\mu_0}{4\pi} \cdot \frac{Idl}{r^2} \sin\theta$$

$$= \frac{\mu_0}{4\pi} \cdot \frac{I}{r^2} \sin\theta \int dl \quad \ldots(5)$$

But $\int dl = 2\pi a$ …(6)

$$\therefore \quad B = \frac{\mu_0}{4\pi} \cdot \frac{I}{r^2} \cdot \sin\theta \cdot 2\pi a \quad \ldots(7)$$

But $r = \sqrt{a^2 + x^2} = (a^2 + x^2)^{\frac{1}{2}}$ …(8)

$$\sin\theta = \frac{a}{(a^2 + x^2)^{\frac{1}{2}}} \quad \ldots(9)$$

$$B = \frac{\mu_0}{(a^2 + x^2)^1} \cdot \frac{a}{(a^2 + x^2)^{\frac{1}{2}}}$$

$$= \frac{\mu_0}{4\pi} \cdot \frac{2\pi I a^2}{(a^2 + x^2) 1 + ^{\frac{1}{2}}}$$

$$\boxed{B = \frac{\mu_0}{4\pi} \cdot \frac{2\pi I a^2}{(a^2 + x^2)^{\frac{3}{2}}}} \quad \ldots(10)$$

Eq^n 10 is a general eq^n for magnetic field on the axial line of circular current carrying loop. It can be generalised for N-turns in the coil.

$$\boxed{B = \frac{\mu_0}{4\pi} \cdot \frac{2\pi I \cdot a^2 N}{(a^2 + x^2)^{\frac{3}{2}}}} \quad \ldots(11)$$

Checking of eq^n—

Magnetic field at centre of circular loop—

$x = 0$ …(12)

$$\text{B centre} = \frac{\mu_0}{4\pi} \cdot \frac{2\pi I \cdot a^2 N}{(a^2 + x^2)^{\frac{3}{2}}}$$

$$= \frac{\mu_0}{4\pi} \cdot \frac{2\pi I \cdot a^2 N}{(a^2+0)^{\frac{3}{2}}}$$

$$= \frac{\mu_0}{4\pi} \cdot \frac{2\pi I \cdot a^2 N}{a^3}$$

$$\boxed{\text{B centre} = \frac{\mu_0}{4\pi} \cdot \frac{2\pi IN}{a}}$$

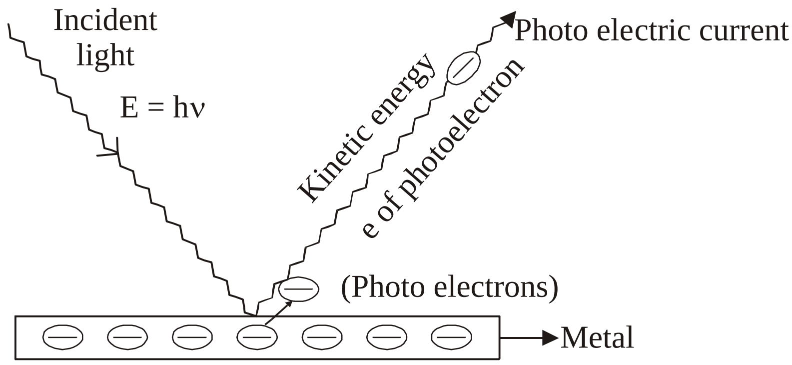
Hence, Eq^n is correct.

14. What do you mean by Photoelectric effect ? State and derive Einstein's Photoelectric equation ?

Ans.—Einsteins photoelectric equation establish the 'Particle Nature' of electron. It is based on conservation of energy.

Einstein received Noble prize for photoelectric equation.

Statement—"Total incident energy of light is used into two forms, same part of the energy is used as a work function and remaining part of the energy is used as a kinetic energy of photo electrons."



Mathematically, Einstein equation can be written as,

Incident energy = Work functions + Kinetic energy ...(1)

$E = \phi + K$

$\therefore \quad \boxed{K = E - \phi}$ ...(2)

But, $E = h\nu$

$\phi = h\nu_0$ ...(3)

Using in Eqn (2)

$\boxed{K = h(\nu - \nu_0)}$ ...(4)

But, $K = eVs = \frac{1}{2}mv^2$ ...(5)

$\therefore \quad \boxed{eVs = h(\nu - \nu_0)}$ ...(6)

and, $\boxed{\frac{1}{2}mv^2 = h(\nu - \nu_0)}$ ...(7)

But $\nu = \frac{c}{\lambda}$ ...(8)

and $\nu_0 = \frac{c}{\lambda}$

Using in eqn (4), (6) and (7)

$$\boxed{K = hc\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right)} \quad \ldots(9)$$

$$\boxed{eVs = hc\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right)} \quad \ldots(10)$$

$$\boxed{\frac{1}{2}eVs = hc\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right)} \quad \ldots(11)$$

Eqn. (4), (7), (9), (10) and (11) are called standard form of Einstein's equation.

Where,

ν = frequency of incident light
ν_0 = Threshold frequency
λ = Wavelength of incident light
λ_0 = Threshold wavelength
h = plenck's constant
c = speed of light
m = mass of electron
e = charge of an electron
V_s = stopping potential
V = velocity of photo electron

Technical Representation of Einstein's equation—Mathematical form of Einstein's eqn—

Kinetic energy = Incident energy – work function ...(1)

$eVs = h\nu - \phi$ ...(2)

Dividing eqn (2) by 'e'

$$\frac{eVs}{e} = \left(\frac{h}{e}\right)\nu - \frac{\phi}{e}$$

$$\boxed{V_s = \left(\frac{h}{e}\right)\nu - \frac{\phi}{e}} \quad \ldots(3)$$

It is in the standard form of eqn :

$$\boxed{y = mx - c} \quad \ldots(4)$$

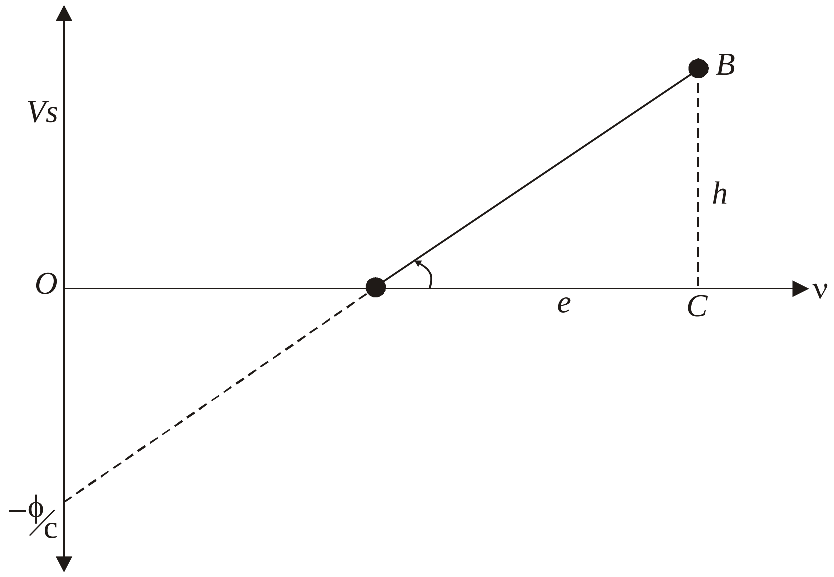
Where, $m = \frac{h}{e} \Rightarrow \text{slope} = \frac{h}{e}$ ...(5)

$$\text{slope} = \tan\theta = \frac{h}{e} \quad \ldots(6)$$

$$\boxed{\text{h} = e \times \tan\theta} \quad \ldots(7)$$

Hence, by knowing slope of $\upsilon - V_s$ group the plenck's constant can be calculated.

The graph of Incident frequency and stopping potential is straight line whose intercept is negative.



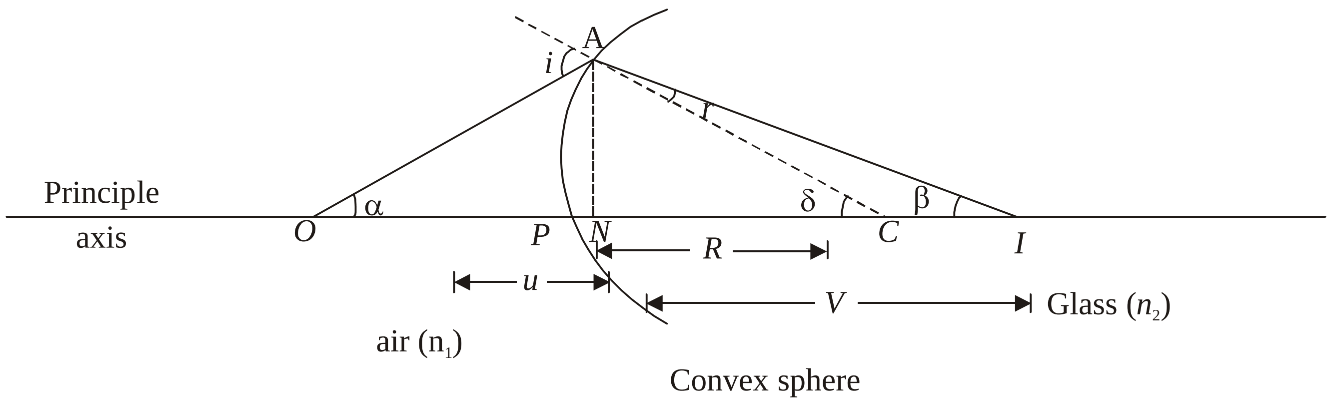
15. State and explain refraction through convex spherical surfaces.

Ans.—Refraction through spherical surface

Convention

1. The spherical surface must by very thin.
2. The object must be lie on the principle axis. The object is point object.
3. The angle made by object image and normal must be very-very small.

Convex surface—Real image



In ΔOAC,

$i^0 = \alpha + \delta$ …(1)

For smaller angle,

$\alpha = \tan\alpha$ …(2)

$\delta = \tan\delta$

∴ $i = \tan\alpha + \tan\delta$ …(3)

In ΔOAN

$$\tan\alpha = \frac{AN}{NO}$$ …(4)

But $NO \ \alpha \ PO$ …(5)

∴ $$\tan\alpha = \frac{AN}{PO}$$ …(6)

In ΔANC

$$\tan\alpha = \frac{AN}{NC} \qquad \ldots(7)$$

But, $NC \sim PC$ …(8)

$$\therefore \qquad \tan\delta = \frac{AN}{PC} \qquad \ldots(9)$$

Using in equation (3)

$$\boxed{i = \left(\frac{AN}{PO} + \frac{AN}{PC}\right)} \qquad \ldots(10)$$

In ΔACI

$\delta = r + \beta$

$r = \delta - \beta$ …(11)

For smaller angle,

$\delta = \tan\delta$

$\beta = \tan\beta$ …(12)

$\therefore \quad r = \tan\delta - \tan\beta$ …(13)

In ΔANI,

$$\tan\beta = \frac{AN}{NI} \qquad \ldots(14)$$

But, $NI \sim PI$ …(15)

$$\tan\beta = \frac{AN}{PI} \qquad \ldots(16)$$

$$\therefore \qquad \boxed{r = \left(\frac{AN}{PC} - \frac{AN}{PI}\right)} \qquad \ldots(17)$$

Using snell's law,

$$\frac{\sin i}{\sin r} = \frac{n_2}{n_1} \qquad \ldots(18)$$

For smaller angle,

$$\frac{\sin i \approx i}{\sin r \approx r} \qquad \ldots(19)$$

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

$$n_1 i = n_2 r \qquad \ldots(20)$$

Using equation (10) and (17)

$$n_1\left[\frac{AN}{PO} + \frac{AN}{PC}\right] = n_2\left[\frac{AN}{PC} - \frac{AN}{PI}\right]$$

$$n_1\ AN\left[\frac{1}{PO} + \frac{1}{PC}\right] = n_2\ AN\left[\frac{1}{PC} - \frac{1}{PI}\right]$$

$$\frac{n_1}{PO} + \frac{n_1}{PC} = \frac{n_2}{PC} - \frac{n_2}{PI}$$

$$\frac{n_2}{PI} + \frac{n_1}{PO} = \frac{n_2 - n_1}{PC} \qquad \ldots(21)$$

Using Proper sign – conversion,

$PI = V$

$PO = \mu$

$PC = R$ …(22)

$$\therefore \quad \boxed{\frac{n_2}{V} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}} \qquad \ldots(23)$$

Equation (23) is the general equation for refraction through spherical surface.