

बिहार विद्यालय परीक्षा समिति, पटना

वर्ष 2017 का मॉडल प्रश्न पत्र एवं उत्तरमाला



PHYSICS

Set-1 to 10

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, $\sigma = \frac{Q}{A}$

The S.I. unit of σ coulomb / metre² (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, $V = \sqrt{3}H$

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

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

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

3. Give two applications of ultra-violet waves.

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

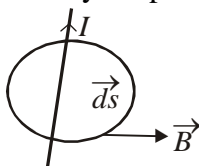
- (i) They are used to preserve food stuff and make drinking water free from bacteria, as these rays can kill bacteria, germs etc.
- (ii) They are used for stirlizing the surgical instruments.

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—

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 I$$



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

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

V is volume which does not change in stretching.

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

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

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

Ans.—Brewster's law—It states that, the refractive index of the refractive medium (n) is numerically equal to the tangent of the angle of incidence (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, $E = h\nu$... (i)

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

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

Photon is mass less ($m_0 = 0$)

$$\therefore E = pc$$

$$\text{we have } h\nu = pc$$

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

Relation (ii) is for wave (photon)

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

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

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,

$$\text{Power of combination, } P = P_1 + P_2$$

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

\therefore Focal length of the combination is given by,

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

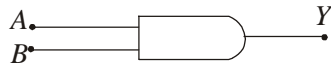
$$= \frac{1}{10} \text{ m}$$

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

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

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
 $A \cdot B = Y$

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

Ans.—'LASER' stands for light Amplification by stimulated emission of radiation.

'MASER' stands for microwave Amplification 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,

$$E_{\max} = 12V,$$

$$E_{\min} = 4V,$$

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

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

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

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

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

$m_a = 50\%$

SECTION-II (NON-OBJECTIVE TYPE QUESTIONS)

Question Nos. 12 to 15 are of long answer type. Answer must be explanatory and in your own language.
Each question carries 5 marks. $4 \times 5 = 20$

LONG QUESTIONS

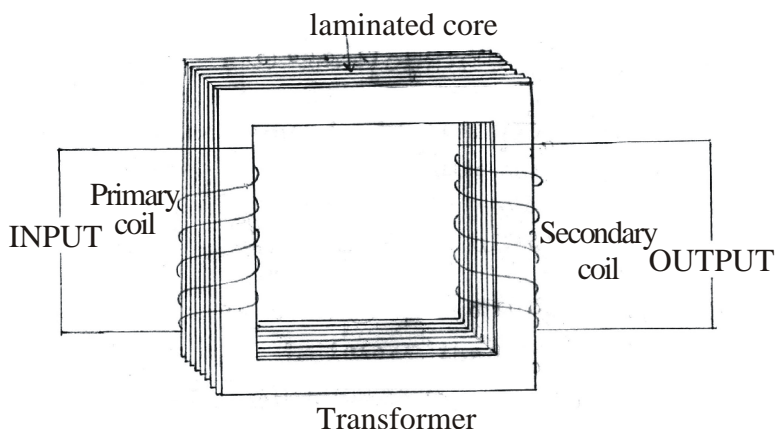
12. With the help of mean and labelled diagram explain the working principle of a transformer. Mention different types of losses in a transformer ?

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



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

$$\frac{d\phi}{dt} = -E \quad \dots(i)$$

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

$$\phi_s \propto N_s \quad \dots(ii)$$

$$\phi_p \propto N_p \quad \dots(iii)$$

Dividing (ii) and (iii)

$$\frac{\phi_s}{\phi_p} = \frac{N_s}{N_p}$$

$$\phi_s = \frac{N_s}{N_p} \phi_p \quad \dots(iv)$$

Differentiating eq (iv) w.r.t.

$$\frac{d\phi_s}{dt} = \frac{N_s}{N_p} \cdot \frac{d\phi_p}{dt} \quad \dots(v)$$

Using eqn (i) in (v)

$$-E_s = \frac{N_s}{N_p} (-\epsilon_p)$$

$$\boxed{E_s = \frac{N_s}{N_p} \epsilon_p}$$

eqⁿ is called working theory of a Transformer upto here only

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

It is represented by k

$$K = \frac{N_s}{N_p} \quad \dots(vi)$$

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 in 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 losses 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, magnetisation 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 wire, 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

Efficiency is the ratio of output power to the input power

Mathematically it can be written as :

$$\eta = \frac{P_{\text{output}}}{P_{\text{input}}} \quad \dots(1)$$

$$\eta = \frac{\epsilon_s I_s}{\epsilon_p I_p} \quad \dots(2)$$

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.

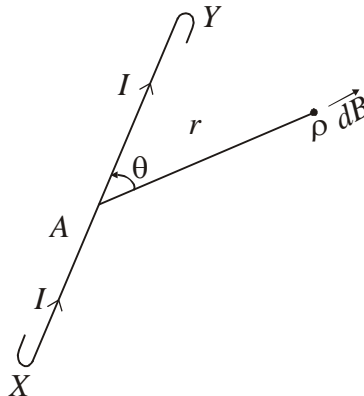
$$\begin{aligned} \epsilon_s I_s &< \epsilon_p I_p \\ \eta &< 1 \end{aligned} \quad \dots(3)$$

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 point on the axis of a current carrying circular 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

$$\text{i.e. } dB \propto I \quad \dots(i)$$

- II. directly proportional to the small length (dl)

$$\text{i.e. } dB \propto dl \quad \dots(ii)$$

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

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

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

$$\text{i.e. } dB \propto \frac{1}{r^2} \quad \dots(iv)$$

Combining eqⁿ (i), (ii), (iii) and (iv)

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

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

Eq¹¹(vi) is scalar form of Biot-Savart's Law.

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

$$\frac{\mu_0}{4\pi} = 10^{-7} \text{ TmA}^{-1} \quad \dots(vii)$$

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

In vector form eqⁿ (vi) can be written as,

$$\boxed{\vec{dB} = \frac{\mu_0}{4\pi} \cdot \frac{I}{r^2} (\vec{dl} \times \hat{r})} \quad \dots(ix)$$

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

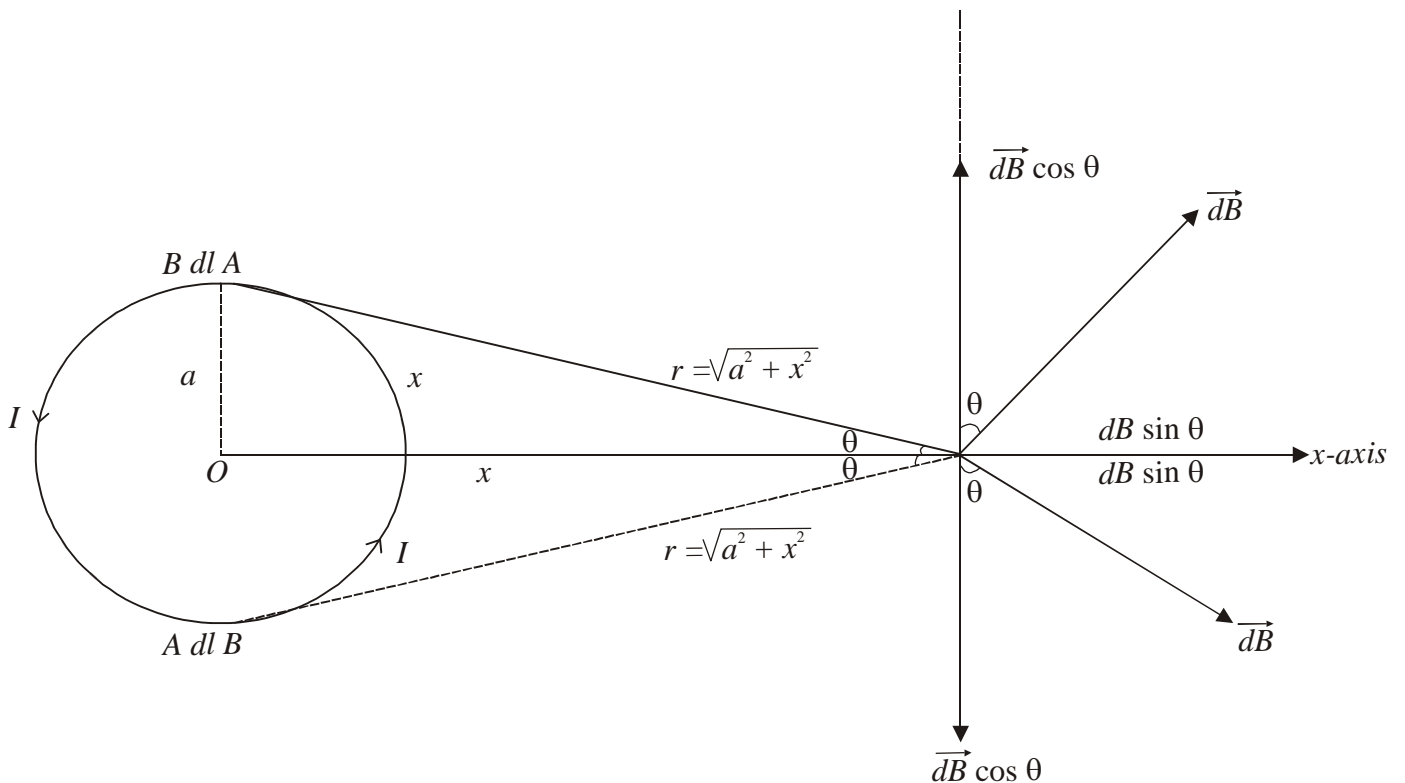
Total magnetic field due to current carrying wire,

$$\vec{B} = \int \vec{dB} \quad \dots(x)$$

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

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 \vec{dB} . Each and Every $\vec{dB} \cos \theta$ component cancelled by each other. Due to its counter part.

$$B = \vec{dB} \cdot \sin \theta \quad \dots(1)$$

$$\text{But, } \theta = 90^\circ \quad \dots(2)$$

$$\therefore dB = \frac{\mu_0}{4\pi} \cdot \frac{Idl \sin 90^\circ}{r^2} \quad \dots(3)$$

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

Using in eqⁿ (1)

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

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

$$\text{But } \int dl = 2\pi a \quad \dots(6)$$

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

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

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

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

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

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

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

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

Checking of eqⁿ—

Magnetic field at centre of circular loop—

$$x = 0 \quad \dots(12)$$

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

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

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

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

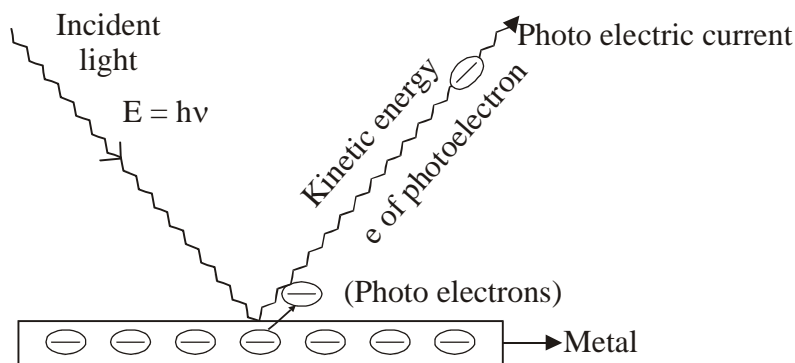
Hence, Eqⁿ is correct.

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

Ans.—Einstein's photoelectric equation establishes 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)

$$E = \phi + K$$

$$\therefore \boxed{K = E - \phi}$$

...(2)

But, $E = h\nu$

$$\phi = h\nu_0$$

...(3)

Using in Eqn (2)

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

...(4)

$$\text{But, } K = eVs = \frac{1}{2}mv^2$$

...(5)

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

...(6)

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

...(7)

$$\text{But } \nu = \frac{c}{\lambda}$$

...(8)

$$\text{and } \nu_0 = \frac{c}{\lambda_0}$$

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

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

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

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

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 = Planck'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—

$$\text{Kinetic energy} = \text{Incident energy} - \text{work function} \quad \dots(1)$$

$$eVs = h\nu - \phi \quad \dots(2)$$

Dividing eqn (2) by 'e'

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

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

It is in the standard form of eqn :

$$y = mx - c \quad \dots(4)$$

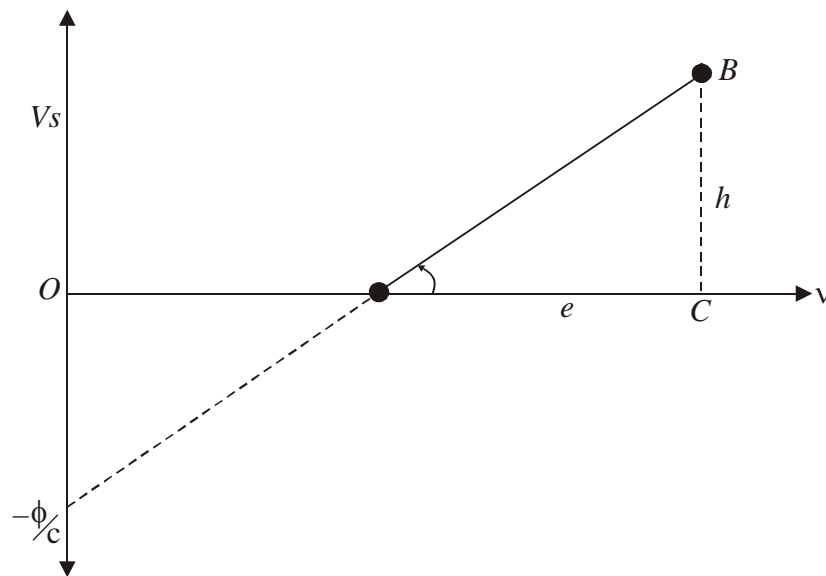
Where, $m = \frac{h}{e} \Rightarrow \text{slope} = \frac{h}{e} \quad \dots(5)$

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

$$h = e \times \tan \theta \quad \dots(7)$$

Hence, by knowing slope of $\nu - V_s$ graph the Planck's constant can be calculated.

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



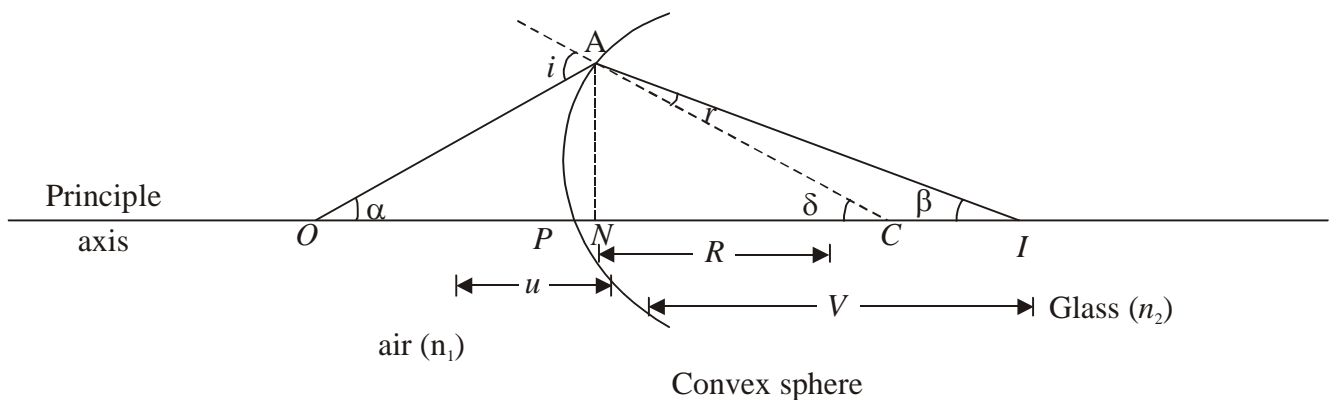
15. State and explain refraction through convex spherical surfaces.

Ans.—Refraction through spherical surface

Convention

1. The spherical surface must be very thin.
2. The object must 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



$$\text{In } \triangle OAC, \quad i^0 = \alpha + \delta \quad \dots(1)$$

$$\text{For smaller angle,} \quad \alpha = \tan \alpha \quad \dots(2)$$

$$\delta = \tan \delta \quad \dots(3)$$

$$\therefore i = \tan \alpha + \tan \delta \quad \dots(3)$$

$$\text{In } \triangle OAN \quad \tan \alpha = \frac{AN}{NO} \quad \dots(4)$$

$$\text{But } NO \propto PO \quad \dots(5)$$

$$\therefore \tan \alpha = \frac{AN}{PO} \quad \dots(6)$$

In $\triangle ANC$

$$\tan \alpha = \frac{AN}{NC} \quad \dots(7)$$

But, $NC \sim PC$...(8)

$$\therefore \tan \delta = \frac{AN}{PC} \quad \dots(9)$$

Using in equation (3)

$$i = \left(\frac{AN}{PO} + \frac{AN}{PC} \right) \quad \dots(10)$$

In $\triangle ACI$

$$\delta = r + \beta$$

$$r = \delta - \beta$$

...(11)

For smaller angle,

$$\delta = \tan \delta$$

$$\beta = \tan \beta$$

...(12)

$$\therefore r = \tan \delta - \tan \beta$$

...(13)

In $\triangle ANI$,

$$\tan \beta = \frac{AN}{NI}$$

...(14)

But, $NI \sim PI$

...(15)

$$\tan \beta = \frac{AN}{PI}$$

...(16)

$$\therefore r = \left(\frac{AN}{PC} - \frac{AN}{PI} \right) \quad \dots(17)$$

Using snell's law,

$$\frac{\sin i}{\sin r} = \frac{n_2}{n_1} \quad \dots(18)$$

For smaller angle,

$$\frac{\sin i}{\sin r} \approx \frac{i}{r} \quad \dots(19)$$

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

$$n_1 i = n_2 r \quad \dots(20)$$

Using equation (10) and (17)

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

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

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

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

Using Proper sign – conversion,

$$PI = V$$

$$PO = \mu$$

$$PC = R$$

...(22)

$$\therefore \boxed{\frac{n_2}{V} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}}$$

...(23)

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

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. Define electric field intensity and write its SI unit with dimension also.

Ans.—The electric field intensity due to a source charge at any point in its electric field is defined as the force experienced by a unit positive charge placed at that point.

Mathematically, it can be expressed as

$$\vec{E} = \frac{\vec{F}}{q_o}$$

The S.I. unit of electric field intensity is newton/coulomb
 it NC^{-1} or volt/ metre

The Dimesion of electric field intensity is,

$$[E] = \frac{[F]}{[q]} = \frac{[F]}{[It]} = \frac{[MLT^{-2}]}{[AT]} = [MLT^{-3}A^{-1}]$$

2. What is the function of ‘moderator’ and ‘Controlling rods’ in a nuclear reactor ?

Ans.—Function of moderator is nuclear reactor—

It slows down the speed of neutrons to make them useful for further fission.

Function on controlling rods is nuclear reactor—

It absorbs the excess no. of neutrons which are produced in reactor.

3. Welders wear special goggles or face masks with glass windows to protect their eyes from electromagnetic radiations. Name the radiations and write the range of their wavelength.

Ans.—ultraviolet rays.

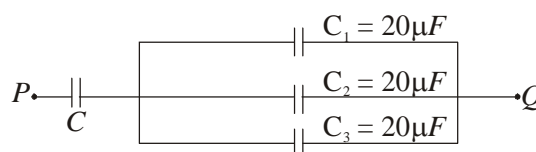
The wavelength of UV rays is 400 nm to 1 nm.

4. Define the activity of a given radioactive substance. Write its S.I. unit.

Ans.—The total decay rate of a radioactive sample is called the activity of the sample.

The S.I. unit of activity is ‘becquerel’.

5. Calculate the capacitance of the capacitor C. The equivalent capacitance of a combination between P and Q is $30 \mu\text{F}$.



Ans.—Capacitors C_1 , C_2 and C_3 are in parallel, so the equivalent capacitance of these capacitors are

$$\begin{aligned} C' &= C_1 + C_2 + C_3 \\ &= 20 + 20 + 20 \end{aligned}$$

$$= 60\mu\text{F}$$

Then, C and C' are in series, so equivalent capacitance, C'' is given by—

$$\frac{1}{C''} = \frac{1}{C} + \frac{1}{C'} \quad \text{But } C'' = 30\mu\text{F}$$

$$\therefore \frac{1}{30} = \frac{1}{C} + \frac{1}{60}$$

$$\text{or, } \frac{1}{C} = \frac{1}{30} + \frac{1}{60} = \frac{2+1}{60} = \frac{1}{20}$$

$$\therefore \boxed{C = 20\mu\text{F}}$$

6. Why the core of a transformer is laminated ?

Ans.—The core of a transformer is laminated to reduce the energy loss due to eddy currents. Laminations break the path of eddy currents. The energy loss due to eddy current also results in unnecessary heating of the transformer which may be harmful for the winding of the transformer.

7. The radius of curvature of the faces of a double convex lens are 10 c.m. and 15 c.m. If focal length of the lens is 12 c.m., find the refractive index of the material of the lens.

Ans.—Given that,

$$R_1 = 10 \text{ c.m.}$$

$$R_2 = -15 \text{ c.m.}$$

$$f = 12 \text{ cm.}$$

As we have from, Lens Maker's formula

$$\frac{1}{f} = (\mu - 1) \left(\frac{1}{R_1} - \frac{1}{R_2} \right)$$

$$\text{or, } \frac{1}{12} = (\mu - 1) \left(\frac{1}{10} - \frac{1}{-15} \right)$$

$$\text{or, } \frac{1}{12} = (\mu - 1) \left(\frac{3+2}{30} \right)$$

$$\text{or, } \frac{1}{12} = (\mu - 1) \frac{5}{30}$$

$$\text{or, } \frac{1}{12} = \frac{\mu - 1}{6}$$

$$\text{or, } 12(\mu - 1) = 6 \text{ or, } 12\mu - 12 = 6$$

$$\text{or, } 12\mu = 6 + 12$$

$$\text{or, } 12\mu = 18$$

$$\therefore \mu = \frac{18}{12} = \frac{3}{2}$$

$$\boxed{\mu = 1.5}$$

8. What is the lens of Presbyopia and Astigmatism ?

Ans.—**Case of Presbyopia**—It arises due to the gradual weakening of the ciliary muscles and diminishing flexibility of the eye lens.

Case of Astigmatism—It arises due to the irregularities in the surface of Cornea.

9. What do you mean by conductivity of a material ? Give its SI units.

Ans.—Conductivity is the reciprocal of the resistivity.

It can be expressed as—

$$\sigma = \frac{1}{\rho}$$

Its S.I. unit is siemen metre⁻¹ (Sm⁻¹) or ohm⁻¹ m⁻¹.

10. What is Photoelectric effect ? Write Einstein's photoelectric equation.

Ans.—Photoelectric effect—Photoelectric effect is the phenomenon of emission of electrons from the surface of metal when exposed to the radiation of suitable frequency.

Einstein's photoelectric equation can be expressed as—

$$\frac{1}{2}mv^2 = h\nu - h\nu_0$$

11. Write the functions of the following in communication system :

- (a) Transducer
- (b) Repeater

Ans.—(a) Transducer—A transducer is a device which converts one form of energy into another form of energy.

(b) Repeater—A repeater is a combination of a receiver and a transmitter. A repeater, picks up the signal from the transmitter, amplifies and retransmits it to the receiver sometimes with a change in carrier frequency. They are used to extend the range of a communication system.

Model Set (Class-XII) 2017
SECTION-II (NON-OBJECTIVE TYPE QUESTIONS)

17

Question Nos. 12 to 15 are of long answer type. Answer must be explanatory and in your own language.
 Each question carries 5 marks. $4 \times 5 = 20$

LONG QUESTIONS

12. With the help of mean and labelled diagram explain the construction, working principle and sensitivity of a moving coil galvanometer ? Mention its conversion into ammeter & voltmeter.

Ans.—

Moving Coil Galvanometer (MCG)

Moving coil Galvanometer is a device used to detect or measure the small electric current flowing in the circuit.

Principle

Moving coil Galvanometer is based on the result that when a current carrying loop or wire is placed in a uniform magnetic field it experiences a torque.

Theory

Let

N = No. of turns

l = length of the coil

b = breath of the coil

B = Strength of magnetic field

A = Area of the coil

For equilibrium, deflecting torque must be equal to resorting torque.

Deflecting Torque = Restoring Torque

...(1)

$N B I A \sin \theta = K \alpha$

...(2)

Where K = Restoring Torque per unit twist

α = Deflection

$$I = \left(\frac{K}{NBA \sin \theta} \right) \alpha$$

...(3)

For normal component, $\theta = 90^\circ$

$$I = \left(\frac{K}{NBA \sin 90^\circ} \right) \alpha$$

...(4)

$$I = \left(\frac{K}{NBA} \right) \alpha$$

...(5)

Where, $\left(\frac{K}{NBA} \right) G$

...(6)

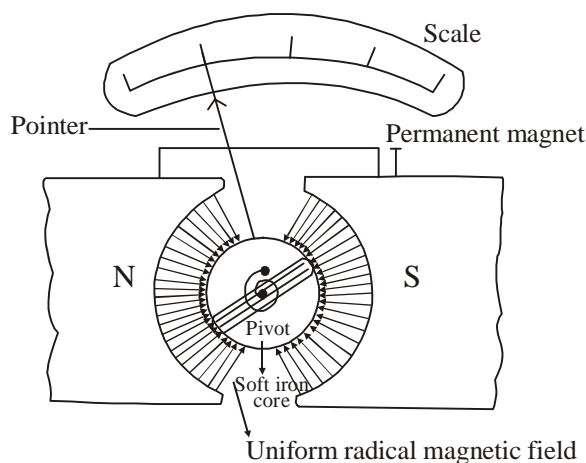
G is called Galvanometer's constant

$$I = G \alpha$$

...(7)

Hence $I \propto \alpha$

The deflection produced in the coil of MCG is directly proportional to the electric current.

Construction**Sensitivity of a Galvanometer**

A galvanometer is said to be sensitive if small current or voltage change produces large deflection in current.

There are two types of sensitivity :

- (1) Current Sensitivity
- (2) Voltage Sensitivity

Current Sensitivity—The current sensitivity of a galvanometer is defined as the deflection produced in the galvanometer per current flowing through it

$$\text{Current Sensitivity} = \frac{\infty}{I} \quad \dots(9)$$

$$I = \left(\frac{K}{NBA} \right) \infty \quad \dots(10)$$

$$\frac{\infty}{I} = \frac{NBA}{K}$$

$$\text{Current Sensitivity} = \frac{NBA}{K} \quad \dots(11)$$

Hence sensitivity of a MCG can be increased by increasing no. of turns, area of cross-section and strength of magnetic field but by decreasing restoring torque per unit twist—

Voltage Sensitivity—Voltage sensitivity of a galvanometer is defined as the deflection produced in the galvanometer per unit voltage applied to it.

$$\text{Voltage Sensitivity} = \frac{\infty}{V} \quad \dots(12)$$

$$\text{But } V = IR \quad \dots(13)$$

$$\text{Voltage Sensitivity} = \frac{\infty}{IR}$$

$$= \left(\frac{\infty}{I} \right) \times \frac{1}{R}$$

$$= \text{Current Sensitivity} \times \frac{1}{R}$$

$$\text{Voltage Sensitivity} = \frac{\text{Current Sensitivity}}{R}$$

Hence voltage sensitivity can be defined as the ratio of current sensitivity and resistance of the wire.

Using eqⁿ (11)

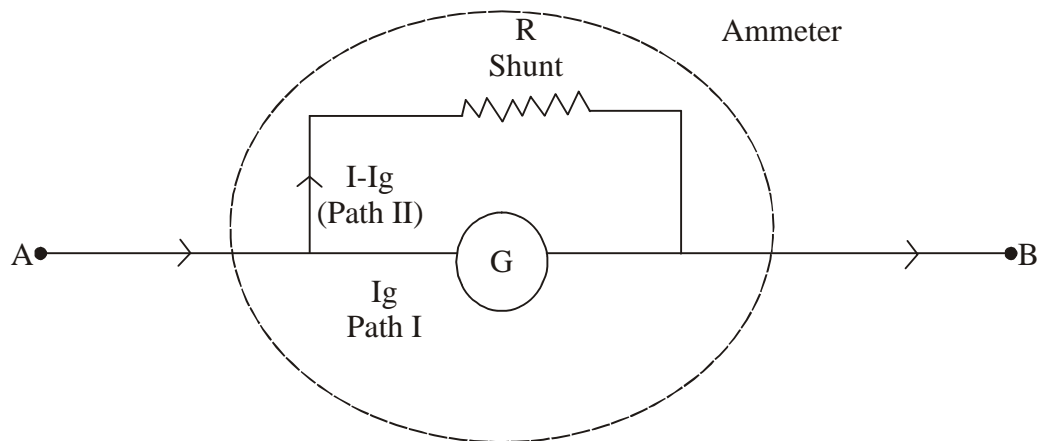
$$\text{Voltage Sensitivity} = \frac{NBA}{KR} \quad \dots(15)$$

Hence voltage sensitivity of a MCG can be increased by increasing no. of turns, strength of magnetic field, area of cross section but by decreasing restoring torque per unit twist and resistance of the wire.

Conversion of MCG into Ammeter

An ammeter is a device that measure current in the electric circuit. For an ideal ammeter, resistance is almost zero.

A MCG can be converted into an ammeter by connecting a low resistance called 'Shunt Resistance' connected in parallel with MCG.



In parallel grouping of resistance, potential must be equal

$$V_{\text{path I}} = V_{\text{path II}} \quad \dots(16)$$

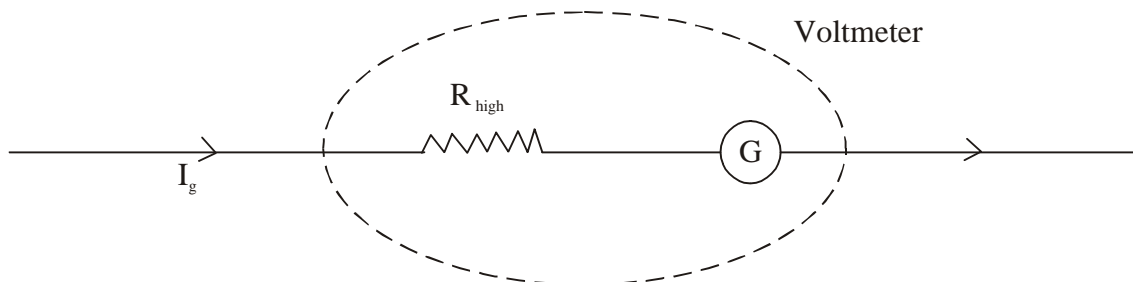
$$I_g G = (I - I_g) R_{\text{shunt}}$$

$$R_{\text{shunt}} = \left(\frac{I_g}{I - I_g} \right) G \quad \dots(17)$$

Conversion of MCG into Voltmeter

A voltmeter is a device that measure potential difference between two terminals of the wire. For ideal voltmeter, it's resistance is infinite.

A moving coil galvanometer can be converted into a voltmeter by connecting a very high resistance in series.



$$V = I_g R_n + I_g G$$

$$V = I_g (R_n + G)$$

$$\frac{V}{I_g} = R_n + G$$

$$R_n = \frac{V}{I_g} - G$$

Advantages of MCG

- (i) It's sensitivity is very high
- (ii) It behaves like linear scale because electric current is directly proportional to deflection produced in the coil.
- (iii) A MCG can be converted into an meter or a voltmeter.

13. Define parallel plate capacitor. Explain its construction and working principle of parallel plate capacitor. Derive an expression for its capacitance ?

Ans.—PARALLEL PLATE CAPACITOR (PPC)—

An arrangement of two plates one plate is positive and other plate is negative placed parallelly separated by dielectrics to store large amount of electric charge in small space is called parallel plate capacitor. It is the simplest form of any kind of capacitor.

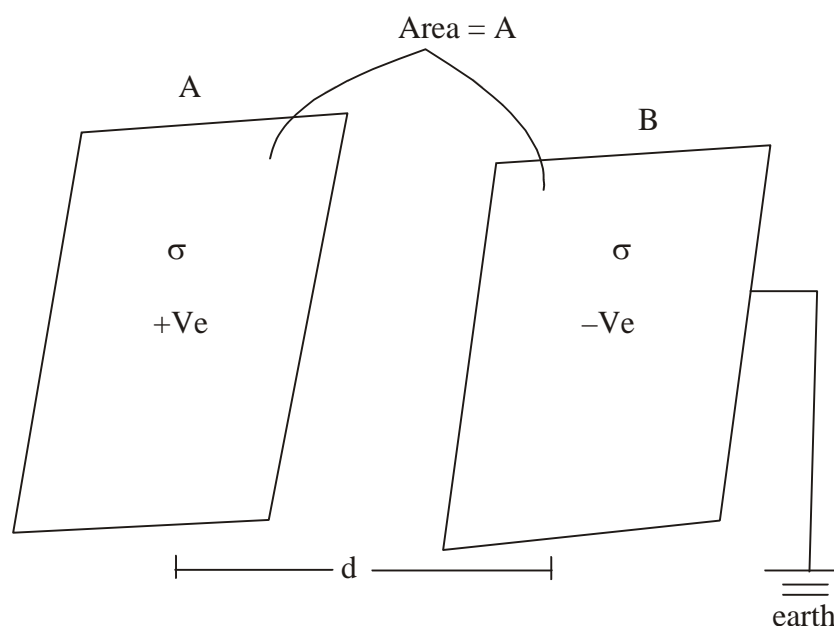
PRINCIPLE—It works on the principle that electric charge stored on the plate is directly proportional to the potential difference between two plates.

$$\text{i.e. } q \propto V \quad \dots(1)$$

$$\therefore q = CV$$

$$\therefore C = \frac{q}{V} \quad \dots(2)$$

CONSTRUCTION:—



Expression For Capacitance—

Let us consider two plates A and B having equal Area separated by a small distance. The surface charge density of plate is ' σ '

As we know that electric field is negative gradient of potential.

$$\therefore E = \frac{-dv}{dr} \quad \dots(3)$$

Taking magnitude only.

$$E = \frac{dv}{dr} \quad \dots(4)$$

If electric field is uniform

$$\begin{aligned} dv &= V \\ dr &= r = d \end{aligned} \quad \dots(5)$$

$$\therefore E = \frac{V}{d} \quad \dots(6)$$

Now, calculation of electric field,

$$E = E_1 + E_2 \quad \dots(7)$$

Where, E_1 is electric field of +ve plate.

E_2 is electric of -ve plate.

$$\begin{aligned} E &= \frac{\sigma}{2\epsilon_0} + \frac{\sigma}{2\epsilon_0} \\ E &= \frac{\sigma + \sigma}{2\epsilon_0} = \frac{2\sigma}{2\epsilon_0} \\ E &= \frac{\sigma}{\epsilon_0} \end{aligned} \quad \dots(8)$$

$$\text{But, } \sigma = \frac{q}{A} \quad \dots(9)$$

$$\therefore \boxed{E = \frac{q}{E_0 A}} \quad \dots(10)$$

Putting the value of E in eqⁿ ... (6)

$$V = \frac{qd}{E_0 A} \quad \dots(11)$$

By defⁿ of capacitance of P.P.C.

$$\begin{aligned} C &= \frac{q}{V} = \frac{q}{\frac{qd}{E_0 A}} \\ \therefore \boxed{C &= \frac{E_0 A}{d}} \end{aligned} \quad \dots(12)$$

Eqⁿ—(12) is the general expression for capacitance of a parallel plate capacitor.

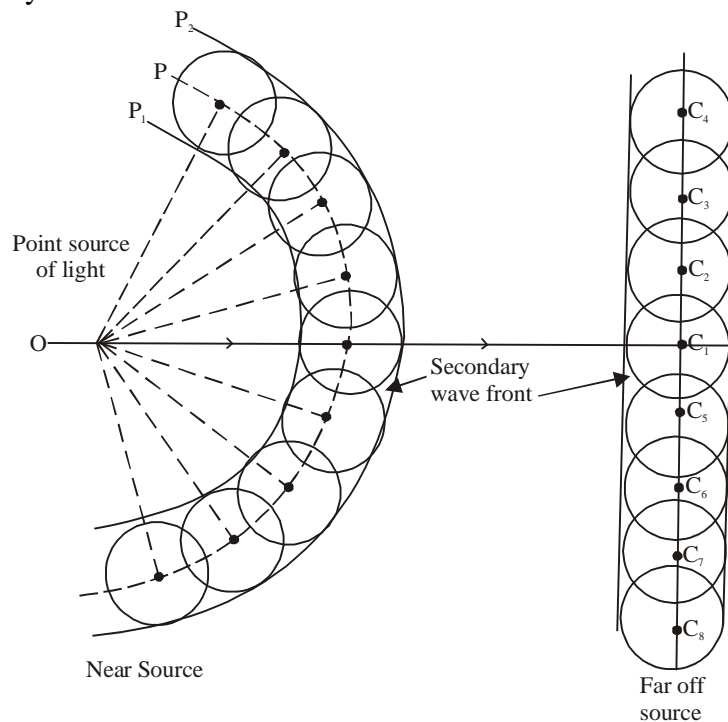
Conclusion—Capacitance of a parallel plate capacitor is—

- (i) Directly proportional to the area of the plate.
- (ii) Inversely proportional to the distance between the plates.

14. Verify laws of reflection or laws of refraction on the basis of Huygen's wave theory ?

Ans.—Huygen's Principle

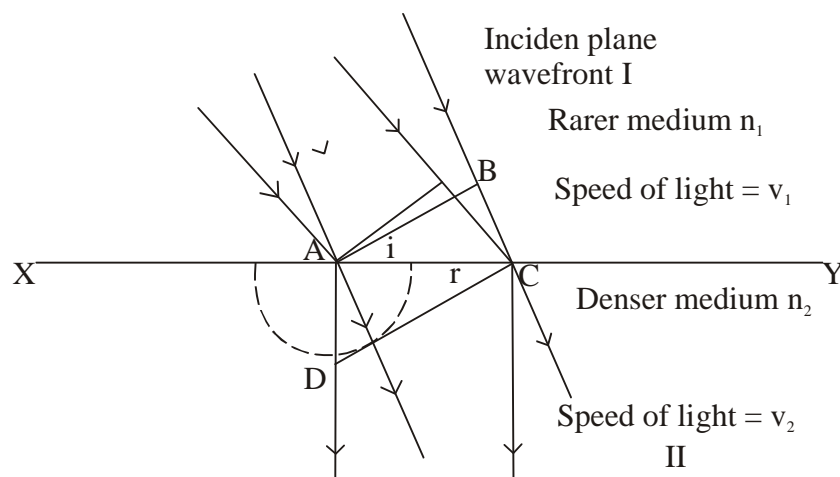
Huygen's principle gives the geometrical details of travelling of a wave. This principle is used to find the position of the given wavelength at any instant of time.



Following are the important assumption made by Huygen's—

1. Each source of light is the centre of disturbance from which waves spread in all direction.
2. Every point on a wavefront is a source of new disturbance which produces secondary wavelength.
3. Only forward envelope enclosing the tangent at the secondary wavelength at any instant gives the new position of wavefront.

Laws of Refraction by Using Huygen's Principle



Let us consider a plane wavelength AB. According to Huygen each and every point on the plane wavefront is the source of secondary disturbance which propagates in all the direction XY is the refracting surface. When a ray of light passes from Rarer to denser medium it bends toward the normal.

Medium-I is rarer medium whose refractive index is n_1 . The speed of light in medium I is V_1 and speed of light in medium-II is V_2 . Refractive index of medium-II is n_2 . n_2 is denser medium.

$$\text{Distance} = \text{Speed} \times \text{time} \quad \dots(1)$$

$$BC = V_1 t \quad \dots(2)$$

$$AD = V_2 t \quad \dots(3)$$

Dividing eqⁿ (2) by (3)

$$\frac{BC}{AD} = \frac{V_1 t}{V_2 t}$$

$$\frac{BC}{AD} = \frac{V_1}{V_2} \quad \dots(4)$$

In $\triangle ABC$

$$\sin i = \frac{BC}{AC} \quad \dots(5)$$

$$BC = AC \sin i \quad \dots(6)$$

In $\triangle ADC$,

$$\sin r = \frac{AD}{AC} \quad \dots(7)$$

$$AD = AC \sin r \quad \dots(8)$$

Using in eqⁿ (4)

$$\frac{AC \sin i}{AC \sin r} = \frac{V_1}{V_2}$$

$$\frac{\sin i}{\sin r} = \frac{V_1}{V_2} \quad \dots(9)$$

By definition of refractive index of medium,

$$n_2 = \frac{\text{speed of light in air}}{\text{speed of light in medium}}$$

$$n_2 = \frac{C}{V_2} \quad \dots(10)$$

$$\text{and } n_1 = \frac{C}{V_1} \quad \dots(11)$$

Dividing eqⁿ (10) by (11)

$$\frac{n_2}{n_1} = \frac{C}{V_2} \times \frac{V_1}{C}$$

$$\therefore \frac{n_2}{n_1} = \frac{V_1}{V_2} \quad \dots(12)$$

Using in eqⁿ (9)

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

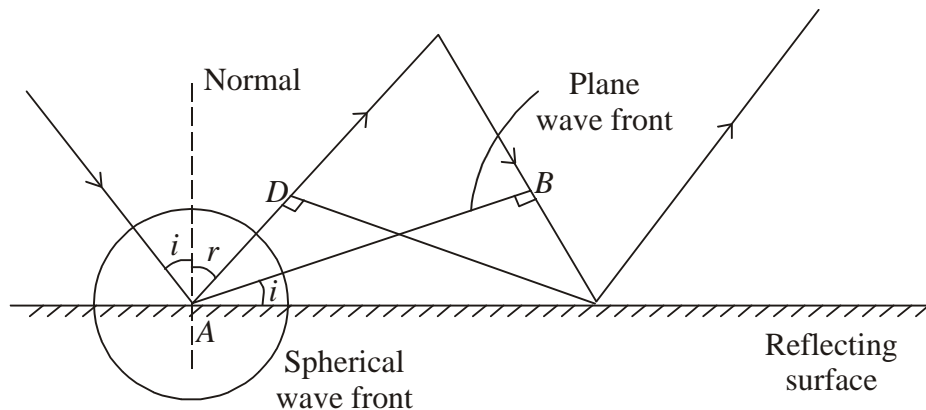
$$\boxed{n_1 \cdot \sin i = n_2 \sin r}$$

...(13)

eqⁿ is Snell's law. Hence, law of reflection can be easily derived by using Huygen's principle.

Laws of Reflection by Using Huygen's Principle

According to Huygen each and every point of the plane wavefront is the source of secondary wavefront which propagates in all the direction. Let us consider a plane wavefront AB. By definition of wavefront distance covered from A to B must be equal to distance covered from B to C.



$$AD = BC \quad \dots(1)$$

In $\triangle ADC$,

$$\sin r = \frac{AD}{AC}$$

$$\therefore AD = AC \sin r \quad \dots(2)$$

In $\triangle ABC$,

$$\sin i = \frac{BC}{AC}$$

$$\therefore BC = AC \sin i \quad \dots(3)$$

Using in eqn (1)

$$AC \sin r = AC \sin i$$

$$\sin i = \sin r \quad \dots(4)$$

For smaller angles,

$$\sin i \sim i \quad \dots(5)$$

$$\sin r \sim r$$

Using in eqⁿ (4)

$$\boxed{i = r}$$

...(6)

$$\therefore \boxed{\text{Angle of incidence} = \text{Angle of reflection}}$$

eqⁿ (7) is law of reflection

Hence by using Huygen's principle law of reflection can be easily derived.

15. Give postulates of Bohr's theory. Explain hydrogen spectrum on the basis of Bohr's theory.

Ans.—Bohr's theory—

Following are the important assumptions made by Bohr—

1. All electrons revolve around the nucleus in the circular orbits.
2. The orbits in which electron revolve are stationary and do not disturb.
3. Only those orbits are said to be stationary and discrete for which angular momentum of electron is an

integral multiple of $\frac{h}{2\pi}$.

Mathematically, it can be written

$$\text{as, } L = \frac{nh}{2\pi} \quad \dots(1)$$

$$\text{But, } L = mvr \quad \dots(2)$$

$$\therefore \boxed{mvr = \frac{nh}{2\pi}} \quad \dots(3)$$

4. An electron / atom can jump from higher orbit / energy state to lower energy state by releasing energy and released energy appears as only one photon.

This is called Bohr's frequency condition.

$$E = E_m - E_n \quad \dots(4)$$

$$h\nu = E_m - E_n$$

$$h \cdot \frac{c}{\lambda} = E_m - E_n$$

$$\therefore \boxed{\frac{1}{\lambda} = \frac{E_m - E_n}{hc}} \quad \dots(5)$$

Bohr's explanation of spectral line series of hydrogen atom

According to Bohr's frequency condition when an electron / atom jumps from higher orbit / energy state to lower orbit / energy state, it releases the corresponding electron is called spectral series.

1. **Lyman series**—The spectral due to the transition of an electron from any outer orbit, n_i to the first orbit ($n_f = 1$) from spectral series is called Lyman series.

It lies in "U V region"

$$n_i = 2, 3, 4, 5, \dots, \infty$$

$$n_f = 1$$

$$\frac{1}{\lambda} = R \left[\frac{1}{n_f^2} - \frac{1}{n_i^2} \right]$$

$$\frac{1}{\lambda} = R \left[\frac{1}{(1)^2} - \frac{1}{n_i^2} \right] = R \left[1 - \frac{1}{n_i^2} \right]$$

For longest wavelength

$$n_i = 2$$

$$\frac{1}{\lambda_{\text{longest}}} = R \left[1 - \frac{1}{(2)^2} \right] = R \times \frac{3}{4}$$

$$\boxed{\lambda_{\text{longest}} = \frac{4}{3R}}$$

For Shortest Wavelength

$$n_i = \infty$$

$$\frac{1}{\lambda_{\text{shortest}}} = R \left[1 - \frac{1}{\infty} \right]$$

$$\lambda_{\text{shortest}} = \frac{1}{R}$$

$$\boxed{\frac{1}{R} = 911 \text{ \AA}}$$

2. Balmer series—The spectral line emitted due to the transition of an electron from any outer orbit (n_i) to the second orbit ($n_f = 2$) from a spectral series is called Balmer series.

It lies in the “Visible region”

$$n_i = 3, 4, 5, \dots, \infty$$

$$n_f = 2$$

$$\frac{1}{\lambda} = R \left[\frac{1}{(2)^2} - \frac{1}{n_i^2} \right]$$

$$\frac{1}{\lambda} = R \left[\frac{1}{4} - \frac{1}{n_i^2} \right]$$

For maximum wavelength $n_i = 3$

$$\frac{1}{\lambda_{\text{max}}} = R \left[\frac{1}{4} - \frac{1}{9} \right]$$

$$\frac{1}{\lambda_{\text{max}}} = R \left[\frac{9-4}{36} \right] = \frac{5}{36} R$$

$$\boxed{\frac{1}{\lambda_{\text{max}}} = \frac{5}{36} R}$$

For minimum wavelength, $n_i = \infty$

$$\frac{1}{\lambda_{\text{min}}} = R \left[\frac{1}{4} - \frac{1}{\infty} \right]$$

$$\frac{1}{\lambda_{\text{min}}} = \frac{R}{4} \quad \lambda_{\text{min}} = \frac{4}{R}$$

3. Paschen series—The spectral line emitted due to the transition of an electron from any outer (n_i) to the third orbit ($n_f = 3$) from a spectral series is called Paschen series.

It lies in the infra red region

$$n_i = 4, 5, 6, \dots, \infty$$

$$n_f = 3$$

$$\frac{1}{\lambda} = R \left[\frac{1}{n_f^2} - \frac{1}{n_i^2} \right]$$

$$\frac{1}{\lambda} = R \left[\frac{1}{9} - \frac{1}{n_i^2} \right]$$

For maximum wavelength $n_i = 4$

$$\frac{1}{\lambda_{\max}} = R \left[\frac{1}{9} - \frac{1}{16} \right] = \frac{7R}{144}$$

$$\boxed{\lambda_{\max} = \frac{144}{7R}}$$

For minimum wavelength $n_i = \infty$

$$\frac{1}{\lambda_{\min}} = R \left[\frac{1}{9} - \frac{1}{\infty} \right]$$

$$\frac{1}{\lambda_{\min}} = \frac{R}{9}$$

$$\lambda_{\min} = \frac{9}{R}$$

4. Bracket series—The spectral liner emitted due to the transition of an electron from any outer orbit (n_i) to the fourth orbit ($n_f = 4$) from spectral liner is called Bracket series.

It lies in “far infrared red” region

$$n_i = 5, 6, 7, 8, 9 \dots \infty$$

$$n_f = 4$$

$$\frac{1}{\lambda} = R \left[\frac{1}{n_f^2} - \frac{1}{n_i^2} \right]$$

$$\frac{1}{\lambda} = R \left[\frac{1}{16} - \frac{1}{n_i^2} \right]$$

For maximum wavelength $n_i = 5$

$$\frac{1}{\lambda_{\max}} = R \left[\frac{1}{16} - \frac{1}{25} \right]$$

$$\frac{1}{\lambda_{\max}} = \frac{9R}{400}$$

$$\boxed{\lambda_{\max} = \frac{400}{9R}}$$

For minimum wavelength, $n_i = \infty$

$$\lambda_{\min} = R \left[\frac{1}{16} - \frac{1}{\infty} \right]$$

$$\boxed{\lambda_{\min} = \frac{16}{R}}$$

5. Pfund series—The spectral liner emitted due to the transition of an electron from any outer orbit (n_i) to the fifth orbit ($n_f = 5$) from a spectral series is called Pfund series.

It also lies in far infra-red region

$$n_i = 6, 7, 8 \dots \infty$$

$$n_f = 5$$

$$\frac{1}{\lambda} = R \left[\frac{1}{n_f^2} - \frac{1}{n_i^2} \right]$$

$$\frac{1}{\lambda} = R \left[\frac{1}{25} - \frac{1}{n_i^2} \right]$$

For maximum wavelength, $n_i = 6$

$$\frac{1}{\lambda_{\max}} = R \left[\frac{1}{25} - \frac{1}{36} \right]$$

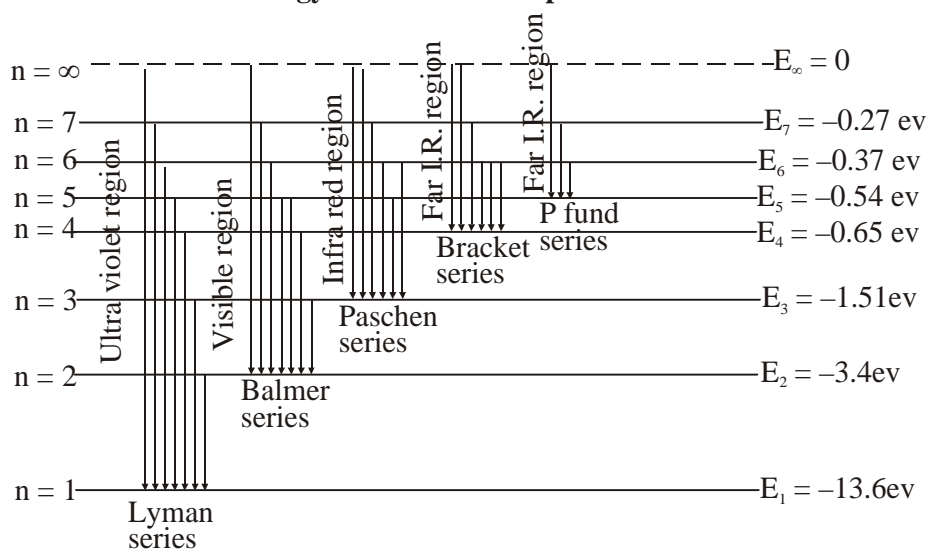
$$\lambda_{\max} = \frac{900}{11R}$$

For minimum wavelength, $n_i = \infty$

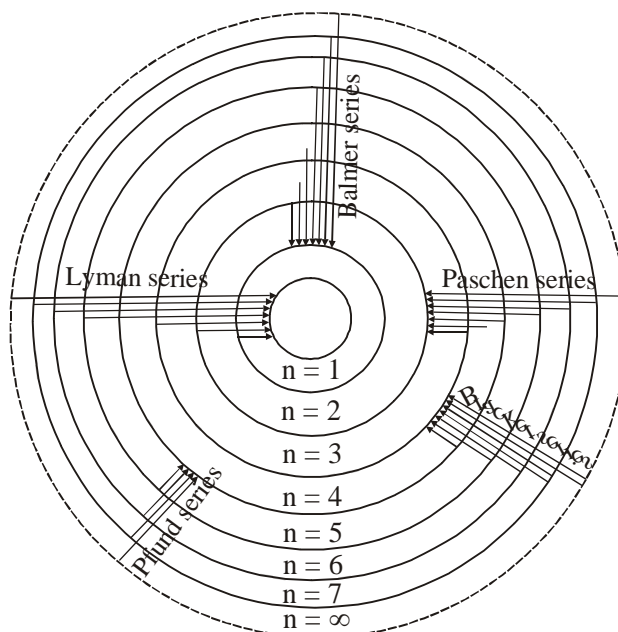
$$\frac{1}{\lambda_{\min}} = R \left[\frac{1}{25} - \frac{1}{\infty} \right]$$

$$\lambda_{\min} = \frac{25}{R}$$

Energy distribution in Spectral liner



Representation of spectral series of hydrogen atom



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. Define electric dipole moment and write its SI unit ?

Ans.—Electric dipole moment—Electric dipole moment of an electric dipole is defined as the product of the magnitude of either charge of the electric dipole and the dipole length. Mathematically, the magnitude of dipole moment is

$$P = q \times 2l$$

It is a vector quantity. The SI unit of electric dipole moment is coulomb metre (cm).

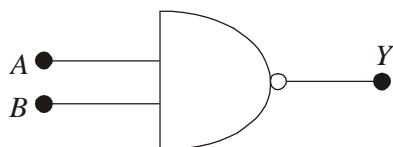
2. Write two characteristics of LASER rays ?

Ans.—Two characteristics of LASER rays are as follows—

1. It is highly directional with parallel beam.
2. It is monochromatic and coherent.

3. Write logic symbol and truth table of 'NOR' gate?

Ans.—The logic symbol of NOR gate is as follows—



Truth table of NOR gate is as follows—

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

4. Define magnetic flux and write SI unit of magnetic flux ?

Ans.—Magnetic flux—It is defined as the number of magnetic field lines passing through a surface.

It is denoted by ϕ

The S.I. unit of magnetic flux is weber (wb).

5. State Biot-Savart law. Mention its expression ?

Ans.—Biot-Savart's law—It states that, the magnitude of the magnetic field dB is proportional to the current I, the element length dl, and inversely proportional to the square of the distance r and its direction is \perp to the plane containing dl and r.

Mathematically, it can be expressed as

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

6. Define critical angle. State two conditions of total internal reflection of light ?

Ans.—Critical angle—The angle of incidence corresponding to which angle of refraction becomes 90° is called critical angle.

Following are the two conditions of total internal reflection of light—

1. The light should travel from denser to rarer medium.
2. The angle of incidence must be greater than the critical angle for the given pair of media.

7. Name the energy losses in a transformer?

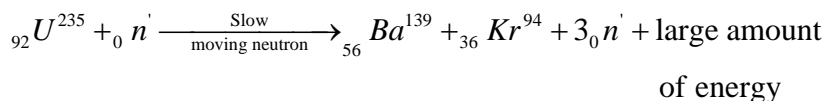
Ans.—Energy losses in a transformer are as follows—

1. Copper losses,
2. Flux leakage losses,
3. Eddy currents losses,
4. Hysteresis losses,
5. Losses due to vibration of core.

8. Define nuclear fission reaction. Mention its nuclear reaction which take place in nuclear reactor ?

Ans.—**Nuclear fission reaction**—A nuclear reaction in which a nearly nucleus of U-235 splits up into light nuclei as a when a slow moving neutron is bombarded it and it releases large amount of nuclear energy, which is called nuclear fission reaction.

The reaction is as follows—



9. Define modulation. Write its types.

Ans.—Modulation—The process of mounting a very low frequency signal over high frequency signal is known as modulation.

Following are the different types of modulation which are as follows—

1. Amplitude Modulation,
2. Frequency Modulation,
3. Phase Modulation,

10. Calculate the frequency associated with a photon of energy 3.3×10^{-20} J. ($h = 6.6 \times 10^{-34}$ Js)

Ans.—Given that,

$$E = 3.3 \times 10^{-20} \text{ J}$$

$$h = 6.6 \times 10^{-34} \text{ Js}$$

$$\nu = ?$$

As we know that,

$$E = h\nu$$

$$\therefore \nu = \frac{E}{h}$$

$$= \frac{3.3 \times 10^{-20}}{6.6 \times 10^{-34}}$$

$$= \frac{1}{2} \times 10^{-20} \times 10^{34}$$

$$= \frac{10}{2} \times 10^{-20} \times 10^{33}$$

$$\boxed{\nu = 5 \times 10^{13} \text{ Hz}}$$

11. Calculate the radius of a nucleus of mass no. 8.

Ans.—As we know that

$$\boxed{R = R_0 A^{\frac{1}{3}}}$$

$$\begin{aligned} \therefore R &= 1.2 \times 10^{-15} \times (8)^{1/3} \\ &= 1.2 \times 10^{-15} \times (2)^{3 \times \frac{1}{3}} = 1.2 \times 10^{-15} \times 2 \end{aligned}$$

$$\boxed{R = 2.4 \times 10^{-15} \text{ m}}$$

Given that,

$$R_0 = 1.2 \times 10^{-15} \text{ m}$$

$$A = 8$$

$$R = ?$$

SECTION-II (NON-OBJECTIVE TYPE QUESTIONS)

Question Nos. 12 to 15 are of long answer type. Answer must be explanatory and in your own language.
Each question carries 5 marks. $4 \times 5 = 20$

LONG QUESTIONS

12. State and explain different types of Telescope. With the help of neat and labelled diagram explain the working and magnifying power of an Astronomical telescope ?

Ans.—TELESCOPE—An optical instrument which is used to see far off objects clearly and distinctly is called telescope. There are two types of telescope.

I. Refracting type Telescope—A telescope in which lenses are used is called refracting type telescope. There are two types of refracting type telescope.

(a) **Astronomical telescope**—A telescope which is used to see heavenly objects such as sun, moon, stars, comets etc is called astronomical telescope.

(b) **Terrestrial telescope**—A telescope which is used to see earthly objects such as mountain, hills, plateaus, sea, etc is called terrestrial telescope.

II. Reflecting type Telescope—

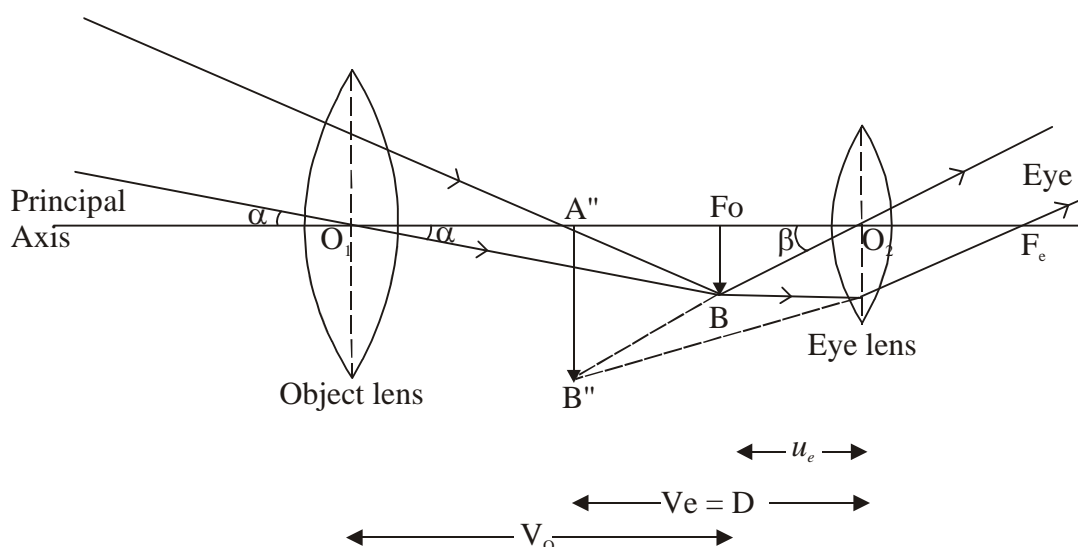
A telescope in which mirror is used is called reflecting type telescope.

There are two types of reflecting type telescope.

(a) **Newtonian Telescope.**

(b) **Cassegrain Telescope.**

ASTRONOMICAL TELESCOPE



It is an optical instrument which is used to see heavenly object such as sun, moon, stars, etc is called astronimcal telescope.

Principal—If object is placed at α its image is formed at focus. $A'B'$ behave like an object for eye lens whose virtual erect, highly magnified image is formed in the same side of object.

CONSTRUCTION & WORKING—It is in an astronomical telescope two lens are used. The lens facing the object is called object lens. Its focal length and aperature is very large. The lens facing the eye is called eye lens. Its focal length and aperature is small. Both the lens are placed co-axially.

Magnifying power or magnification—It is the ratio of angle subtended by the eye to see the image (β) to the angle subtended by the eye to see the object (α). Magnification or M.P.

$$M.P. = \frac{\beta}{\alpha} \quad \dots(1)$$

For smaller angle,

$$\left[\begin{array}{l} \beta = \tan \beta \\ \alpha = \tan \alpha \end{array} \right] \quad \dots(2)$$

$$\therefore M.P. = \frac{\tan \beta}{\tan \alpha} \quad \dots(3)$$

In $\Delta O_2 A' B'$

$$\tan \beta = \frac{A' B'}{O_2 A'} \quad \dots(4)$$

In $\Delta O_1 A' B'$

$$\tan \alpha = \frac{A' B'}{O_1 A'} \quad \dots(5)$$

Using in eqn (3)

$$M.P. = \frac{A' B'}{O_2 A'} \times \frac{O_1 A'}{A' B'}$$

$$\therefore M.P. = \frac{O_1 A'}{O_2 A'} \quad \dots(6)$$

Using proper sign-convention

$$\left[\begin{array}{l} O_1 A' = f_o \\ O_2 A' = -ve \end{array} \right] \quad \dots(7)$$

Using in eqn. (1)

$$M.P. = \frac{-f_o}{-u_e}$$

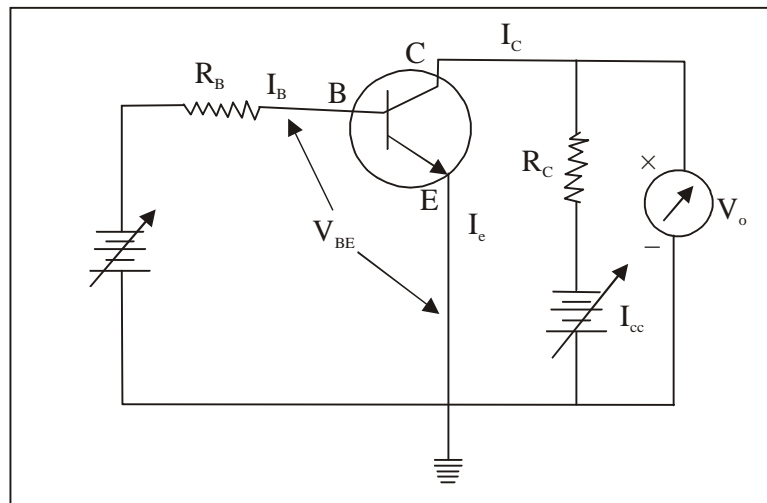
$$\therefore M.P. = \frac{-f_o}{u_e} \quad \dots(8)$$

Equation (8) is the general equation for magnification produced by an astronomical telescope.

13. Explain transistor as a switch and transistor as an amplifier ?

Ans.—Transistor as a Device—Transistor can be used as a switch when it operates in cut off region (open switch) and saturation region (closed switch). On the other hand, transistor is used as an amplifier to increase the magnitude of the output signal when it operates in the active region.

(I) Transistor as a switch—A device which turns ON or OFF electric current in an electric circuit is known as a switch. A transistor acts as a switch when it is driven back and forth between saturation and cut off regions. Circuit diagram showing transistor as a switch is shown in figure.



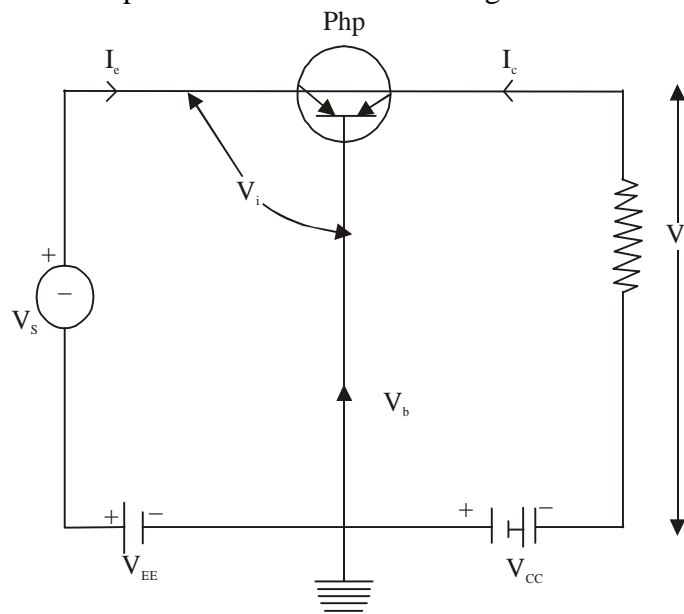
When base input voltage V_{BB} is very low so that the transistor is not forward bias, then no current flows through R_C i.e. $I_C = 0$. Hence, the output voltage $= V_{CC}$. The transistor is in the cut off mode and acts as an open switch i.e. OFF state. When base input voltage is enough positive, the transistor is forward biased. Therefore, the current I_C flows through R_C . In this situation, voltage drop across $R_C = V_{CC}$. Hence, $I_C = \frac{V_{CC}}{R_C}$ and $V_{CE} = 0$. Therefore the transistor acts as a closed switch i.e. ON state.

Transistor as an amplifier—A device which increases the amplitude of the input signal is called amplifier.

The weak input signal (i.e. a signal of small amplitude) is fed to the amplifier which turns amplifiers it and we get output signal or large amplitude.



The basic circuit of npn transistor amplifier in common base configuration is shown in figure.



Transistor is biased in the active region i.e. emitter-base junction is forward biased with a battery V_{EE} and the collector-base junction is reverse biased with a battery V_{CC} . The emitter-base circuit is known as input circuit and the collector-base circuit is known as output circuit. The signal voltage V_s to B_e amplified is fed to the input circuit. The output is taken across load resistance R_L in the output circuit. When signal voltage V_{EE} , then input voltage V_i is increased to ΔV_i . Due to this increased voltage, emitter current increases by ΔI_e . This will increase the collector current by ΔI_c . Therefore, the output voltage across R_L will increase to ΔV_c , Where,

$$\Delta V_c = \Delta I_c R_L$$

Since $\alpha = \frac{\Delta I_c}{\Delta I_e}$ Or $\Delta I_c = \alpha \Delta I_e$... (i)

$$\therefore \Delta V_c = \alpha \Delta I_e R_L$$

If R_e is the resistance of input circuit, then

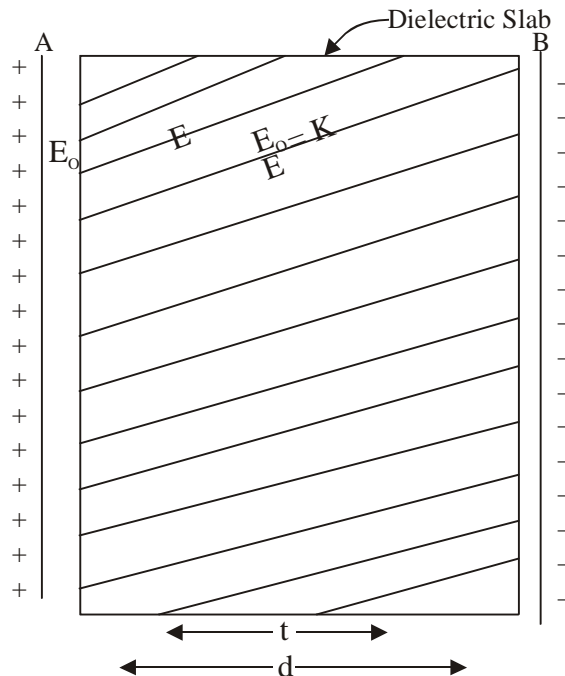
$$\Delta V_i = R_e \Delta I_e$$

Thus, the voltage gain,

$$\begin{aligned} AV &= \frac{\Delta V_c}{\Delta V_i} = \frac{\alpha \Delta I_e R_L}{R_e \Delta I_e} \\ &= \alpha \left(\frac{R_L}{R_e} \right) \end{aligned}$$

14. Deduce an expression for parallel plate capacitor with dielectric slab ?

Ans.—



If dielectric slab is not placed in between the plate of P.P.C. its capacitance.

$$C_o = \frac{E_o dA}{d}$$

... (1)

Where, A is area of the plate

d is the distance between the two plates

Initial electric field is E_o .

Now, dielectric slab is placed in between the two plates of dielectric constant “K”

K is always ‘+ve’ and greater than one

By defⁿ of polarisation.

$$\frac{E_o}{E} = K \quad \dots(2)$$

$$E = \frac{E_o}{K} \quad \dots(3)$$

From relation between electric field and potential.

$$E = \frac{-dv}{dr} \quad \dots(4)$$

Taking magnitude of eqⁿ ... (4)

$$E = \frac{dv}{dr} \quad \dots(5)$$

If electric field is uniform,

$$dv = v$$

$$dr = r$$

$$\dots(6)$$

$$\therefore E = \frac{v}{r}$$

$$\therefore V = Er \quad \dots(7)$$

$$V = V_1 + V_2$$

$$\dots(8)$$

V_1 is for free space

V_2 is for dielectric slab.

From eqn... (7)

$$V = E_1 r_1 + E_2 r_2$$

$$V = E_o (d - t) + E \cdot t$$

From eqⁿ (3)

$$\boxed{V = E_o (d - t) + \frac{E_o}{K} \cdot t} \quad \dots(9)$$

$$\text{But, } E_o = \frac{\sigma}{E_o} = \frac{q}{E_o A} \quad \dots(10)$$

Using in eqⁿ... (9)

$$V = \frac{q}{E_o A} \left[d - t + \frac{t}{K} \right] \quad \dots(11)$$

By defn of capacitance of the capacitor

$$C = \frac{q}{V} \quad \dots(12)$$

$$C = \frac{q}{\frac{q}{E_o A} \left(d - t + \frac{t}{K} \right)}$$

$$\therefore \boxed{C = \frac{E_o A}{\left(d - t + \frac{t}{K} \right)}} \quad \dots(13)$$

Eqⁿ (13) is the general equation for capacitance of d parallel plate capacitor with dielectric slab of dielectric constant 'K'.

Special case—If dielectric slab completely filled the plate.

$$\therefore d = t$$

...(14)

$$C = \frac{E_o A}{\left(d - d + \frac{d}{k}\right)}$$

$$C = k \left(\frac{E_o d}{d} \right)$$

...(15)

Using eqn ...(1)

$$C = KC_o$$

...(16)

Conclusion—If a dielectric slab is placed in between two plate of ppc its capacitance increases 'K' times in which k is positive and greater than one.

15. Define nuclear reactor. Discuss its different components with their functions. Draw diagram also.

Ans.—Nuclear-Reactor—An apparatus in which controlled nuclear chain reaction.

In a nuclear reactor the energy released through fission is used to generate electricity several nuclear power for the generation of electricity are operating in India.

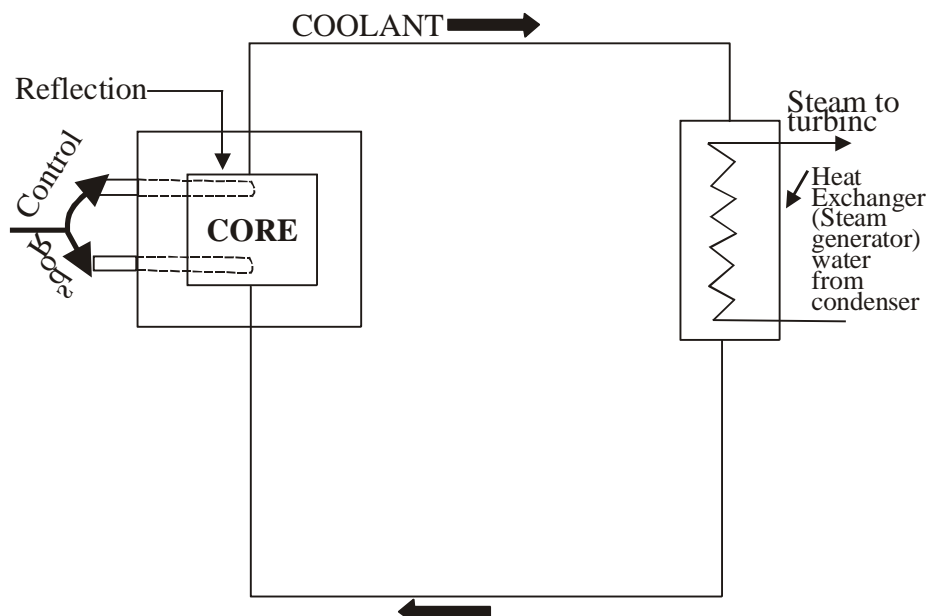
Following are the important components of nuclear reaction.

- | | | |
|------------------|----------------------|---|
| (i) Nuclear fuel | (iii) Coolant | (v) Radio active protection arrangement |
| (ii) Moderator | (iv) Controlled rods | |

(i) Nuclear fuel—The elements undergoing fission in a reactor are called nuclear fuel. Uranium, Isotopes, Thorium. Isotopes and plutonium Isotopes are most commonly used nuclear fuels.

(ii) Moderator—Moderator are used to slow down the fast moving neutrons are passed through moderator which are generally element of Low atomic number graphite, heavy water, beryllium oxides etc are used as a moderator D₂O (Heavy water) is best known moderator.

(iii) Coolant—A coolant removes the tremendous heat develops inside the nuclear reactor core. This energy is developed due to slow down of fast moving neutron water, steam, helium, CO₂, water, air, molten metals etc are used as a coolant.



(iv) **Controlled Rods**—To start and stop the nuclear reactor controlled rods are used due to large absorptional area those materials are used as a controlled rods. Whose area of cross-section is large.

Cadmium and Boron are most commonly used controlled rods.

(v) **Radio-active protection Arrangement**—For safe the life of Human beings from harmful radiations a dome shaped concrete wall of minimum thickness 2m is net. So that it has no any harmful side effect to the common people. Normally nuclear is made in the place where population is minimum.

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. Write two properties of electric field lines ?

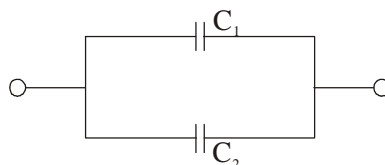
Ans.—Following are the two properties of electric field lines—

- (1) Two electric field lines do not cross each other,
- (2) The electric field lines begin from positive charge and terminated on negative charge.

2. Two condensers have capacitances C_1 and C_2 . Show their parallel combination and series combination circuits.

Ans.—**Paralle combination :**

$$C = C_1 + C_2$$



Series combination :



3. Write Lenz's law of electromagnetic induction.

Ans.—**Lenz's law of electromagnetic in direction :**

It states that—“The direction of induced e.m.f. or current is such that it opposes the cause which produces it.”

Its expression is as follows :

$$\epsilon = -N \frac{d\phi_B}{dt}$$

It gives the direction of induced e.m.f.

Here, -ve sign shows that induced e.m.f. opposes the change in magnetic flux. It was explained by Lenz.

4. Write any two properties of X-rays.

Ans.—Two properties of X-rays are as follows—

- (1) They are not deflected by electric or magnetic field.
- (2) They travel with the speed of light as electromagnetic wave.

5. Write any two N-type and P-type semiconductors.

Ans.—Following are the difference between n-type and p-type semiconductor—

n-type semiconductors

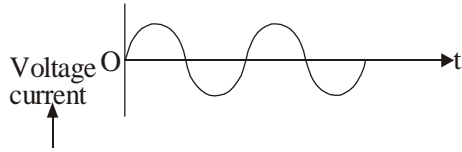
1. When pentavalent impurity atoms like As, Sb etc. are added in the intrinsic semiconductor, we get n-type semiconductor.
2. The majority carriers in the n-type semiconductor are electrons and minority carriers are holes.
3. $n_e \gg n_h$

p-type semiconductors

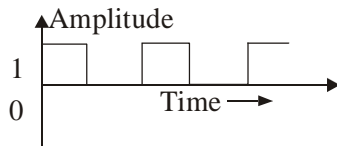
1. When trivalent impurity atoms like gallium, indium etc. are added in the intrinsic semiconductor, we get p-type semiconductors.
2. The majority carriers in p-type semiconductor are holes and minority carriers are electrons.
3. $m_h \gg n_e$

6. What do you mean by analog and digital signal ?

Ans.—Analog signal—It is an electrical waveform continuously changing in magnitude with time.



Digital signal—It is a discontinuous and discrete signal having only binary variations 1 and 0 with time.



7. Define current density. Write its SI unit and dimension.

Ans.—Current density—Current density of a conductor is defined as the amount of current passing per unit area of the conductor held to the flow of charges :

It can be expressed as—

$$J = \frac{I}{A} \quad \text{It is a vector quantity.}$$

The S.I. unit of current density is ampere/ metre² (Am⁻²)

The dimension of current density is [M⁰L⁻²T⁰A]

8. State Kirchhoff's two laws of electrical network.

Ans.—Kirchhoff's first law—It states that—

“The algebraic sum of all the currents meeting at a junction in a closed electrical circuit is zero.”

$$\sum I = 0$$

It is also called junction law. It is based on the law of conservation of charges. Actually it is Kirchhoff's current law.

Kirchhoff's second law—It states that—

“The algebraic sum of all voltage that is, the potential difference across all elements and e.m.f. of all sources in any closed electrical circuit is zero.

$$\sum E + \sum \Delta V = 0 \quad \text{or,} \quad \Delta V = 0$$

It is also called loop law and Kirchhoff's voltage law.

It is based on the law of conservation of energy.

9. State two properties of nuclear force.

Ans.—Two properties of nuclear forces are as follows :

- (1) It is mainly an attractive force.
- (2) It is strong fundamental force in nature.

10. What is the de-Broglie wavelength associated with an electron, accelerated through a potential difference of 100 volt.

Ans.—As we know that,

$$\lambda = \frac{12.27}{\sqrt{V}} \text{ \AA}, \text{ for electron}$$

$$= \frac{12.27}{\sqrt{100}}$$

$$= \frac{12.27}{10}$$

$$\boxed{\lambda = 1.22 A^\circ}$$

- 11.** An astronomical telescope having a magnifying power of 8 consists of two thin lenses 45 cm. apart. Find the focal length of the lenses.

Ans.—We have,

$$M.P. = \frac{f_o}{f_e}$$

$$8 = \frac{f_o}{f_e}$$

$$\therefore f_o = 8f_e$$

$$f_o = 8 \times 5$$

$$\boxed{f_o = 40 \text{ c.m.}}$$

Length of the telescope,

$$L = f_o + f_e$$

$$45 \text{ cm} = 8f_e + f_e$$

$$45 \text{ c.m.} = 9f_e$$

$$\therefore f_e = \frac{45 \text{ cm}}{9}$$

$$\boxed{f_e = 5 \text{ c.m.}}$$

SECTION-II (NON-OBJECTIVE TYPE QUESTIONS)

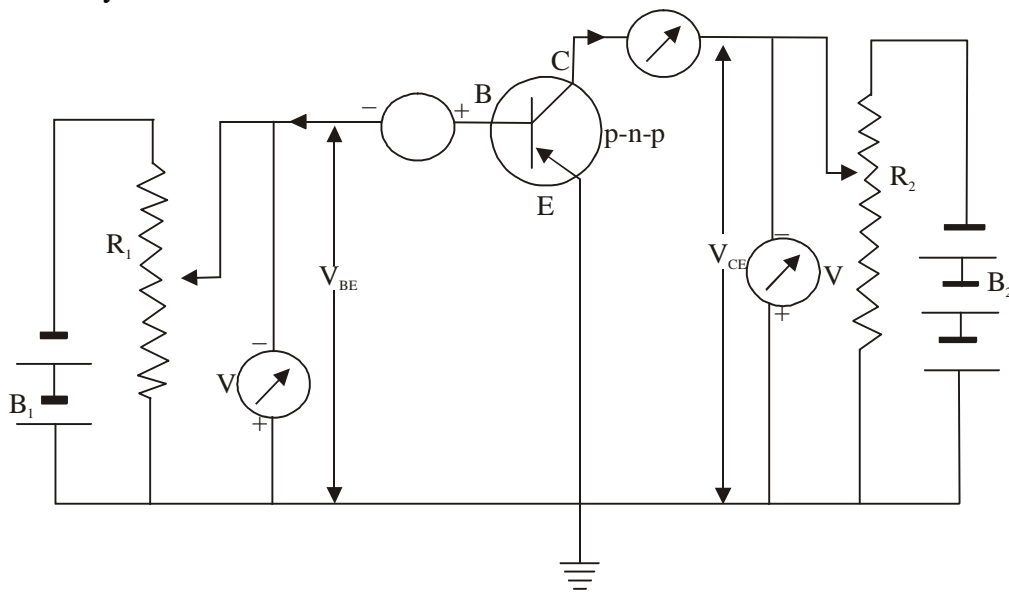
Question Nos. 12 to 15 are of long answer type. Answer must be explanatory and in your own language.
Each question carries 5 marks. $4 \times 5 = 20$

LONG QUESTIONS

12. Discuss common transistor biasing in the case of p-n-p transistor. Discuss its characteristics curve and current amplification factor ?

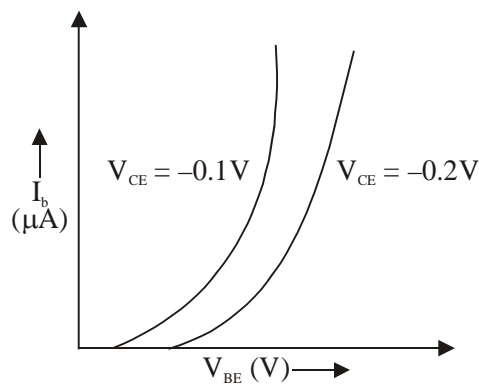
Ans.—The variation of base current I_b (input) with base emitter voltage (V_{BE}) at constant collector emitter voltage (V_{CE}) is called input characteristic.

Circuit diagram to study the common-emitter characteristics of a transistor is shown.



Conclusion—

- (i) The input characteristics are similar to forward bias characteristics of a junction diode.
- (ii) For a given value of emitter-base voltage (V_{BE}), the base current decrease with the increase in collector emitter voltage.

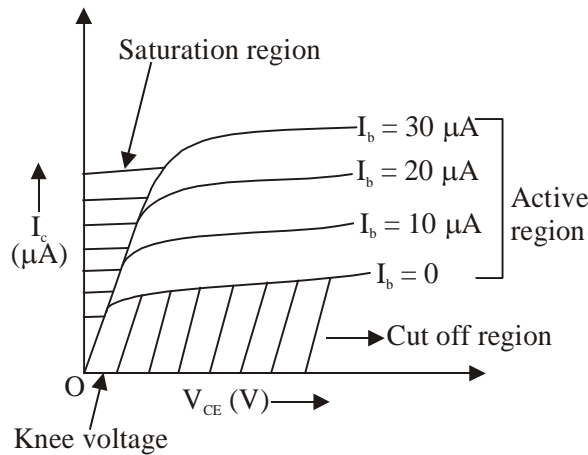


Output Characteristics of Common Emitter Transistor

The variation of the collector current I_C (output) with collector-emitter voltage (V_{CE}) at constant base current (I_b) is called output characteristic.

- (i) Keep the base current (I_b) fixed (say, $10 \mu A$).

- (ii) Now change the collector-emitter voltage (V_{CE}) using variable resistance R_2 and note the corresponding values of collector current. (I_C)
- (iii) The graph between the various values of V_{CE} and I_C is plotted which is the output characteristic of the transistor.
- (iv) A set of such curves can be plotted at different fixed values of base current (say $20\mu A$, $30\mu A$, $40\mu A$).



Conclusion—

- (i) For a given value of base current, collector current increases rapidly with the collector-emitter voltage in the beginning but at high value of V_{CE} , collector current becomes constant.
- (ii) For a given value of V_{CE} , the collector current (I_C) is higher for high value of base current (I_b).

Output resistance (r_o) is defined as the ratio of small change in V_{CE} (i.e. ΔV_{CE}) to the small change in collector current (ΔI_C) at constant base current.

$$\text{i.e. } r_o = \frac{\Delta V_{CE}}{\Delta I_C} / I_b = \text{constant}$$

This is also known as a.c. resistance (i.e. effective resistance in the output for an a.c. input signal).

$$\text{D.C. resistance} = \frac{V_{CE}}{I_C}$$

Output characteristics of a transistor in common-emitter configuration are divided into three regions :

- (i) active region, (ii) cut off region and (iii) saturation region

Active region—Active region lies above $I_b = 0$ as shown in figure. In this region, collector junction is reverse biased and emitter junction is forward biased for a given value of I_B , collector current increases as V_{CE} increases. A transistor is operated in active region if it is used as an amplifier.

Cut off region—Cut off region lies below $I_B = 0$. The collector current has finite value under this condition. In order to cut off the transistor, the emitter junction has to be made slightly reverse biased in addition to $I_B = 0$.

Saturation region—Saturation region lies close to zero voltage axis where all the curves coincide. In this region, collector current is independent of the base current.

Current Amplification factor (β) :

- (i) **d.c. current gain (β_{dc})**—

It is defined as the ratio of the collector current (I_c) to the base current (I_B). That is $\beta_{dc} = \frac{I_C}{I_B}$

Since $I_C > I_B$, so β_{dc} is greater than 1. The value of β_{dc} lies between 20 and 200.

(ii) Small signal current gain (β_{ac})—

It is defined as the ratio of small change in collector current (ΔI_C) to the small change in base-current (ΔI_B) at constant collector-emitter voltage (V_{CE}).

That is,
$$\beta_{ac} = \frac{\Delta I_C}{\Delta I_B} / V_{CE} = \text{constant}$$

- 13.** Define and deduce the general expression of mutual inductance. In the case of solenoid, prove that, $M_{12} = M_{21} = M$?

Ans.—Mutual Induction—Mutual induction of two coil can be defined as the magnetic flux linked to the secondary coil due to the flow of induced current in primary coil.

Mathematically, it can be written as,

$$\phi_s \propto I_p \quad \dots(1)$$

$$\boxed{\phi_s = MIP} \quad \dots(2)$$

Where, M is a proportionally constant which is called mutual inductance.

$$\therefore \boxed{M = \frac{\phi_s}{I_p}} \quad \dots(3)$$

Hence, mutual induction of two coils is the ratio of magnetic flux changes in secondary coil to the induced current produced in primary coil.

$$\text{If } I_p = 1A \quad \dots(4)$$

$$\boxed{M = \phi_s} \quad \dots(5)$$

Mutual inductance of two coils is numerically equal to change in magnetic flux in secondary coil provided induced current produced in primary coil is 1A.

According to Faraday's second law

$$\epsilon_s = \frac{-d\phi_s}{dt} \quad \dots(6)$$

Using eqⁿ (2)

$$\epsilon_s = \frac{-d}{dt}(MIP)$$

$$\epsilon_s = M \cdot \left(\frac{dI_p}{dt} \right)$$

$$M = \frac{\epsilon_s}{\left(\frac{-dI_p}{dt} \right)} \quad \dots(7)$$

Hence, mutual inductance of two coils is the ratio of induced emf produced in secondary coil to the rate of loss of induced current produced in primary coil with respect to time

$$\text{If } \frac{-dI_p}{dt} = 1A s^{-1} \quad \dots(8)$$

$$\boxed{M = \epsilon_s} \quad \dots(9)$$

Therefore, mutual inductance of two coils is numerically equal to induced emf produced in secondary coil provided rate of loss of induced current produced in secondary coil with respect to time is $1A s^{-1}$.

$$\text{S.I. unit of inductance, } L = \frac{\phi}{I} = \frac{\text{weber}}{\text{ampere}} = \text{WbA}^{-1}$$

$$1 \text{ henry} = 1 \text{ weber} / 1 \text{ ampere}$$

Solenoid—Prove that $M_{12} = M_{21} = M$

N-turns coil wrapped around soft iron core is called solenoid two solenoid S_1 and S_2 are placed co-axially as shown in next page. The magnetic field of solenoid S_1 can be expressed as,

$$B_1 = \mu_0 n_1 I_1 \quad \dots(1)$$

Magnetic field of solenoid S_2 ,

$$B_2 = \mu_0 n_2 I_2 \quad \dots(2)$$

For solenoid S_1 , N_1 is the total number of turns, n_1 is the total number of turns per unit length and the since they are placed co-axially.

$$\therefore l_1 = l_2 = l \quad \dots(3)$$

For solenoid S_2 , N_2 is the total number of turns, n_2 is the total no. of turns per unit length.

$$B_1 = \mu_0 n_1 I_1 \quad \dots(1)$$

Magnetic field of solenoid S_2

$$B_2 = \mu_0 n_2 I_2 \quad \dots(2)$$

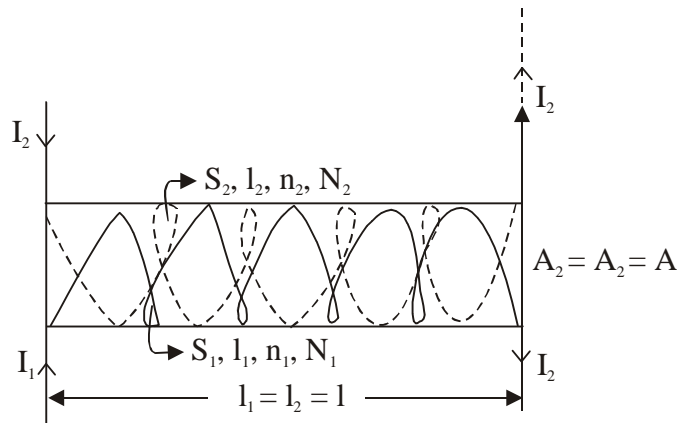
$$l_1 = l_2 = l (\text{say}) \quad \dots(3)$$

$$\left. \begin{aligned} n_1 &= \frac{N_1}{l_1} = \frac{N_1}{l} \\ n_2 &= \frac{N_2}{l_2} = \frac{N_2}{l} \end{aligned} \right\} \quad \dots(4)$$

Using in eqⁿ (1) & (2)

$$B_1 = \frac{\mu_0 N_1 I_1}{l} \quad \dots(5)$$

$$B_2 = \frac{\mu_0 N_2 I_2}{l} \quad \dots(6)$$



$$\phi_1 = N_1 B_2 A_1 \quad \dots(7)$$

$$\therefore A_1 = A_2 = A (\text{say}) \quad \dots(8)$$

Using eqⁿ (6)

$$\phi_1 = \frac{N_1 \mu_0 N_2 I_2}{l} \cdot A_1$$

$$\phi_1 = \frac{\mu_0 N_1 N_2 A \cdot I_2}{l} \quad \dots(9)$$

$$\text{Similarly, } \phi_2 = N_2 B_1 A_2$$

$$\phi_2 = N_2 B_1 A \quad \dots(10)$$

Using eqⁿ (5)

$$\phi_2 = \frac{\mu_0 N_2 N_1 I_1 \cdot A}{l}$$

$$\boxed{\phi_2 = \frac{\mu_0 N_1 N_2 A \cdot I_2}{l}} \quad \dots(11)$$

By defⁿ of mutual inductance, for primary coil

$$\phi \propto I_2 \quad \dots(12)$$

$$\boxed{\phi_1 = M_2 \cdot I_2} \quad \dots(13)$$

Equating eqⁿ (9) and (13)

$$M_2 I_2 = \frac{\mu_0 N_1 N_2 A_2}{l}$$

$$\therefore \boxed{M_{21} = \frac{\mu_0 N_1 N_2 A}{l}} \quad \dots(14)$$

By defⁿ of mutual inductance for secondary coil.

$$\phi_2 \propto I_1 \quad \dots(15)$$

$$\boxed{\phi_2 = M_{12} I_1} \quad \dots(16)$$

Equating eqⁿ (16) & (11)

$$M_{12} I_1 = \frac{\mu_0 N_2 N_1 A I_1}{l}$$

$$\boxed{M_{12} = \frac{\mu_0 N_1 N_2 A}{l}}$$

From eqn (14) & (17)

$$\boxed{M_{12} = M_{21} = M}$$

Conclusion—Mutual inductance of primary coil is numerically equal to mutual inductance of secondary coil with respect to primary coil which is simply called mutual inductance of two coil.

14. What do you mean by Wheatstone bridge. Discuss its balanced condition ?

Ans.—Wheatstone bridge—It is an arrangement of four resistance connected with galvanometer in the form of a bridge. It is used to find unknown resistance accurately.

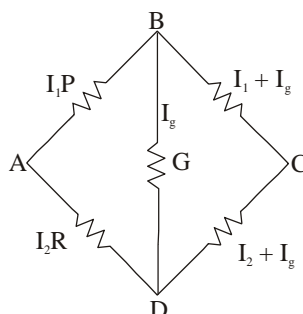
Principle—If no electric current passed through galvanometer for balanced bridge, $I_g = 0$

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

Working theory—There are three resistance P, Q and R are but S is unknown. With the help of known resistance unknown resistance can be determined R is known resistance.

If no electric current passed through galvanometer the bridge is said to be balanced.

Construction—



In loop ABDA

$$I_1 P - I_g G + I_2 R = 0 \quad \dots(3)$$

For balanced bridge, $I_g = 0$

$$\therefore I_1 P + I_2 R = 0$$

$$I_1 P = I_2 R$$

$$\frac{I_1}{I_2} = \frac{R}{P}$$

...(4)

In loop BCB

$$-(I_1 - I_g)Q + (I_2 + I_g)S + I_g G = 0 \quad \dots(5)$$

For balanced bridge, $I_g = 0$

$$\therefore I_1 Q + I_2 S = 0$$

$$I_1 Q = I_2 S$$

$$\frac{I_1}{I_2} = \frac{S}{Q}$$

...(6)

Equating eqⁿ (4) & (6)

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

$$\therefore PS = RS$$

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

...(7)

Equation (7) is the required condition for a balanced wheatstone bridge.

Advantages—

- (i) It works on deflection method therefore its reading is very accurate.
- (ii) In the help of known resistance unknown resistance can be determined in the order of high accuracy.

Disadvantage—

It gives very accurate measurement only when all the resistance are nearly equal.

It is extremely difficult to select unknown resistance in the order of known resistance.

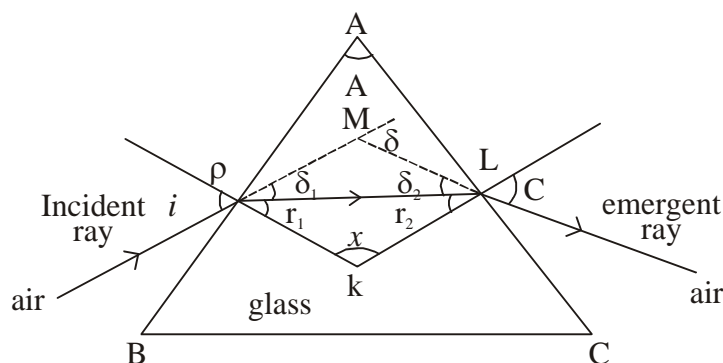
15. Deduce Prism equation and find the expression for minimum deviation produced by a prism ?

Ans.—Prism equation OR Prism formula OR Refraction through prism—

In a prism there are two refracted surfaces AB and AC.

Case-I—When a ray of light passes from rare to denser medium it bends towards the normal.

Case-II—When a ray of light passes from denser to rarer medium it bends away from the normal.



In $\triangle PML$:—

$$\delta = \delta_1 + \delta_2 \quad \dots(1)$$

$$i = \delta_1 + r_1$$

$$\therefore \delta_1 = i - r_1 \quad \dots(2)$$

$$e = \delta_2 + r_2$$

$$\dots(3)$$

Using in eqⁿ (1)

$$\delta = i - r_1 + e - r_2$$

$$\boxed{\delta = (i + e) - (r_1 + r_2)}$$

$$\dots(4)$$

In $\triangle PLK$:—

$$r_1 + r_2 + x = 180^\circ$$

$$x = 180^\circ - (r_1 + r_2)$$

$$\dots(5)$$

In quadrilateral ALKP :—

$$\angle PAL + \angle ALK + \angle LKP + \angle KPA = 360^\circ$$

$$\dots(6)$$

$$A + 90^\circ + x + 90^\circ = 360^\circ$$

$$A + x = 360^\circ - 180^\circ$$

$$A + x = 180^\circ$$

$$\dots(7)$$

Using eqⁿ (5)

$$A + 180^\circ - (r_1 + r_2) = 180^\circ$$

$$A - (r_1 + r_2) = 0$$

$$\therefore \boxed{(r_1 + r_2) = A}$$

$$\dots(8)$$

Eqn (8) is called 1st eqn of prism.

Hence angle of prism is the sum total of angle of refraction through both the surface.

Using eqⁿ (8) in (4)

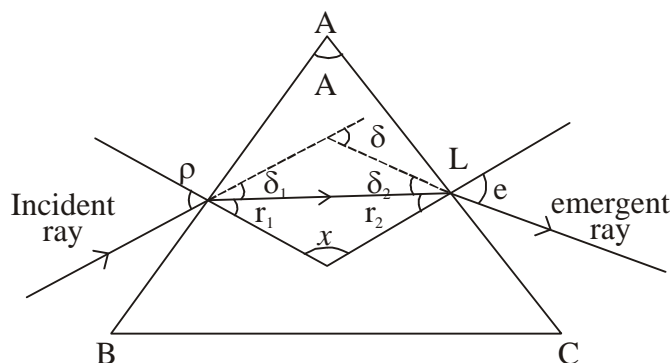
$$\delta = (i + e) - A$$

$$\therefore \boxed{(i + e) = (\delta + A)}$$

$$\dots(9)$$

Eqⁿ (9) is called 2nd eqn of prism. It states that the sum total of angle of incidence & angle of emergence is equal to sum angle of deviation and angle of prism.

Case-III Minimum deviation produced by a prism—



Deviation produced by a prism is the angle b/w extended line of incident ray and emergent ray.

For min^m deviation produced by prism,

$$\text{if } \delta = \delta_m \quad \dots(1)$$

$$\text{then } i = e \quad \dots(2)$$

$$r_1 = r_2 = r \text{ (say)}$$

$$\dots(3)$$

A/C to prism's first relation

$$r_1 = r_2 = A$$

$$\dots(4)$$

$$r + r = A$$

$$2r = A$$

$$\therefore r = \left(\frac{A}{2} \right) \quad \dots(5)$$

A/C to prism's second relation,

$$i + e = \delta + A$$

...(6)

$$i + i = \delta m + A$$

$$2i = \delta m + A$$

$$\therefore i = \left(\frac{\delta m + A}{2} \right) \quad \dots(7)$$

A/C to snell's law,

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

Using eqⁿ (7) & (5)

$$\boxed{\frac{\sin \left(\frac{\delta m + A}{2} \right)}{\sin \left(\frac{A}{2} \right)} = n} \quad \dots(9)$$

Eqn (9) is the general expression for minimum deviation produced by a prism.

SECTION-II (NON-OBJECTIVE TYPE QUESTIONS)

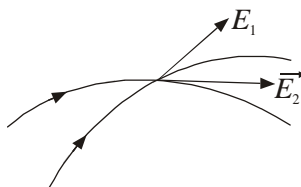
Question Nos. 1 to 11 are of short answer type. Each question carries 2 marks.

$11 \times 2 = 22$

SHORT QUESTIONS

1. No two electric field lines can intersect each other. Why ?

Ans.—There would be two directions of electric field intensity at the same point if at the point of intersection two electric lines of force intersect each other, which is not possible. Hence, no two electric field lines can intersect each other.



2. State Gauss's Theorem. Express it mathematically.

Ans.—Gauss's theorem—It states that “The total electric flux (ϕ) through any closed surface (s) in free space is equal to $\frac{1}{\epsilon_0}$ times the total electric charge (q) enclosed by the surface.”

Mathematically, it can be expressed as

$$\phi = \oint_s \vec{E} \cdot \vec{ds} = \frac{q}{\epsilon_0}$$

3. Differentiate between potentiometer and ordinary voltmeter.

Ans.—Following are the difference between Potentiometer and Ordinary voltmeter—

Potentiometer

1. It works on null method.
2. It is a very accurate device.

Ordinary voltmeter

1. It works on deflection method.
2. It is an approximate instrument.

4. Calculate the resistance of two coils if their equivalent resistance in series and parallel are respectively 18Ω and 4Ω .

Ans.—Given that, $R_s = 18\Omega$, $R_p = 4\Omega$
 $R_1 = ?$, $R_2 = ?$

As we know that,

$$R_s = R_1 + R_2$$

$$18\Omega = R_1 + R_2$$

$$R_p = \frac{R_1 R_2}{R_1 + R_2}$$

As we have, $4 = \frac{R_1 R_2}{18} \therefore R_1 R_2 = 4 \times 18 = 72\Omega$

...(1)

$$\begin{aligned}
 (R_1 - R_2)^2 &= (R_1 + R_2)^2 - 4R_1R_2 \\
 &= (18)^2 - 4 \times 72 \\
 &= 324 - 288 = 36
 \end{aligned}$$

$$\therefore R_1R_2 = \sqrt{36} = 6\Omega \quad \dots(2)$$

From eqⁿ (1) & (2), we get

$$\begin{array}{r}
 R_1 + R_2 = 18 \\
 R_1 - R_2 = 6 \\
 \hline
 2R_1 = 24
 \end{array}$$

$$R_1 = \frac{24}{2} = 12\Omega$$

$$R_1 + R_2 = 18$$

$$12 + R_2 = 18 \therefore R_2 = 18 - 12$$

$$R_2 = 6\Omega$$

$$\begin{aligned}
 \therefore R_1 &= 12\Omega \\
 R_2 &= 6\Omega
 \end{aligned}$$

5. The magnetic permeability of a substance is $7.5 \times 10^{-3} \text{ TmA}^{-1}$. Then, find (i) relative permeability and (ii) magnetic susceptibility of the substance.

Ans.—Given that,

$$\mu = 7.5 \times 10^{-3} \text{ TmA}^{-1}$$

- (i) As we know that,

$$\begin{aligned}
 \mu_r &= \frac{\mu}{\mu_0} \\
 &= \frac{7.5 \times 10^{-3}}{4\pi \times 10^{-7}} = \frac{7.15 \times 7 \times 10^{-3}}{4 \times 22 \times 10^{-7} \times 10} \\
 &= \frac{15 \times 7 \times 10^{-3} \times 10^7}{4 \times 22 \times 2} = \frac{15 \times 7 \times 10^{-4}}{4 \times 22 \times 2} \\
 &= \frac{15 \times 7 \times 100 \times 100}{4 \times 22 \times 2} \\
 &= \frac{105 \times 625}{11} = \frac{65625}{11}
 \end{aligned}$$

$$\boxed{\mu_r = 0.6 \times 10^4}$$

(ii) $\mu_r = 1 + X_m$

$$\begin{aligned}
 \therefore X_m &= \mu_r - 1 \\
 &= 0.6 \times 10^4 - 1 \\
 &= 6000 - 1
 \end{aligned}$$

$$\boxed{X_m = 5999}$$

6. Define inductive reactance (X_L). Write its S.I. unit and dimension.

Ans.—Inductive reactance (X_L)—It is the effective opposition offered by the inductor to the flow of current in the circuit. Its S.I. unit is ohm.

The dimension of inductive reactance is $[ML^2T^{-3}A^{-2}]$

It can be expressed as $X_L = LW$

7. Define mean value of a.c. and r.m.s. value of a.c. mention their expression only.

Ans.—**Mean value of alternating current**—It is that value of steady current which sends the same amount of charge through a circuit in a certain time interval as is sent by an a.c. through the same circuit in half cycle.

Its expression is as follows—

$$I_{av} = \frac{2I_o}{\pi}$$

$$I_{av} = 0.637 I_o$$

Root Mean square Value of alternating current—It is that steady current which produces the same amount of heat in a conductor in a certain time interval as a produced by the a.c. in the same conductor during the time period, T. (it full cycle)

Its expression is as follows—

$$I_{r.m.s.} = \frac{I_o}{\sqrt{2}}$$

$$I_{r.m.s.} = 0.707 I_o$$

8. A step up transformer is used on a 120V line to provide a potential difference of 2400V. If the primary has 75 turns, how many turns must the secondary have ?

Ans.—Given that,

$$E_p = 120V, E_s = 2400 V$$

$$N_p = 75, N_s = ?$$

We know that,

$$\frac{E_s}{E_p} = \frac{N_s}{N_p}$$

$$\text{So, } N_s = N_p \times \frac{E_s}{E_p}$$

$$= \frac{75 \times 2400}{120} = 1500$$

$$N_s = 1500$$

9. State two difference between interference and diffraction.

Ans.—Two differences between interference and diffraction are as follows—

Interference

1. It is due to the super position.
2. In interference patter, the dark fringes are usually almost perfectly dark.

Diffraction

1. It is due to the super position of secondary wavelets originating from the different points of the same wave front.
2. In diffraction pattern, the dark fringes are not perfectly dark.

10. State principle of reversibility of light. Define lateral shift.

Ans.—Principle of reversibility of light—If the path of a ray of light is reversed after suffering a no. of reflections and phenomena is called principle of reversibility of light. Briefly we may say that—“The path of a ray of light is reversible.”

Lateral shift—The \perp distance between the direction of incident ray and the emergent ray is known as the lateral shift.

11. Explain briefly—

(a) WWW

(b) FAX

Ans.—(a) WWW—It stands for world wide web. It is a collection of static and dynamic web pages containing information (text, pictures, videos, graphics etc) for sharing with others.

(b) FAX—It stands for facsimile telegraphy. In this form of communication, electronic copy of a document is sent to distant places. The original written document is converted into transmittable codes at the sending end. These codes are converted back into a copy of the original document at the receiving end.

SECTION-II (NON-OBJECTIVE TYPE QUESTIONS)

Question Nos. 12 to 15 are of long answer type. Answer must be explanatory and in your own language.
Each question carries 5 marks.

$4 \times 5 = 20$

LONG QUESTIONS

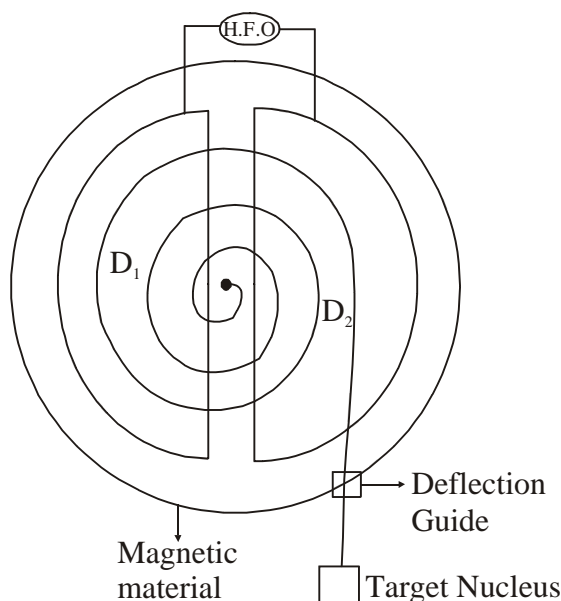
12. With the help of neat and labelled diagram explain the working of cyclotron. Deduce an expression for time period, frequency and total energy.

Ans.—Cyclotron—Cyclotron is a device which is used to accelerate positive charged particle such as proton, α -particle, electron etc. to acquire sufficient, amount of energy to carry out nuclear disintegration reaction.

Principle—

It is the particle application of cross-field. Cross field is that field in which electric field is perpendicular to the magnetic field.

Construction—



Let us consider a follow metallic chamber D_1 and D_2 . D_1 is called left D and D_2 is called right D. Both the dees are convert through high frequency oscillator called HFO.

The main function of HFO is to control the acceleration of positive charge partide. In follow space magnetic material is filled which produce the magnetic field.

Theory—

Necessary centripetal force is provided by lorentz magnetic force.

$$= F_c = f_b \quad \dots(1)$$

$$= \frac{mv^2}{r} = qvB \sin \theta \quad \dots(2)$$

$$\theta = 90^\circ$$

$$= \frac{mv^2}{r} = qvB \sin 90^\circ$$

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

$$= \boxed{v = \frac{qBr}{m}} \quad \dots(3)$$

For Dec—

$$(1) \quad \text{Time} = \frac{\text{Distance}}{\text{Speed}} = \frac{\pi r}{v} = \frac{\pi m}{qB}$$

$$\therefore \boxed{\text{Time} = \frac{\pi m}{qB}} \quad \dots(5)$$

2. **Time period**—The total time taken by the charge particle to cross both the dees,

$$T = 2t \quad \dots(6)$$

Using Eqn (5)

$$\boxed{T = \frac{2\pi m}{qB}} \quad \dots(7)$$

Eqn (7) is the general expression for time period of cyclotron.

3. **Cyclotron frequency (ν)**—

The recipycal of time period is called cyclotron's frequency (ν). It is represented by (ν).

Using Eqn (7)

$$= \nu = \frac{1}{T} \quad \dots(8)$$

Using in Eqn (7)

$$\boxed{\nu = \frac{qB}{2\pi m}} \quad \dots(9)$$

Eqn (9) is the general Eqn for cyclotron's frequency

4. **Cyclotron's singal frequency**—

It can be defined as,

$$W = \frac{2\pi}{T} \quad \dots(10)$$

$$W = e_{\pi} \times \frac{1}{T} \quad \dots(11)$$

$$W = 2\pi v \quad \dots(12)$$

Using Eqⁿ (9)

$$= W = 2\pi \times \frac{9B}{2\pi m}$$

$$= \boxed{W = \frac{9B}{m}} \quad \dots(13)$$

5. Total energy acquired by charge particle—Since charge particle in motion, therefore it possess only kinetic energy.

$$E = K \cdot E = \frac{1}{2}mv^2 \quad \dots(14)$$

Using in Eqⁿ (4)

$$= E = \frac{1}{2}m \left(\frac{9Br}{m} \right)^2$$

$$= E = \frac{1}{2}m \frac{9^2 B^2 r^2}{m^2}$$

$$= \boxed{E = \frac{9^2 B^2 r^2}{2m^2}} \quad \dots(15)$$

For Max^m energy of charged particle radius must be Max^m.

$$\boxed{E_{\max} = \frac{1}{2} \frac{9^2 B^2 r_{\max}^2}{m}} \quad \dots(16)$$

Hence, energy of particle is maximum of periphery.

Limitation of cyclotron—

1. Cyclotron cannot accelerate uncharged particle such as Neutron.
2. Cyclotron cannot accelerate negative charge particle such as Electron.
3. Cyclotron cannot accelerate positive charge particle having larger mass.

13. Define Potentiometer. With the help of potentiometer compare the e.m.f.s of two cells and measure internal resistance of the cell ?

Ans.—Potentiometer—Potentiometer is a device which is used to compare the emf of two cells and its used to measure the internal resistance of the cell.

Principle—

- (i) Potentiometer wire should be of uniform area of cross-section.
- (ii) Electric current passed through the wire must be constant.

Theory— Using Ohm's law.

$$V = IR \quad \dots(1)$$

But, $R = \int \frac{l}{A}$... (2)

$$\therefore V = \frac{I \int l}{A} \quad \dots(3)$$

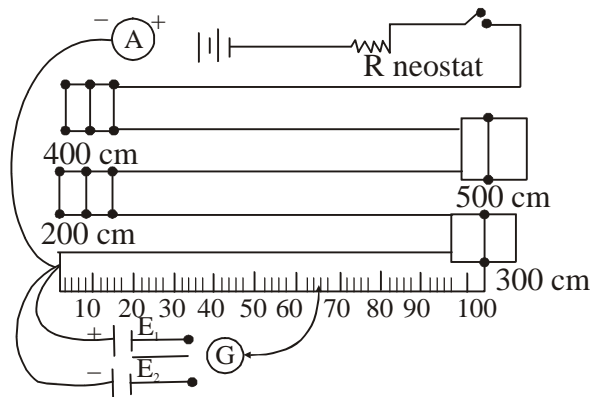
$\therefore \rho, I$ and A is constant

$\therefore V \propto l$

...(4)

The potential difference between two terminals of the wire is directly proportional to the length of the wire.

1. Compare the emf of two cell—



Working—

Potentiometer of wire of length 5 metre is attached with the scale Galvanometer. Then it is called balanced point. If one way key (k) is connected with cell of e.m.f. E_1 jockey is working. Its balanced point is G.

If one way (k_2) is connected with cell of e.m.f. E_0 jockey 'J' is working. Its balanced point is Driver's battery E is used to determine the balanced point.

Rheostat is a variable resistance.

According to the theory of potentiometer for first cell.

$$E_1 \propto l_1 \quad \dots(5)$$

$$\therefore E_1 = kl_1 \quad \dots(6)$$

For second cell

$$E_2 \propto l_2 \quad \dots(7)$$

$$E_2 = kl_2 \quad \dots(8)$$

According equation (6) by (7)

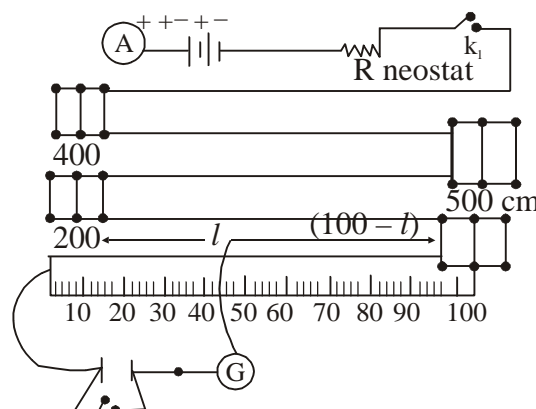
$$\frac{E_1}{E_2} = \frac{kl_1}{kl_2}$$

$$\frac{E_1}{E_2} = \frac{l_1}{l_2} \quad \dots(9)$$

Conclusion—

By knowing the length for null deflection or balanced points, E.m.f. of two cells can be easily compared.

II. To measure the internal resistance of the cell—



Working—Potentiometer of wire 5 metre is attached with the scale. Driver's battery is used to determine the balanced point or null deflection. If k_2 is open Emf of the cell can be measured. In case of E.m.f jockey I is working its balance point is l_1 .

If k_2 is closed terminal voltage of the cell is applied its null deflection or balanced point is l_2 . In case of close key (k_2) jockey 'J' is working.

Expression

According to the theory of potentiometer
for open circuit.

$$\epsilon \propto l_1 \quad \dots(5)$$

$$\epsilon \propto k l_1 \quad \dots(6)$$

for closed circuit

$$v \propto l_2 \quad \dots(7)$$

$$v \propto k l_2 \quad \dots(8)$$

Dividing equating (6) by (8)

$$\frac{\epsilon}{v} = \frac{k l_1}{k l_2}$$

$$\frac{\epsilon}{v} = \frac{l_1}{l_2} \dots(9)$$

By definition of E.m.f.

$$\epsilon = V + IR \quad \dots(10)$$

Dividing equation (10) by V

$$\frac{\epsilon}{v} = \frac{v}{v} + \frac{IR}{V}$$

$$\frac{\epsilon}{v} = 1 + \frac{r}{R}$$

$$\frac{r}{R} = \left(\frac{\epsilon}{v} - 1 \right) \quad \dots(11)$$

$$r = \left(\frac{\epsilon}{v} - 1 \right) R \quad \dots(12)$$

Where

$$\frac{r}{R} = \frac{\text{Internal resistance}}{\text{External resistance}}$$

By equation (9)

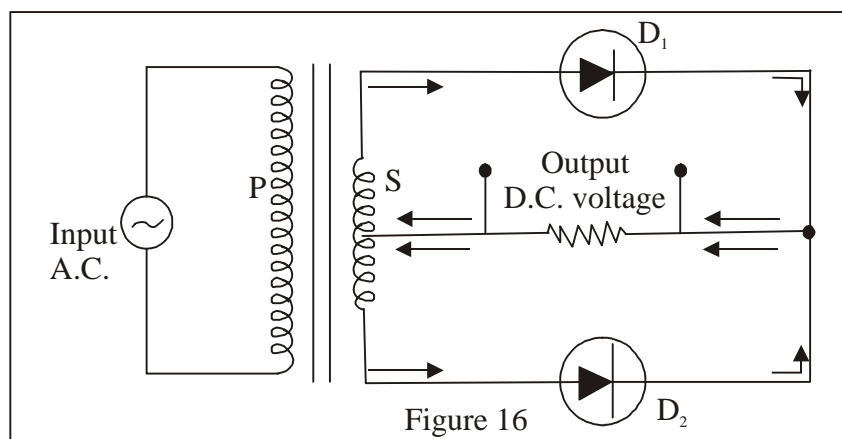
$$r = \left(\frac{l_1}{l_2} - 1 \right) R$$

Hence, by knowing the length of balanced point internal resistance of a cell can be easily determine with the help of potentiometer.

14. Explain p-n junction diode as a full wave rectifier ?

Ans.—Junction Diode as a full wave rectifier—Full wave rectifier rectifies both halves of a.c. input signal.

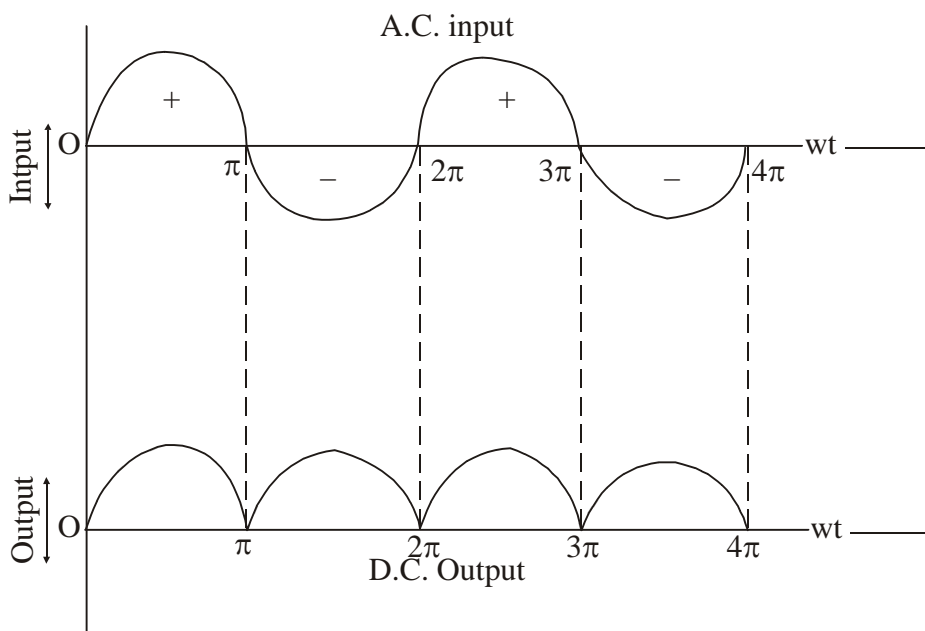
The circuit diagram of full wave rectifier as show in figure 16.



The a.c. input signal is fed to the primary (p) coil of the transformer. The p-regions of both the diodes D_1 and D_2 are connected to the two ends of the secondary coil (s). The load resistance R_L across which output voltage is obtained is connected between common point of n regions of diodes and central tapping of the secondary coil.

Working—When positive half cycle of input a.c. signal flows through the primary coil, induced e.m.f. is set up in the secondary coil due to mutual induction. The direction of induced e.m.f. is such that the upper end of the secondary coil becomes positive while the lower end becomes negative. Thus, D_1 is forward biased and diode D_2 is reverse biased, So the current due to diode D_1 flows through the output voltage which varies in accordance with the input half cycle is obtained across the load resistance (R_L).

During negative half cycle of input a.c. signal, diode D_1 is reverse biased and diode D_2 is forward biased. The current due to diode D_2 flows through the circuit in a direction shown by arrows (below R_L). The output voltage is obtained across the load resistance (R_L).

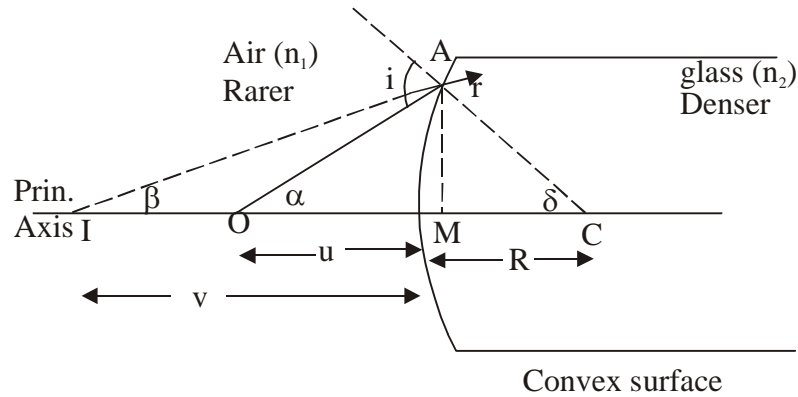


15. For virtual image, prove the relation

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

Ans.—Refraction through convex surface—Virtual image Assumption—

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



In ΔOAC
 $i = \alpha + \delta$... (1)

For smaller angle,

$$\left. \begin{aligned} \alpha &\approx \tan \alpha \\ \delta &\approx \tan \delta \end{aligned} \right\} \dots (2)$$

$\therefore i = \tan \alpha + \tan \delta$... (3)

In ΔOAM

$$\tan \alpha = \frac{AM}{MO} \dots (4)$$

But, $MO = PO$... (5)

$$\therefore \tan \alpha = \frac{AM}{PO} \dots (6)$$

In ΔACM

$$\tan \alpha = \frac{AM}{MC} \dots (7)$$

But, $MC = PC$... (8)

$$\therefore \tan \alpha = \frac{AM}{PC} \dots (9)$$

Using in eqⁿ (3)

$$\therefore i = \left(\frac{AM}{PO} + \frac{AM}{PC} \right) \dots (10)$$

In ΔIAC

$$r = \beta + \delta \dots (11)$$

For smaller angle,

$$\left. \begin{aligned} \alpha &\approx \tan \beta \\ \delta &\approx \tan \delta \end{aligned} \right\} \dots (12)$$

$$\therefore r = \tan \beta + \tan \delta \dots (13)$$

In $\triangle IAM$

$$\tan \beta = \frac{AM}{MI} \quad \dots(14)$$

But $MI = PI$...(15)

$$\therefore \tan \beta = \frac{AM}{PI}$$

Using in eqⁿ (13)

$$\boxed{r = \left(\frac{AM}{PI} + \frac{AM}{PC} \right)} \quad \dots(17)$$

Using Snell's law

$$\frac{\sin i}{\sin r} = \frac{n_2}{n_1} \quad \dots(18)$$

For smaller angle,

$$\left[\begin{array}{l} \sin i \simeq i \\ \sin r \simeq r \end{array} \right] \quad \dots(19)$$

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

$$n_1 i = n_2 r \quad \dots(20)$$

Using eqn (10) + (17)

$$n_1 \left(\frac{AM}{PO} + \frac{AM}{PC} \right) = n_2 \left(\frac{AM}{PI} + \frac{AM}{PC} \right)$$

$$n_1 \left(\frac{1}{PO} + \frac{1}{PC} \right) = n_2 \left(\frac{1}{PI} + \frac{1}{PC} \right)$$

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

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

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

Using proper sign-convention,

$$\left[\begin{array}{l} PI = -v \\ PO = -u \\ PC = R \end{array} \right] \quad \dots(22)$$

$$\therefore \boxed{\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}} \quad \dots(23)$$

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. Write two basic properties of electric charge.

Ans.—Two basic properties of charge are as follows—

(1) Quantization of electric charge—It is the property of an electric charge by virtue of which any charged body can have charge which is an integral multiple of the basic charge 'e'.

$$q = \pm ne$$

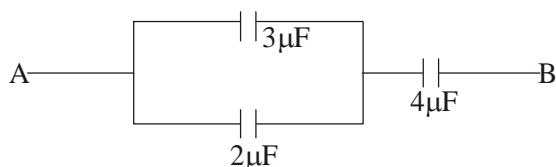
(2) Conservation of electric charge—Total charge in an isolated system remains conserved. Charges appear in pair of equal and opposite sign.

2. State superposition principle. Give its one importance.

Ans.—**Superposition principle**—It states that—“Total force acting on a given point charge due to a number of point charge around it is the vector sum of the individual forces acting that point charge due to all other point charges.”

By using the principle of superposition, we can apply coulomb's law to any collection of point charges.

3. Calculate the equivalent capacitance between A and B.



Ans.—As $2\mu F$ and $3\mu F$ are in parallel, so their equivalent capacitance is given by—

$$\begin{aligned} C_p &= C_1 + C_2 \\ C_p &= 3\mu F + 2\mu F \\ C_p &= 5\mu F \end{aligned}$$

Then, $5\mu F$ and $4\mu F$ are in series, so the equivalent capacitance between A and B is—

$$\frac{1}{C_s} = \frac{1}{5\mu F} + \frac{1}{4\mu F}$$

$$\frac{1}{C_s} = \frac{4+5}{20} = \frac{9}{20}$$

$$C_s = \frac{20}{9} \mu F = 2.3\mu F$$

4. Mention two factors on which resistivity depends.

Ans.—Two factors on which resistivity depends are as follows—

(1) It depends on the nature of the material of the conductor.

(2) It depends on the temp. of the conductor.

5. Mention different uses of cyclotron.

Ans.—Uses of cyclotron are as follows—

- (1) It is used to produce radioactive material for medical purposes.
- (2) It is used to bombard the atomic nuclei with highly accelerated particles to study the nuclear reactions.
- (3) It is used to improve the quality of solids by adding ions.

6. What is Shunt ?

Ans.—Shunt is a low resistance connected in parallel with coil of galvanometer. Due to low resistance maximum current by passes through it so there is no jerk on the coil. Since galvanometer and shunt are parallel to each other.

$$\text{So, } I_g \cdot G = I_s \cdot S$$

$$\text{or, } \frac{S}{G} = \frac{I_g}{I_s}$$

$$\text{or, } \frac{S}{G} + 1 = \frac{I_g}{I_s} + 1$$

$$\text{or, } \frac{S+G}{G} = \frac{I_g + I_s}{I_s}$$

$$\text{or, } I_s (S + G) = G (I_g + I_s)$$

$$\therefore I = I_g + I_s$$

$$\text{So, } I_s (S + G) = G \times I$$

$$\therefore I_s = \frac{IG}{S + G}$$

So, shunt resistance can be expressed as,

$$S = \left(\frac{I_g}{I - I_g} \right) G$$

7. What are eddy currents ?

Ans.—In 1875, Forcault observed that when a metal piece is kept in variable magnetic field, current are always induced in the plate which is of whirling nature. They are called eddy currents or Forcault's current. Core of transformer is laminated to prevent the induction of these currents. They are used to made moving coil galvanometer dead beat. The direction of eddy currents is given by Lenz's law.

8. Define power of Lens. Write its S.I. unit.

Ans.—Power of Lens—The power of a lens is defined as the reciprocal of its focal length in meters.

$$P = \frac{1}{f(\text{in metre})}$$

The S.I. unit of power of lens is 'diopetre' (D).

9. What are the necessary conditions for obtaining pure spectrum ?

Ans.—For obtaining pure spectrum following conditions should be satisfied—

- (1) Slit should be narrow,
- (2) Rays coming out from convex lens should have parallel incidence,
- (3) Prism should be in condition of minimum deviation,

- (4) Emerging light rays should be focussed by achromatic lens.

10. Mention applications of Laser technology ?

Ans.—Following are the applications of laser technology—

- (1) It is used in industry,
- (2) It is used in surgery,
- (3) It is used in communication,
- (4) It is used in making holograms,
- (5) It is used in scientific research.

11. Mention the advantages of 'LED' ?

Ans.—Following are the advantages of LED—

- (1) Light emitting diodes are easily manufactured,
- (2) LEDs have low cost,
- (3) LED works at low voltage as compared to the incandescent bulb,
- (4) No warm up time is taken by them,
- (5) They can emit monochromatic light as well as bright light.

SECTION-II (NON-OBJECTIVE TYPE QUESTIONS)

Question Nos. 12 to 15 are of long answer type. Answer must be explanatory and in your own language.
Each question carries 5 marks.

$4 \times 5 = 20$

LONG QUESTIONS

12. Draw a neat and labelled diagram of human eye. Discuss the various types of defect of vision briefly ?

Ans.—The human eye is called defected eye which may be due to old age, biological change or any other reason. It can be corrected then the eye is called corrected eye.

Following are the importance defects of vision—

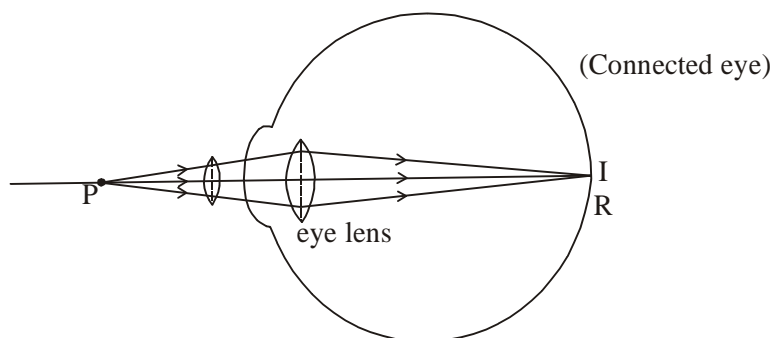
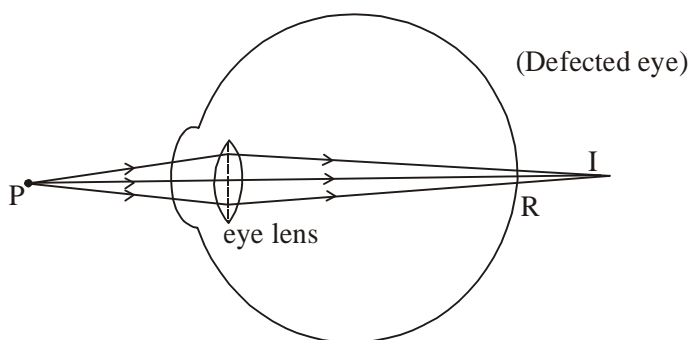
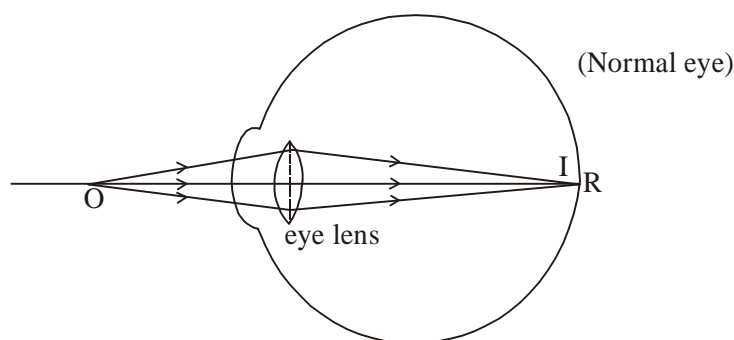
(1) **Hypermetropia**—(or longsightedness or farsightedness), The human eye is said to be hypermetropic if it can see the far objects clearly but cannot see near objects clearly and distinctly.

Cause—

(a) It is due to increase in focal length of eye lens.

(b) Decrease in the size of eye ball.

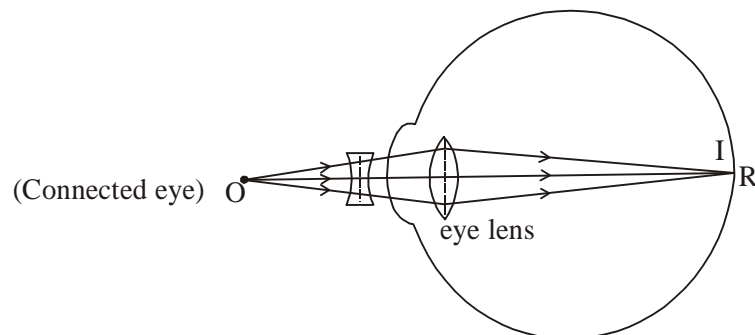
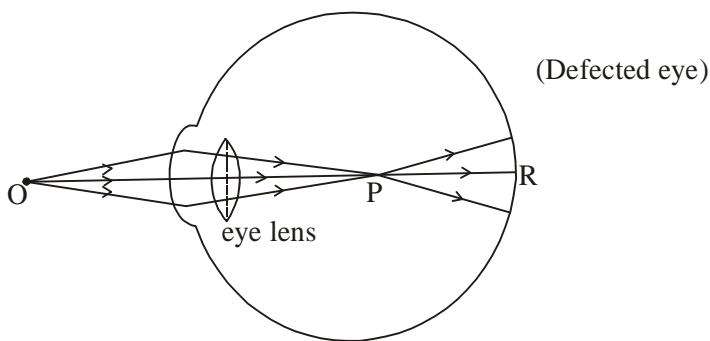
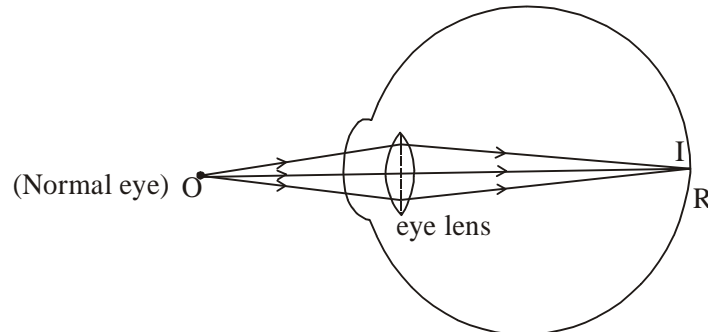
Correction—It is corrected by convex lens.



2. Myopia—The human eye is said to be myopia if it can see the near object clearly and distinctly but can not see the far objects clearly and distinctly.

Cause—The defect arises due to elongation of the eye ball or excessive curvature of cornea.

Correction—It is corrected by concave lens.



3. Presbyopia—(or old sight) The human eye is said to be presbyopic if it can not see near objects as well as far objects clearly and distinctly.

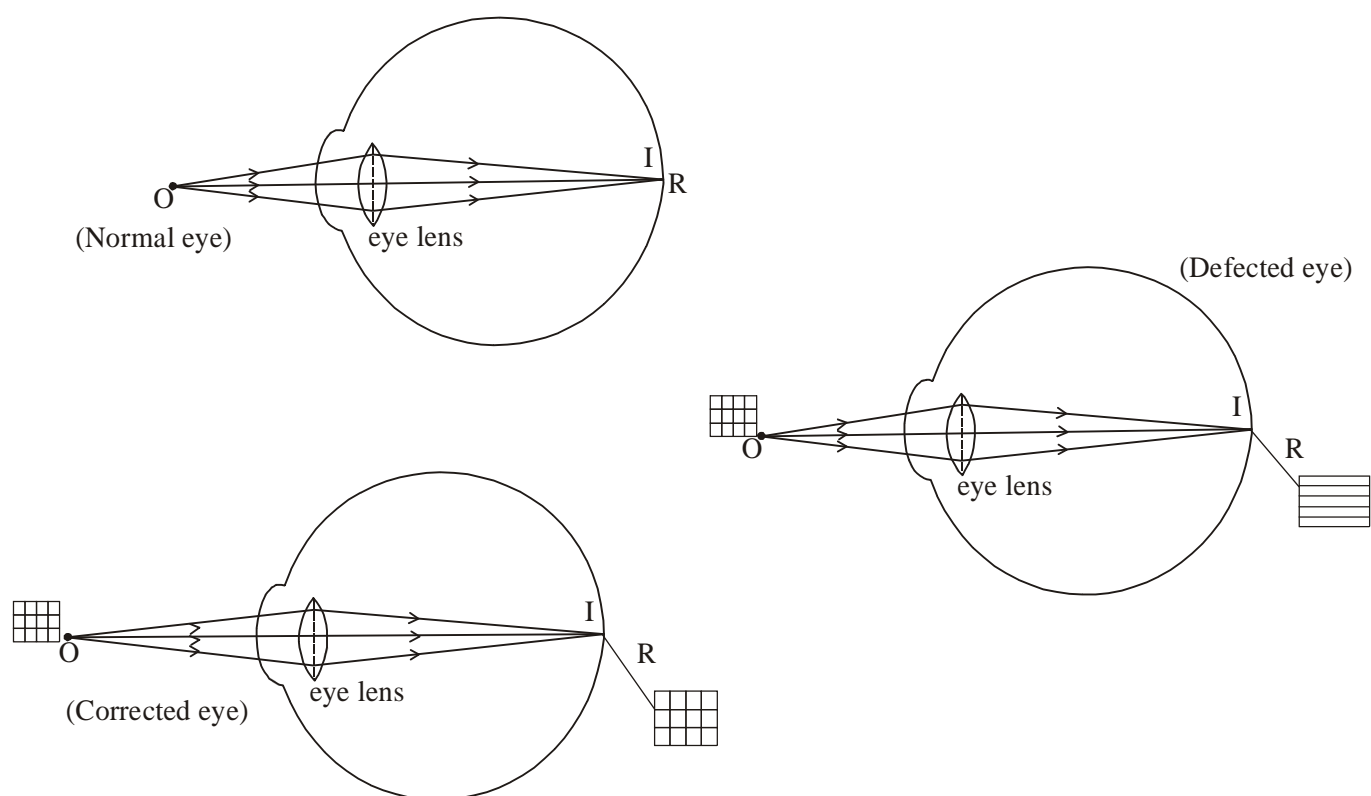
Cause—It is due to the weakened strength of ciliary muscles.

Correction—It is corrected by “bifocal lens”. Upper part is concave lens & power part is convex lens.

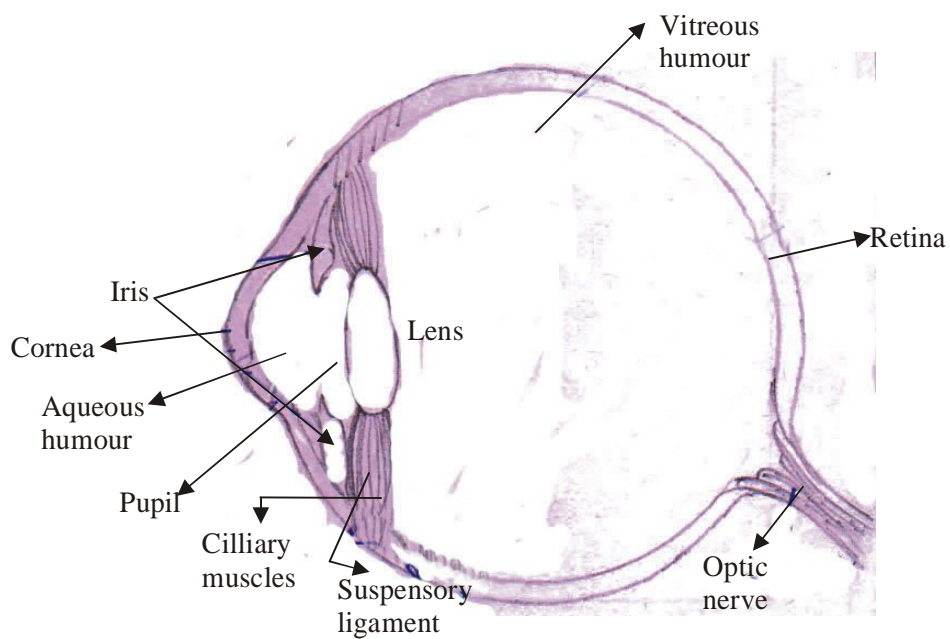
4. Astigmatism—The human eye is said to be astigmatic if horizontal lines and verticle can not be distinguished at the same time.

Cause—The defect arises due to different curvature in different direction of cornea.

Correction—It is corrected by cylindrical lens.



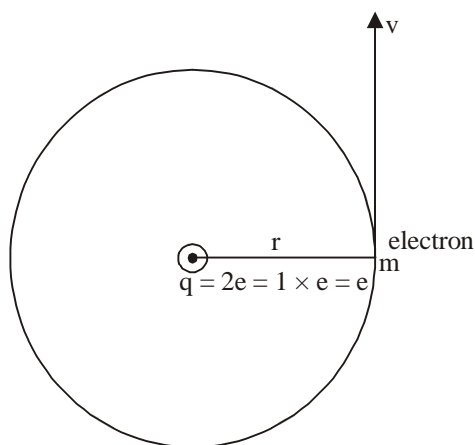
CONSTRUCTION OF AN HUMAN EYE



13. Explain Bohr's atomic model for hydrogen atom. Calculate its radius, velocity and energy.

Ans.—

Bohr's atomic model for hydrogen atom



Electron moves in hydrogen atom in a circular path the necessary centripetal force is provided by electrostatic force between electron & proton.

$$F_C = F_E$$

$$\frac{mv^2}{r} = \frac{kq_1q_2}{r^2}$$

$$mv^2 = \frac{k \cdot q_1q_2}{r}$$

But, $q_1 = e$

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

$q_2 = e$

$$\boxed{r = \frac{ke^2}{mv^2}}$$

1. Calculation of radius—According to Bohr's third postulate, only those orbits are said to be stationary and discrete for which angular momentum is an integral multiple of $\frac{h}{2\pi}$.

From eqn. (3) $mvr = \frac{nh}{2\pi}$ or $v = \frac{nh}{2\pi mr}$... (7)

Using in eqn. (6)

$$r = \frac{ke^2 \cdot 4\pi^2 m^2 r^2}{m \cdot n^2 \cdot h^2}$$

$$4\pi^2 mke^2 \cdot r = n^2 h^2$$

$$\therefore r = \left(\frac{h^2}{4\pi^2 mke^2} \right) n^2 \quad \dots (8)$$

For nth orbit—

$$\therefore r_n = \left(\frac{h^2}{4\pi^2 m k e^2} \right) n^2$$

Where, $h = 6.626 \times 10^{-34} \text{ Js}$
 $\pi = 3.14$
 $m = 9.1 \times 10^{-31} \text{ kg}$
 $k = 9 \times 10^9 \text{ Nm}^2\text{C}^{-2}$
 $C = 1.6 \times 10^{-19} \text{ C}$

2. Calculation of velocity—According to Bohr's third postulate only those orbits are said to be stationary

and discrete for which angular momentum is as integral multiple of $\frac{h}{2\pi}$

From eqn (7) $V = \frac{nh}{2\pi m r}$

Using in eqn (7)

$$V = \frac{nh \times 4\pi^2 m k e^2}{2\pi m \cdot h^2 n^2}$$

$$V = \left(\frac{2\pi k e^2}{n} \right) \cdot \frac{1}{h}$$

For nth orbit

$$\therefore V_n = \left(\frac{2\pi k e^2}{n} \right) \cdot \frac{1}{h}$$

Where, $k = 9 \times 10^9 \text{ Nm}^2\text{C}^{-2}$
 $c = 1.6 \times 10^{-19}$
 $h = 6.626 \times 10^{-34}$

Using in eqn (9)

$$V_n = \frac{2 \times 3.14 \times 9 \times 10^9 \times (1.6 \times 10^{-19})^2}{6.626 \times 10^{-34}} \cdot \frac{1}{n}$$

$$r_n = \frac{(6.626 \times 10^{-34})^2}{4 \times (3.14)^2 \times 9.1 \times 10^{-31} \times 9 \times 10^9 \times (1.6 \times 10^{-19})^2} \cdot n^2$$

$$r_n = (0.529 \times 10^{-10}) n^2$$

$$r_n = (0.53) n^2 \text{ Å}$$

...(8)

If $n = 1$, then it is called Bohr's radius which is represented by r_o .

$$r_o = 0.53 \text{ Å}$$

Using in eqn (8)

$$r_n = r_o \cdot n^2$$

$$\therefore r_n \propto n^2$$

$$r_1 = (0.53)n^2 = 0.53 \times (1)^2 = 0.53$$

$$r_2 = (0.53)n^2 = 0.53 \times (2)^2 = 2.12$$

$$r_3 = (0.53)n^2 = 0.53 \times (3)^2 = 4.77$$

$$r_4 = (0.53)n^2 = 0.53 \times (4)^2 = 8.48$$

$$r_5 = (0.53)n^2 = 0.53 \times (5)^2 = 36.25$$

$$V_n = (21.84 \times 10^5) \times \frac{1}{n}$$

$$V_n = 2.18 \times 10^6 \times \frac{1}{n}$$

If ($n = 1$) n is equal to 1, then it is called Bohr's velocity.

$$V_o = 21.84 \times 10^5 \text{ m/s}$$

In term of Bohr's velocity the above eqn. can be written as,

$$\boxed{V_n = \frac{V_o}{n}} \quad \therefore \quad \boxed{V_n \propto \frac{1}{n}}$$

$$\therefore V_1 = \frac{V_o}{n} = \frac{21.84 \times 10^5}{1} = 21.84 \times 10^5 \text{ m/s}$$

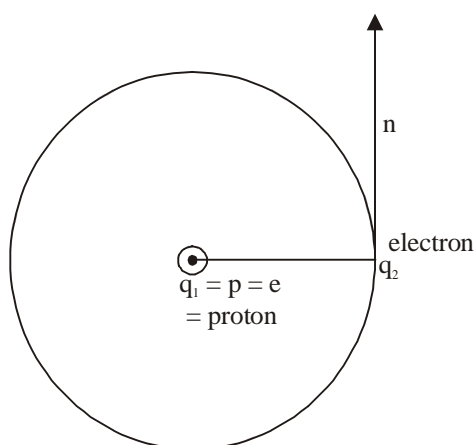
$$V_2 = \frac{V_o}{n} = \frac{21.84 \times 10^5}{2} = 10.92 \times 10^5 \text{ m/s}$$

$$V_3 = \frac{V_o}{n} = \frac{21.84 \times 10^5}{3} = 7.28 \times 10^5 \text{ m/s}$$

$$V_4 = \frac{V_o}{n} = \frac{21.84 \times 10^5}{4} = 5.46 \times 10^5 \text{ m/s}$$

$$V_5 = \frac{V_o}{n} = \frac{21.84 \times 10^5}{5} = 4.36 \times 10^5 \text{ m/s}$$

3. Calculation of energy—



The revolving electron possess both types of energy i.e kinetic energy as well as potential energy.

$$E = K \cdot E + E \cdot P E$$

...(1)

The necessary centripetal force is provided by electrostatic force

$$F_C = F_E$$

$$\frac{mv^2}{r} = \frac{k \cdot q_1 q_2}{r^2}$$

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

But, $K \cdot E = \frac{1}{2}mv^2$

$$K \cdot E = \frac{1}{2} \cdot \frac{ke^2}{r}$$

Electrostatic potential energy

$$E \cdot P \cdot E = \frac{k \cdot q_1 q_2}{r}$$

$$E \cdot P \cdot E = \frac{k e(-e)}{r}$$

$$E \cdot P \cdot E = \frac{-ke^2}{r}$$

Using in eqn (1)

$$E = \frac{1}{2} \frac{ke^2}{r} - \frac{ke^2}{r}$$

For nth orbit

$$\therefore \boxed{E_n = \frac{-ke^2}{2r_n}}$$

But, $r_n = \frac{n^2 h^2}{4\pi^2 m k e^2}$

Using in above eqn.

$$E_n = \frac{-4\pi^2 \cdot k^2 e^4 m}{2r^2 h^2}$$

$$\therefore E_n = \frac{-2\pi^2 k^2 e^4 m}{n^2 h^2}$$

$$E_n = -\left(\frac{2\pi^2 k^2 e^4 m}{h^2}\right) \cdot \frac{1}{n^2}$$

Where, $\pi = 3.14$
 $k = 9 \times 10^9 \text{ Nm}^2\text{C}^{-2}$
 $e = 1.6 \times 10^{-19} \text{ C}$
 $m = 9.1 \times 10^{-31} \text{ kg}$
 $h = 6.626 \times 10^{-34} \text{ Js}$

$$E_n = -\left(2 \times (3.14)^2 \times (9 \times 10^9) \times (1.6 \times 10^{-19})^4 \times 9.1 \times 10^{-31} \times 6.62 \times 10^{-34}\right) \cdot \frac{1}{n}$$

If $n = 1$, the corresponding energy is called Bohr's energy. It is represented by E_0 .

$$\therefore E_j = E_o = -13.6\text{eV}$$

In term of Bohr's energy

$$E_n = \frac{-13.6}{n^2} \text{eV}$$

$$\text{For } n = 1, E_1 = \frac{-13.6}{(1)^2} = -13.6\text{eV}$$

$$\text{For } n = 2, E_2 = \frac{-13.6}{(2)^2} = -3.4\text{eV}$$

$$\text{For } n = 3, E_3 = \frac{-13.6}{(3)^2} = -1.51\text{eV}$$

$$\text{For } n = 4, E_4 = \frac{-13.6}{(4)^2} = -0.85\text{eV}$$

$$\text{For } n = 5, E_5 = \frac{-13.6}{(5)^2} = -0.54\text{eV}$$

$$\text{Conclusion : (1) } E_k = \frac{ke^2}{2r}$$

$$(2) E \cdot P \cdot E = \frac{-ke^2}{r}$$

$$(3) E = \frac{-ke^2}{r}$$

14. For an alternating current find the expression for average power ?

Ans.—Power of Ac—The instantaneous power of DC circuit can be defined as the product of instantaneous emf and instantaneous current

Let us consider,

$$\varepsilon = \varepsilon_o \sin \omega t \quad \dots(1)$$

$$I = I_o \sin (\omega t + \phi) \quad \dots(2)$$

For AC small work done

$$d\omega = \varepsilon I dt \quad \dots(3)$$

$$\begin{aligned} d\omega &= \varepsilon_o \sin \omega t \cdot I_o \sin (\omega t + \phi) \cdot dt \\ &= d\omega = \varepsilon_o I_o \sin \omega t (\sin \omega t - \cos \phi + \cos \omega t + \sin \phi) dt \end{aligned} \quad \dots(4)$$

Total work done during complete cycle of AC,

$$w = \int_0^T dw \quad \dots(5)$$

Using Eqn (4)

$$w = \int_0^T \varepsilon_o I_o \sin \omega t \cdot \cos \phi dt + \int_0^T \varepsilon_o I_o \sin \omega t \cos \omega t \sin \phi dt$$

$$w = \varepsilon_o I_o \cos \phi \int_0^T \sin^2 \omega t dt + \varepsilon_o I_o \sin \phi \int_0^T \sin \omega t \cos \omega t dt$$

Let us consider,

$$= I_1 \int_0^T \sin^2 \omega t dt \quad \dots(6)$$

$$= I_2 \int_0^I \sin wt \cdot \cos wt \, dt \quad \dots(7)$$

$$I_1 = \int_0^I \sin wt \, dt \quad \dots(8)$$

$$= \int_0^I \frac{(1 - \cos wt)}{w} \, dt$$

$$= \int_0^I \frac{1}{w} \, dt - \int_0^I \frac{\cos 2wt}{2} \, dt$$

$$= I_1 = \frac{1}{w} [I - 0] - \frac{1}{4w} [\sin 2wt]_0^I \quad \dots(9)$$

But $w = \frac{2\pi}{T}$... (10)

$$= I_1 = \frac{T}{2} - \frac{T}{2\pi} \left[\sin \frac{4\pi}{T} \cdot t \right]_0^T$$

$$= I_1 = \frac{T}{2} - \frac{T}{2\pi} [\sin 4\pi - \sin 0]$$

$$= I_1 = \frac{T}{2} - \frac{T}{2\pi} [0 - 0]$$

$$\boxed{I_1 = \frac{T}{2}}$$

... (11)

$$I_2 = \int_0^T \sin wt \cos wt \, dt \quad \dots(12)$$

$$= \int_0^T \frac{2 \sin wt \cos wt}{2} \, dt$$

$$= \int_0^T \sin 2wt \, dt$$

$$= \frac{1}{2} \left[\frac{-\cos 2wt}{2w} \right]_0^T$$

$$= \frac{1}{2 \times 2w} [-\cos 2w \times T + \cos 2w \times 0]$$

$$= \frac{1}{4w} \left[-\cos \frac{2 \times 2\pi}{T} \times T + \cos 0 \right]$$

$$= \frac{1}{4w} [-\cos 4\pi + 1] = \frac{1}{4w} [-1 + 1] = \frac{1}{400} [0]$$

$$\boxed{I_2 = 0}$$

... (15)

Putting the value of I_1 & I_2 in Eqn. (5)

$$= w = \epsilon_0 I_0 \cos \phi \cdot \frac{T}{2} + \epsilon_0 I_0 \sin \phi \times 0$$

$$= \boxed{w = \frac{\varepsilon_0 I_0 \cos \phi}{2} T} \quad \dots(16)$$

Therefore, Average power of AC circuit,

$$P_{ave} = \frac{w}{T} \quad \dots(17)$$

Using in Eqn (16)

$$\begin{aligned} P_{ave} &= \varepsilon_0 I_0 \frac{\cos \phi T}{2T} \\ &= P_{ave} = \varepsilon_0 I_0 \frac{\cos \phi}{2} \end{aligned} \quad \dots(18)$$

$$= P_{ave} = \frac{\varepsilon_0}{\sqrt{2}} \cdot \frac{I_0}{\sqrt{2}} \cos \phi \quad \dots(19)$$

Where, $\frac{\varepsilon_0}{\sqrt{2}} = \varepsilon_r$

$$\frac{I_0}{\sqrt{2}} = I_v \quad \dots(20)$$

Using in Eqn (19)

$$\boxed{P_{ave} = \varepsilon_r \cdot I_v \cos \phi}$$

Where, ε_r I_v = virtuos power

$\cos \phi$ = power factor ... (22)

$$\therefore \boxed{P_{ave} = \text{virtual power} \times \text{power factor}}$$

15. Define amplitude modulation and discuss the production of amplitude modulation.

Ans.—AMPLITUDE MODULATION (AM)—The process of sending of low signal from transmitter to receiver with the help of carrier signal by increasing its amplitude without loss of signal in the channel or link is called Amplitude Modulation (AM).

Modulation signal as a function of time

$$m(t) = A_m \sin \omega_m t \quad \dots(i)$$

Where, A_m = Amplitude of modulated wave.

ω_m = Angular frequency of modulated wave.

$$\omega_m = 2\pi \nu_m$$

Similarly, carrier signal as a function of time

$$c(t) = A_c \sin \omega_c t \quad \dots(ii)$$

Where, A_c = Amplitude of carrier wave

ω_c = Angular frequency of carrier wave

$$\omega_c = 2\pi \nu_c$$

Carrier modulated wave as a function of time.

$$C_m(t) = (A_c + A_m \sin \omega_m t) \sin \omega_c t \quad \dots(iii)$$

$$C_m(t) = A_c \left[1 + \left(\frac{A_m}{A_c} \right) \sin \omega_m t \right] \cdot \sin \omega_c t \quad \dots(iv)$$

$$\text{Where, } \frac{A_m}{A_c} = \text{modulation Index} = \mu \quad \dots(v)$$

Modulation Index is the ratio of amplitude of modulated wave to the amplitude of carrier wave. It has no unit and no dimension. It is a number because it is the ratio of two amplitudes.

for no distortion—

$$\boxed{\frac{A_m}{A_c} \leq 1}$$

i.e. $\boxed{\mu \leq 1}$...(vi)

using in eqn (iv)

$$cm(t) = A_c [1 + \mu \sin w_m t] \cdot \sin w_c t.$$

$$= [A_c + \mu A_c \sin w_m t] \cdot \sin w_c t$$

$$cm(t) = A_c \sin w_c t + \mu A_c \cdot \sin w_m t \sin w_c t \quad \dots(vii)$$

$$\therefore \sin A \cdot \sin B = \frac{1}{2} [\cos(A - B) - \cos(A + B)] \quad \dots(viii)$$

$$\therefore cm(t) = A_c \sin w_c t + \mu A_c \left(\frac{1}{2} \cos(w_c - w_m)t - \cos(w_c + w_m)t \right)$$

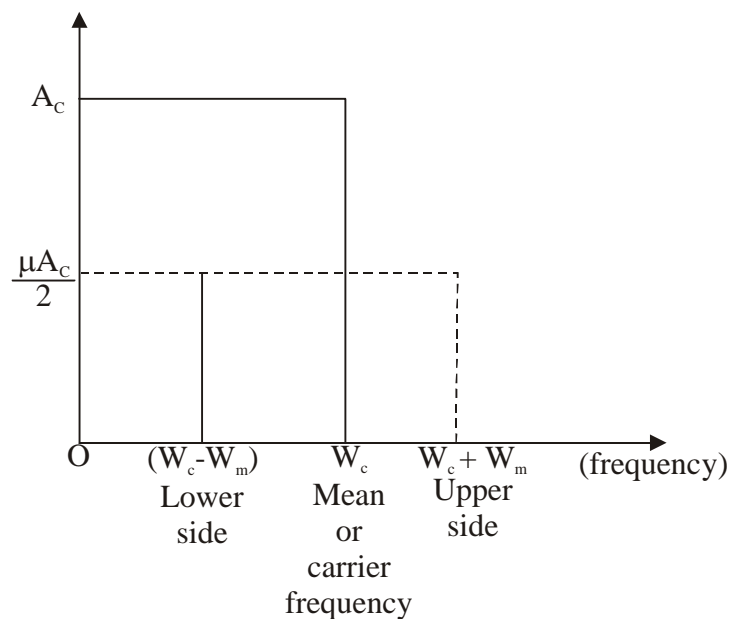
$$\therefore \boxed{cm(t) = A_c \sin w_c t + \frac{\mu A_c}{2} \cos(w_c - w_m)t - \frac{\mu A_c}{2} \cos(w_c + w_m)t} \quad \dots(ix)$$

Eqⁿ (ix) is the general eqⁿ for amplitude modulation.

$W_c - W_m$ = Lower side frequency

W_c = Frequency of carrier or mean frequency.

GRAPHICAL REPRESENTATION OF AMPLITUDE VERSUS FREQUENCY



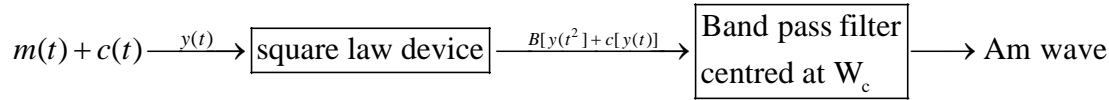
PRODUCTION OF AMPLITUDE MODULATED WAVE (AM WAVE)

There are variety of methods for production of amplitude modulated wave.

One of the famous method is square law device method (SLD method)

When a mixture of modulated wave and carrier wave passed through square law device followed by band pass filter concentration at W_c produced Am wave.

The block diagram of the Am wave can be expressed as



The modulated wave as a function of time and carrier wave as a function of time can be expressed as—

$$m(t) = A_m \sin w_m t \quad \dots(i)$$

$$c(t) = A_c \sin w_c t \quad \dots(ii)$$

The mixture of modulated wave and carrier wave is expressed by $y(t)$ and its SLD expression can be written as.

$$y(t) = m(t) + c(t) \quad \dots(iii)$$

Using eqⁿ (i) and (ii)

$$y(t) = [A_m \sin w_m t + A_c \sin w_c t] \quad \dots(iv)$$

$$y(t) \xrightarrow[\text{Square law device}]{\text{S.L.D.}} B[y(t)] + c[y(t)]^2 \quad \dots(v)$$

Where, B and C is + ve constants.

$$\begin{aligned} y(t) &\xrightarrow{} B [A_m \sin W_m t + A_c \sin W_c t] + C [A_m \sin W_m t + A_c \sin w_c t]^2 \\ &\xrightarrow{} B [A_m \sin W_m t + A_c \sin W_c t] + C [A_m^2 \sin^2 W_m t + A_c^2 \sin^2 W_c t + 2A_m A_c \sin W_c t \cdot \sin W_m t] \end{aligned} \quad \dots(vi)$$

$$\therefore \left[\begin{aligned} \sin^2 \theta &= \frac{1 - \cos \theta}{2} \\ \sin A \sin B &= \frac{1}{2} [\cos(A - B) + \cos(A + B)] \end{aligned} \right] \quad \dots(vii)$$

$$\begin{aligned} &\xrightarrow{} B A_m \sin W_m t + B A_c \sin W_c t + C \left[A_m^2 \left(\frac{1 - \cos 2W_m t}{2} \right) \right. \\ &\quad \left. + A_c^2 \left(\frac{1 - \cos 2W_m t}{2} \right) + 2A_m A_c \cos(W_c - W_m)t - \cos(W_c + W_m)t \right] \end{aligned}$$

$$\boxed{y(t) \xrightarrow{\text{S.L.D.}} B A_m \sin W_m t + B A_c \sin W_c t + \frac{C A_m^2}{2} - \frac{C A_m^2}{2} \cos 2W_m t + \frac{C A_c^2}{2} - \frac{C A_c^2}{2} \cos 2W_c t + A_m A_c \cos(W_c - W_m)t - A_m A_c \cos(W_c + W_m)t} \quad \dots(viii)$$

SECTION-II (NON-OBJECTIVE TYPE QUESTIONS)

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

$11 \times 2 = 22$

SHORT QUESTIONS

1. State two characters of Coulomb's force.

Ans.—Two characteristics of Coulomb's force are as follows—

1. Coulomb's force between two charges is a central force.
2. Coulomb's force between two charges obeys inverse square law.

2. State two properties of equipotential surfaces.

Ans.—Two properties of equipotential surface are as follows—

1. No work is done in moving a test charge from one point to another point on an equipotential surface.
2. The electric field is \perp to the equipotential surface.

3. Define electrostatic shielding. Mention the dimension of dielectric strength.

Ans.—Electrostatic shielding—The method of protecting a certain region from the effect of electric field is called electrostatic shielding.

Dimension of dielectric strength : $[MLT^{-3}A^{-1}]$

4. State Ohm's law. Give its mathematical expression.

Ans.—**Ohm's law**—“At constant temperature, current is directly proportional to its potential difference.”

Mathematical expression can be given as—

$$\boxed{V = IR} \text{ Where, } V \text{ represents potential difference; } I \text{ represents current and } R = \text{Resistance (constant).}$$

5. Which of the two has higher resistance : a 1000W heater or a 100 W tungsten bulb, both marked for 230V.

Ans.—As we know that,

$$\begin{aligned} \text{Resistance of heater, } R_H &= \frac{V^2}{P} \\ &= \frac{230 \times 230}{1000} = \frac{529}{10} = 52.9\Omega \end{aligned}$$

$$\text{Resistance of bulb, } R_B = \frac{230 \times 230}{1000} = 529 \Omega (\text{ohm's})$$

$$\boxed{R_B > R_H}$$

6. Write two uses of a potentiometer.

Ans.—Two uses of potentiometer are as follows—

1. It is used to compare the e.m.f.'s of two cells,
2. It is used to determine the internal resistance of the cell.

7. Write two uses of galvanometer.

Ans.—Two uses of galvanometer are as follows—

1. It is converted to an ammeter by connecting a low resistor parallel to it,
2. It is converted to a voltmeter by connecting a high resistance in series with it.

8. What do you mean by retentivity and coercivity.

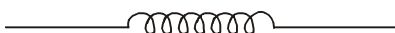
Ans.—Retentivity—It is the property of a magnetic material by which magnetism is left in the specimen even when magnetising field is reduced to zero.

Coercivity—It is the property of a magnetic material which depends upon reverse value of magnetising field required to reduce residual magnetism to zero.

9. Define inductor. Give its symbol.

Ans.—Inductor—An element of an electric circuit like a tightly wound coil of insulated wire which opposes the change in current flowing through it is called an inductor.

The symbol of an inductor in an electric circuit is shown as follows—



10. A radioactive element reduces to 25% of its initial mass in 1000 yrs. Find its half-life period.

Ans.—As we know that, Given that, $t = 1000$ yrs

$$\frac{N}{N_0} = \left(\frac{1}{2}\right)^{\frac{t}{T_1}} \quad \frac{N}{N_0} = \frac{25}{100} = \frac{1}{4}$$

$$\text{or,} \quad \left(\frac{1}{2}\right) = \left(\frac{1}{2}\right)^{\frac{t}{T_1}} \quad \frac{N}{N_0} = \left(\frac{1}{2}\right)^2$$

$$\text{or,} \quad \frac{t}{T_1} = \frac{2}{1}$$

$$\text{or,} \quad t = 2 \times \frac{T_1}{2} \therefore T_1 = \frac{t}{2} = \frac{1000}{2} = \frac{500}{2}$$

$$\boxed{\frac{T_1}{2} = 500 \text{ yrs}}$$

11. What is doping ? Why is it done ?

Ans.—Doping—The process of adding impurities in an intrinsic semiconductor is known as doping. It is done to increase the conductivity of a semiconductor even at low temperature.

SECTION-II (NON-OBJECTIVE TYPE QUESTIONS)

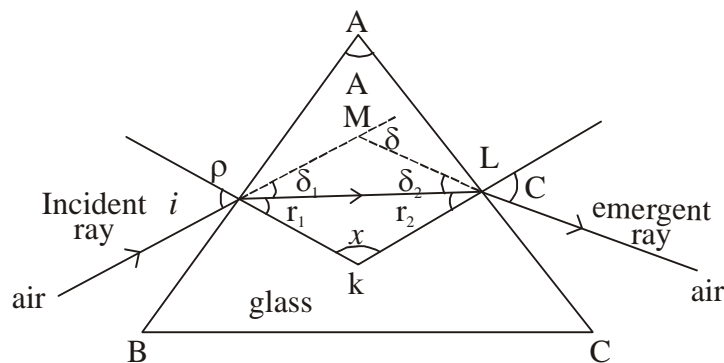
Question Nos. 12 to 15 are of long answer type. Answer must be explanatory and in your own language.
Each question carries 5 marks. $4 \times 5 = 20$

LONG QUESTIONS

12. For a Prism, explain deviation and establish the relation $\delta = A(n - 1)$.

Ans.—Deviation through Prism—

Angle of deviation produced by a prism is the angle between extended line on incident ray and emergent ray. It is represented by δ .



Snell's law for refracting surface AB—

$$\frac{\sin i}{\sin r} = n \quad \dots(1)$$

For smaller angle,

$$\left[\begin{array}{l} \sin i \approx i \\ \sin r_1 \approx r_1 \end{array} \right] \quad \dots(2)$$

$$\therefore \frac{i}{r_1} = n$$

$$\therefore \boxed{i = nr_1} \quad \dots(3)$$

Snell's law for refracting surface AC—

$$\frac{\sin e}{\sin r_2} = n \quad \dots(4)$$

For smaller angle,

$$\left[\begin{array}{l} \sin e \approx e \\ \sin r_2 \approx r_2 \end{array} \right] \quad \dots(5)$$

$$\therefore \frac{e}{r_2} = n$$

$$\boxed{e = nr_2} \quad \dots(6)$$

According to prism's relation,

$$i + e = \delta + A \quad \dots(7)$$

Using eqⁿ (3) & (4)

$$nr_1 + nr_2 = \delta + A$$

$$n(r_1 + r_2) = \delta + A \quad \dots(8)$$

But, $r_1 + r_2 = A$

$$\therefore n_A = \delta + A \quad \dots(9)$$

$$\delta = nA - A$$

$$\boxed{\delta = A \cdot (n - 1)} \quad \dots(10)$$

Conclusion—Angle of deviation produced by a prism is equal to angle of prism times refractive index minus unity.

13. Define self inductance. Derive an expression for it.

Ans.—Self Inductance—It is the property of a coil by the virtue of which it possesses the growth or decay of induced current in a single coil.

Mathematically,

Magnetic flux changes in the coil is directly proportional to the induced current produced in the coil.

$$\phi \propto I \quad \dots(1)$$

$$\phi = LI \quad \dots(2)$$

Where, L is a proportionality constant which is called self inductance.

$$L = \frac{\phi}{I} \quad \dots(3)$$

Hence, co-efficient of self-inductance is the ratio of flux changes in the coil to the induced current produced in the coil.

$$\text{If } I = 1 \text{ A} \quad \dots(4)$$

$$L = \phi \quad \dots(5)$$

Self Inductance of a single coil is numerically equal to flux changes in the coil, provided induced current provided in the coil is 1 ampere.

Using Faraday Second law,

$$\varepsilon = -\frac{d\phi}{dt} \quad \dots(6)$$

Using in eqⁿ 2

$$\varepsilon = \frac{-d}{dt} [LI]$$

$$\varepsilon = -L \frac{dI}{dt}$$

$$\boxed{L = \frac{\varepsilon}{\left(-\frac{dI}{dt}\right)}} \quad \dots(7)$$

Hence, self Inductance of a single coil is the ratio of induced emf produced in the coil to the ratio of loss of induced current with respect to time.

$$\frac{-dI}{dt} = 1 \text{ AS}^{-1}$$

$$L = \phi$$

Therefore, self inductance of a simple coil is numerically equal to induced emf produced in the coil provided ratio of induced current with respect to time is 1 AS^{-1} .

14. Explain Faraday's law of electromagnetic induction and discuss Lenz correction.

Ans.—Law of Electromagnetic Induction

1. First law—Whenever there is change in magnetic flux linked with the coil changes induced emf produced in the coil.

The induced emf lasts as long as the change in magnetic flux linked with the coil.

2. Second law—Rate of change of magnetic flux linked with the coil is directly proportional to the induced emf.

If ϕ_1 is the initial flux at t_1

If ϕ_2 is the final flux at t_2

$$\therefore \frac{\phi_2 - \phi_1}{t_2 - t_1} \propto \varepsilon \quad \dots(1)$$

$$\frac{\Delta\phi}{\Delta t} = K\varepsilon \quad \dots(2)$$

$$\text{For all practical purposes, } K = 1 \quad \dots(3)$$

$$\frac{\Delta\phi}{\Delta t} = \varepsilon \quad \dots(4)$$

For small time,

$$\Delta t_{\lim \rightarrow 0} \frac{\Delta\phi}{\Delta t} = \varepsilon$$

$$\therefore \frac{d\phi}{dt} = \varepsilon$$

From Eqⁿ (5)

direction of induced emf is not well definition emf without direction is useless.

The direction of emf was calculated by lenz. The corrected form is called Faraday lenz law.

Faraday-lenz correction—Hence, emf induced in the coil opposes its cause, In other words direction of emf is opposite to change in magnetic flux takes place in the coil.

The magnetic of induced emf in a circuit is equal to the time rate of change of magnetic flux through the circuit.

Mathematically, the induced emf is given by

$$\varepsilon = \frac{-d\phi_B}{dt}$$

The negative sign indicates the direction of E. In case of a closely wound coil of N turns, change of flux associated with each turn, is the same. Therefore the expression for the total induced emf is given by

$$\varepsilon = -N \frac{d\phi_B}{dt}$$

The induced emf can be increases by increasing the number of N turns of a closed coil.

15. Derive an expression for energy stored in a capacitor.

Ans.—Capacitor is either fully charged or fully discharged.

Therer is no any condition in between the two.

Fully charged means $q = q$ and fully discharged means $q = 0$

Changing of a capacitor is a continuous process. Therefore, small work done in terms of electrostatic potential,

$$dw = v \cdot dq \quad \dots(1)$$

By definition of capacitance

$$q = CV \quad \dots(2)$$

$$V = \frac{q}{c} \quad \dots(3)$$

Using in eqⁿ (1)

$$dw = \frac{q}{c} \cdot dq \quad \dots(4)$$

$$dw = \frac{q}{c} \cdot dq$$

Therefore, total work done in complete changing of a capacitor,

$$w = \int_0^q \frac{q}{c} \cdot dq$$

$$w = \frac{1}{c} \int_0^q q \cdot dq$$

$$= \frac{1}{c} \left[\frac{q^1 + 1}{1 + 1} \right]_0^q$$

$$= \frac{1}{c} \left[\frac{q^2}{2} \right]_0^q$$

$$W = \frac{1}{2c} [q^2]_0^q$$

$$W = \frac{1}{2c} q^2 - 0$$

$$\therefore W = \frac{q^2}{2c}$$

$$W = \frac{1}{2} \cdot \frac{q^2}{C} \quad \dots(6)$$

This work done is stored in the form of electrostatic potential energy of a capacitor.

$$\therefore U = \frac{1}{2} \cdot \frac{q^2}{C} \quad \dots(7)$$

$$\text{But, } q = CV \quad \dots(8)$$

$$U = \frac{1}{2} \cdot \frac{q^2}{C}$$

$$U = \frac{1}{2} \cdot \frac{C^2 V^2}{C}$$

$$\boxed{U = \frac{1}{2} \cdot CV^2} \quad \dots(9)$$

$$\text{Now, } C = \frac{q}{V} \quad \dots(10)$$

Using in eqⁿ (9)

$$U = \frac{1}{2} \cdot \frac{q}{V} \cdot V^2$$

$$\boxed{U = \frac{1}{2} \cdot qV} \quad \dots(11)$$

Conclusion :

$$U = \frac{1}{2} CV^2 = \frac{1}{2} qV = \frac{1}{2} \cdot \frac{q^2}{C}$$

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. Differentiate between intrinsic semiconductor and extrinsic semiconductors briefly.

Ans.—Following are the difference between intrinsic semiconductor and extrinsic semiconductors—

Intrinsic Semiconductors	Extrinsic Semiconductors
1. They are the crystals of pure elements like germanium and silicon.	1. When some impurity is added in the intrinsic semiconductor, we get an extrinsic semiconductor.
2. $M_e = n_h$	2. $M_e \neq n_h$
3. The electrical conductivity of intrinsic semiconductor is low.	3. Its electrical conductivity is high.
4. Resistivity is higher.	4. Resistivity is lower.

2. A TV tower is 80 m tall. Calculate the maximum distance upto which the signal transmitted from the tower can be received.

Ans.—Given that, $h = 80\text{m}$, $R = 6.4 \times 10^6\text{m}$

We have,

$$d = \sqrt{2hR}$$

$$\therefore d = \sqrt{2 \times 80 \times \frac{64}{10} \times 10^6}$$

$$d = 32 \times 10^3\text{m} = 32\text{km}$$

3. Define Internet. Mention major applications of Internet.

Ans.—**Internet**—The global network connecting millions of computers is known as Internet.

The major applications of Internet are as follows—

1. E-mail,
2. File transfer,
3. World Wide Web,
4. E-Commerce,
5. Chat.

4. Name the spectral series of hydrogen spectrum lying in ultraviolet, infra-red and visible regions ?

Ans.—Following are the spectral series of hydrogen spectrum given under as follows—

1. Lyman series—ultra-violet region,
2. Balmer series—visible region,
3. Paschen series—Infra-red region,
4. Brackett series—Infra-red region,
5. Pfund series—Infra-red region.

5. Define half life. Mention the relation between half-life and decay constant.

Ans.—Half life—The half life of a radioactive substance is the time in which the no. of radioactive atoms of the substance is reduced to half of its original value.

Relation between – life and decay constant can be expressed as—

$$T = \frac{0.6931}{\lambda}$$

6. Two slits are made 1mm apart and the screen is placed 1 m away. What is the fringe width when blue-green light of wavelength 500 nm is used ?

Ans.—Given that,

$$2d = 1\text{mm} = 1 \times 10^{-3} \text{ m},$$

$$D = 1\text{m}$$

$$\lambda = 500 \text{ nm} = 500 \times 10^{-9} \text{ m}$$

As we have, $\beta = ?$ $\lambda = 5 \times 10^{-7} \text{ m}$

$$\beta = \frac{D\lambda}{2d} = \frac{1 \times 5 \times 10^{-7}}{1 \times 10^{-3}} = 5 \times 10^{-7} \times 10^3$$

$$\boxed{\beta = 5 \times 10^{-4} \text{ m}}$$

7. What are the important uses of polaroids ?

Ans.—Important uses of polaroids are as follows—

1. Sun glasses fitted with polaroid sheets protect the eye from glare,
2. Wind shields of automobiles are also made of polaroid sheets,
3. They are useful in three dimensional motion pictures.

8. A lamp placed 70 c.m. from a screen on one side produces the same illumination as a standard 60 cd lamp placed 105 c.m. away on the other side of the screen.

Ans.—Given that, $r_1 = 70 \text{ c.m.}$, $r_2 = 105 \text{ c.m.}$

$$I_1 = ?, \quad I_2 = 60 \text{ cd}$$

As we have,

$$\frac{I_1}{I_2} = \frac{r_1^2}{r_2^2}$$

$$\text{or, } \frac{I_1}{60} = \frac{(70)^2}{(105)^2} \quad \text{or, } I_1 \times 105 \times 105 = 60 \times 70 \times 70$$

$$\therefore I_1 = \frac{60 \times 70 \times 70}{105 \times 105}$$

$$\boxed{I_1 = 26.67 \text{ cd}} \quad I_1 = \frac{80}{3} = 26.67 \text{ cd}$$

9. Name the principle on which optical fibre works. Mention its two applications.

Ans.—Optical fibre works on the principle of total internal reflection of light.

Two applications are as follows—

1. It is used for optical signal transmission.
2. It is used for transmitting and receiving electrical signals which are converted to light by suitable transducers.

10. A prism of angle 60° gives a minimum deviation of 30° . What is the refractive index of the material of the prism ?

Ans.—Given that,

$$\angle A = 60^\circ,$$

$$\delta_m = 30^\circ,$$

$$n = ?$$

We have,

$$n = \frac{\sin \frac{A + \delta_m}{2}}{\sin \frac{A}{2}} = \frac{\sin 45^\circ}{\sin 30^\circ}$$

$$n = \frac{\frac{1}{\sqrt{2}}}{\frac{1}{2}} = \frac{1}{\sqrt{2}} \times \frac{2}{1} = \sqrt{2} = 1.41$$

11. Why does sky appear blue ?

Ans.—Sky appear blue due to the phenomenon of scattering of light. As we know that, the wavelength of blue colour is much smaller than that of red colour. Therefore, intensity of the blue light scattered is much more than that of the red colour. Thus the blue colour becomes the major colour and it so happen.

SECTION-II (NON-OBJECTIVE TYPE QUESTIONS)

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

LONG QUESTIONS

12. State and Prove Gauss's theorem.

Ans.—Statement—Total Electric flux is $\frac{1}{\epsilon_0}$ times total electric charge enclosed by the given surface.

Mathematically, Gauss law can be written as

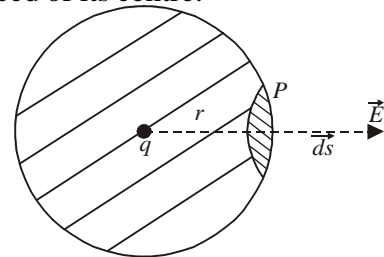
$$\phi = \frac{q}{\epsilon_0} \quad \text{where } q = \text{total enclosed charge}$$

$\epsilon_0 = \text{a constant.}$

Proof—Let us consider a solid sphere of radius r of charge q is placed of its centre.
By basic defⁿ of electric flux

$$\phi = \oint \vec{\epsilon} \cdot \vec{ds}$$

$$\phi = \oint_s \epsilon \cdot ds \cos \theta$$



...(1)

...(2)

Since, electric field $\left(\vec{\epsilon}\right)$ and area vector \vec{ds} are in the same direction Hence angle between them is 0° .

$$\phi = \oint \epsilon ds \cos \theta$$

$$\phi = \oint \epsilon ds \cos 0^\circ$$

$$\phi = \oint_s \epsilon ds$$

...(3)

Since electric field is constant. Therefore it is taken away from integration.

$$\phi = \epsilon \oint_s ds$$

...(4)

$$\phi = \epsilon \times 4\pi r^2$$

...(5)

Total electric field at point P, $E = \frac{1}{4\pi\epsilon_0} \cdot \frac{q}{r^2}$

Using in eqⁿ 5 $\phi = \frac{1}{4\pi\epsilon_0} \cdot \frac{q}{r^2} \times 4\pi r^2$

$$\phi = \frac{q}{\epsilon_0} \quad \dots(1) \text{ Eqⁿ (7) is called Gauss Law.}$$

13. With the help of Gaussian surface find the electric field due to uniformly charge distributed rod.

Ans.—(1) Electrical field due to uniformly charge distributed rod.

Let us consider a uniformly charge distributed rods, its linear charge

density is $\lambda = \frac{q}{L} \dots (1)$

Therefore $q = \lambda L \dots (2)$

We want to calculate electric field at point P which is distance away from the rod. The direction of electric

Field and are a vector is same therefore angle between them is 0.

A Gaussian cylinder of radius r can be drawn.

Using gauss law,

$$\phi = \frac{q}{\epsilon_0} \dots (3)$$

$$\phi = \frac{\lambda l}{\epsilon_0} \dots (4)$$

$$[XL = q \text{ in eq}^n - 2]$$

By basic defⁿ of electric flux

$$\phi = \oint_s \vec{\epsilon} \cdot \vec{ds} \cos \theta$$

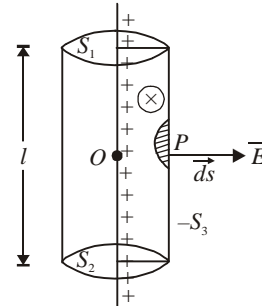
$$\phi = \oint_{S_1} \vec{\epsilon} \cdot \vec{ds} \cos 90^\circ + \oint_{S_2} \vec{\epsilon} \cdot \vec{ds} \cos 90^\circ + \oint_{S_3} \vec{\epsilon} \cdot \vec{ds} \cos 0^\circ$$

$$\phi = 0 + 0 + \epsilon \oint_{S_3} ds$$

$$\phi = \epsilon \cdot 2\pi l$$

$$\frac{\lambda l}{\epsilon_0} = \frac{1}{2\pi \epsilon_0} \cdot \frac{\lambda}{r}$$

$$\therefore \boxed{E = \frac{1}{2\pi \epsilon_0} \cdot \frac{\lambda}{r}}$$



14. State and explain mathematical expression for alternating current passed through inductor and capacitor.

Ans.—A.C. through L.C. [Inductor and Capacitor]—If Inductor and capacitor is connected in any circuit is called L.C. circuit. The total Emf of the circuit is a sum of Emf of Inductor and Emf of capacitor

Total = 0 ...(1)

$$E_L + E_c = 0$$

$$-L \cdot \frac{dI}{dt} + \frac{q}{c} = 0$$

$$L \cdot \frac{dI}{dt} - \frac{q}{c} = 0 \quad \dots (2)$$

Dividing equation (2) L

$$\frac{dI}{dt} - \frac{q}{LC} = 0$$

As current Increases the electric charge decreases.

$$I = -\frac{dq}{dt} \quad \dots(3)$$

Using in eq (3)

$$\frac{d}{dt} \left(-\frac{dq}{dt} \right) - \frac{q}{LC} = 0$$

$$-\left(\frac{d^2q}{dt^2} + \frac{q}{LC} \right) = 0$$

$$\therefore \frac{d^2q}{dt^2} + \frac{q}{LC} = \frac{0}{-1} = 0 \quad \dots(5)$$

$$\therefore \text{ If } \frac{1}{LC} = W^2 \quad \dots(6)$$

$$\therefore \frac{d^2q}{dt^2} + W^2q = 0 \quad \dots(7)$$

eq (7) is the second order different equation in “q”. The solution of second order different eqⁿ be written as.

$$q = A \cdot \cos wt + B \cdot \sin wt$$

Where

A and B are + ve constant

$$q = A \cdot \cos wt + B \cdot \sin wt \quad \dots(8)$$

$$\text{At } t = 0, q = q_0 \quad \dots(9)$$

$$q_0 = A \cdot \cos w \times 0 + B \cdot \sin 0$$

$$q_0 = A \times 1 + B \times 0$$

$$q_0 = A \quad \dots(10)$$

$$A = q_0$$

Differentiating eq (8) w.r.t. “t”

$$\frac{dq}{dt} = A \cdot \frac{d}{dt} [\cos wt] + B \frac{d}{dt} [\sin wt]$$

$$I = A \cdot w [-\sin wt] + B w \cos wt$$

$$I = -Aw \sin wt + Bw \cos wt \quad \dots(11)$$

$$\text{At } t = 0, I = 0 \quad \dots(12)$$

$$0 = -Aw \times \sin w \times 0 + Bw \times \cos w \times 0$$

$$0 = -q_0 w \sin 0 + Bw \cos 0$$

$$0 = -q_0 w \times 0 + Bw \times 1$$

$$0 = 0 + Bw$$

$$B = \frac{0}{w}$$

$$B = 0 \quad \dots(13)$$

Putting the value of A & B in eq. (8)

$$q = q_0 \cos \omega t + 0 \sin \omega t$$

$$\boxed{q = q_0 \cos \omega t}$$

...(14)

eqⁿ in the general eqⁿ for solution of second order differentiation.

15. Define generator. Discuss its different components with the help of diagram.

Ans.—A.C. Generator—Generator is a misnomer in physics, it generates nothing but it is a converter.

Generator is an electrical device which is used to convert mechanical energy into electrical energy.

Principle—It works on the principle of electromagnetic induction. When a coil is rotated in a uniform magnetic field induced emf is produced.

Components—There are two components in a generator.

(i) **Armature**—It is a coil in which large number of turns are present. It is rectangular in shape. The wire is made up of insulated copper wrapped around soft iron core.

(ii) **Field magnet**—The main function of field magnet is to produce large magnetic field. Permanent magnet or electromagnet may be used for this purpose but their strength must be very large. The rectangular coil is placed in between two magnets.

(iii) **Slit Rings**— R_1 and R_2 are two slip rings. It is attached with the armature coil. As coil rotates slip rings also rotate.

(iv) **Carbon Brushes**— B_1 and B_2 are two carbon brushes. It is compressed with the coil, as coil rotates it is not rotated. These brushes are connected to the load through which output can be obtained.

Theory—By defⁿ of angular speed

$$\omega = \frac{\theta}{t} \quad \dots(1)$$

$$\theta = \omega t \quad \dots(2)$$

By defⁿ of magnetic flux

$$\phi = \vec{B} \cdot \vec{A} \quad \dots(3)$$

$$\phi = BA \cos \theta$$

Using eqⁿ (2)

$$\phi = BA \cos \omega t \quad \dots(4)$$

For N-turns in the coil,

$$\phi = NBA \cos \omega t \quad \dots(5)$$

According to Faraday's second law,

$$\boxed{\varepsilon = \frac{-d\phi}{dt}}$$

...(6)

$$\frac{-d}{dt} [NBA \cos \omega t]$$

$$-NBA \frac{d}{dt} [\cos \omega t]$$

$$-NBA \omega (-\sin \omega t)$$

$$\varepsilon = -NBA \omega (-\sin \omega t)$$

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

...(7)

Let us consider

$$NBA \omega = \varepsilon_0$$

...(8)

$$\varepsilon = \varepsilon_0 \sin \omega t$$

...(9)

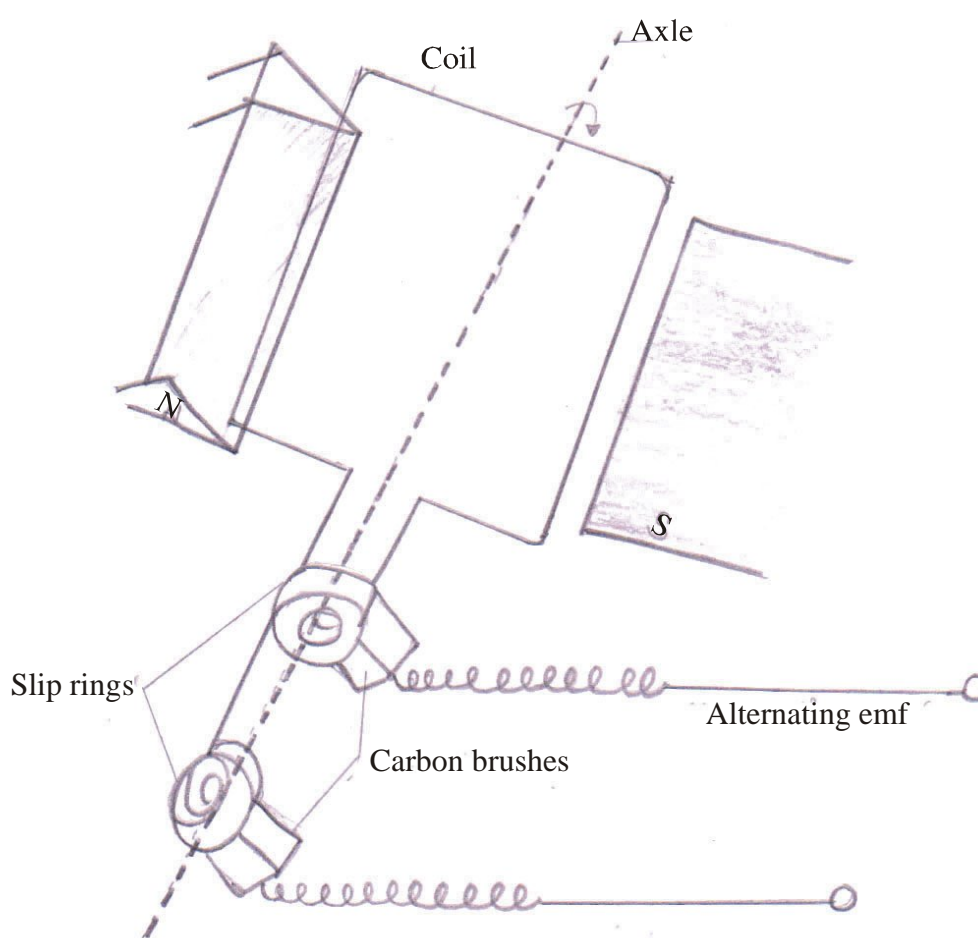
$$I = \frac{\varepsilon}{R} \quad \dots(10)$$

$$I = \frac{\varepsilon_0}{R} \cdot \sin \omega t \quad \dots(11)$$

But, $\frac{\varepsilon_0}{R} = I_0$... (12)

$\therefore \boxed{I = I_0 \sin \omega t}$... (13)

Hence, alternating current is induced in the coil.



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. A wire of resistance 12Ω is elongated to double its length. Find the new resistance.

Ans.—Given that, $R_1 = 12\Omega$

When the wire is stretched, then its volume will remain same, so we can will

$$L_1 A_1 = L_2 A_2 \quad V(\text{Volume})$$

$$\text{As we have, } R_1 = P \frac{L_1}{A_1} = P \frac{L_1 \times L_1}{A_1 \times L_1} = P \frac{L_1^2}{V}$$

$$12 = P \frac{L_1^2}{V} \quad \dots(1)$$

Similarly,

$$R_2 = P \frac{L_2^2}{V} \quad \dots(2)$$

$$\text{Dividing eq}^n(1), \text{ we get } \frac{R_2}{R_1} = \frac{P \frac{L_1^2}{V}}{P \frac{L_1^2}{V}}$$

$$\therefore \frac{R_2}{12} = \left(\frac{L_2}{L_1} \right)^2 \quad \frac{R_2}{12} = P \frac{L_2}{V} \times \frac{V}{L_1^2}$$

$$\frac{R_2}{12} = \left(\frac{2L_1}{L_1} \right)^2 \quad \therefore L_2 = 2L_1$$

$$\frac{R_2}{12} = \left(\frac{2L_1}{L_1} \right)^2 \quad \frac{R_2}{12} = \frac{4}{1}$$

$$\therefore \boxed{R_2 = 12\Omega \times 4 = 48\Omega}$$

2. A wire of resistivity 'P' is stretched to double its length. What will be its new resistivity ?

Ans.—New resistivity will be remains same that is no change in its resistivity. It is so because resistivity of a substance does not depends upon its length shape and area of cross-section.

3. Define transformer and transformation ratio.

Ans.—**Transformer**—It is a device which is used to convert low alternating voltage at higher current into high alternating voltage at lower current and vice-versa.

It works on the principle of mutual induction.

Transformation ratio—It is ratio of number of turns in secondary coil (N_s) and number of turns in primary coil (N_p).

$$K = \frac{N_s}{N_p} \text{ where, } k \text{ is transformation ratio.}$$

4. What is the use of a starter ?

Ans.—When a motor is just switched on, back e.m.f. is zero and hence due to large current through the armature, the motor may burn out. A starter is a variable resistance. When it is used in series with the motor then due to the resistance of the starter, a small current will flow even in the absence of back e.m.f. when motor is switched on.

5. State Snell's law of refraction of light. Express it mathematically.

Ans.—Snell's law—It states that—“The ratio of $\sin i$ to that of $\sin r$ is constant for a given pair of media. “Mathematically, it can be expressed as

$$n = \frac{\sin i}{\sin r} \text{ where 'n' is constant which is called refractive index.}$$

6. State two factors by which the range of transmission of TV signal can be increased.

Ans.—Two factors are as follow—

1. Range of transmission of TV signal can be increased by increasing the height of antenna.
2. By Amplitude modulation.

7. A carrier wave of peak voltage 12 V is used to transmit a message signal. What should be the peak voltage of the modulating signal in order to have a modulation index of 75% ?

Ans.—Given that,

$$E_c = 12V, \text{ ma} = 75\% = \frac{75}{100} = \frac{3}{4}$$

As we know that,

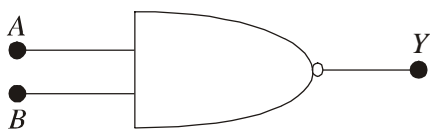
$$m_a = \frac{E_m}{E_c}$$

$$\begin{aligned} \therefore E_m &= \text{ma} \times E_c \\ &= \frac{3}{4} \times 12 = 9 \end{aligned}$$

$$E_m = 9V$$

8. Give the symbol and truth table for ‘NAND Gate’.

Ans.—Symbol of ‘NAND Gate’



Truth table of 'NAND Gate'

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

9. Define choke coil. Mention two applications of eddy currents.

Ans.—Choke coil—A Choke coil is an electrical appliance used for controlling current in an a.c. circuit. Two applications of eddy currents are as follows—

1. It is used in induction furnace,
2. It is used in making dead beat galvanometer.

10. Write down the Lens maker's formula and what do you mean by spherical aberration of a lens.

Ans.—Lens maker's formula can be expressed as—

$$\frac{1}{f} = (\mu - 1) \left(\frac{1}{R_1} - \frac{1}{R_2} \right)$$

Spherical aberration—Spherical aberration of a lens is defined as its inability to focus all the rays of light falling on it at a single point.

11. Two lenses, one diverging of power 2 dioptres and the other converging of power 6 dioptres, are combined together. Calculate the focal length and power of the combination.

Ans.—Given that,

$$P_1 = -2D, P_2 = +6D$$

$$\therefore \text{Power of combination, } P = P_1 + P_2 \\ = -2D + 6D$$

$$\boxed{P = +4D}$$

Focal length of combination,

$$f = \frac{1}{P} = \frac{1}{4} = 0.25m$$

$$\boxed{f = 25\text{cm.}} = \frac{0.25}{100} \times 100 = 25\text{cm}$$

SECTION-II (NON-OBJECTIVE TYPE QUESTIONS)

Question Nos. 12 to 15 are of long answer type. Answer must be explanatory and in your own language.
Each question carries 5 marks. $4 \times 5 = 20$

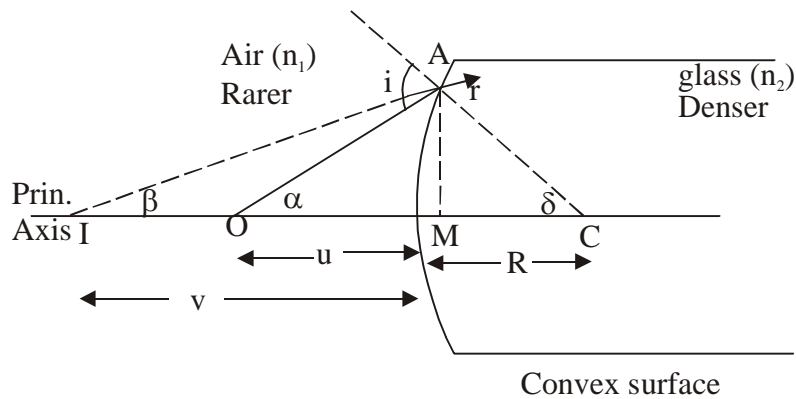
LONG QUESTIONS

12. For virtual image, prove the relation

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

Ans.—Refraction through convex surface—Virtual image Assumption—

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



In $\triangle OAC$
 $i = \alpha + \delta$...(1)

For smaller angle,

$$\left. \begin{array}{l} \alpha \approx \tan \alpha \\ \delta \approx \tan \delta \end{array} \right\} \quad \text{...(2)}$$

$\therefore i = \tan \alpha + \tan \delta$...(3)

In $\triangle OAM$

$$\tan \alpha = \frac{AM}{MO} \quad \text{...(4)}$$

But, $MO = PO$...(5)

$\therefore \tan \alpha = \frac{AM}{PO}$...(6)

In $\triangle ACM$

$$\tan \alpha = \frac{AM}{MC} \quad \text{...(7)}$$

But, $MC = PC$...(8)

$\therefore \tan \alpha = \frac{AM}{PC}$...(9)

Using in eqⁿ (3)

$$\therefore \boxed{i = \left(\frac{AM}{PO} + \frac{AM}{PC} \right)} \quad \dots(10)$$

In ΔIAC

$$r = \beta + \delta \quad \dots(11)$$

For smaller angle,

$$\left. \begin{aligned} \alpha &\approx \tan \beta \\ \delta &\approx \tan \delta \end{aligned} \right] \quad \dots(12)$$

$$\therefore r = \tan \beta + \tan \delta \quad \dots(13)$$

In ΔIAM

$$\tan \beta = \frac{AM}{MI} \quad \dots(14)$$

$$\text{But } MI = PI \quad \dots(15)$$

$$\therefore \tan \beta = \frac{AM}{PI}$$

Using in eqⁿ (13)

$$\boxed{r = \left(\frac{AM}{PI} + \frac{AM}{PC} \right)} \quad \dots(17)$$

Using Snell's law

$$\frac{\sin i}{\sin r} = \frac{n_2}{n_1} \quad \dots(18)$$

For smaller angle,

$$\left. \begin{aligned} \sin i &\approx i \\ \sin r &\approx r \end{aligned} \right] \quad \dots(19)$$

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

$$n_1 i = n_2 r \quad \dots(20)$$

Using eqn (10) + (17)

$$n_1 \left(\frac{AM}{PO} + \frac{AM}{PC} \right) = n_2 \left(\frac{AM}{PI} + \frac{AM}{PC} \right)$$

$$n_1 \left(\frac{1}{PO} + \frac{1}{PC} \right) = n_2 \left(\frac{1}{PI} + \frac{1}{PC} \right)$$

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

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

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

Using proper sign-convention,

$$\left. \begin{array}{l} PI = -v \\ PO = -u \\ PC = R \end{array} \right\} \dots(22)$$

$$\therefore \boxed{\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}} \dots(23)$$

- 13.** Using application of Gauss's law find the electrical field to uniformly charge thin shell in case of point lies outside, on the surface & inside the charge shell.

Ans.—Electric field due to uniformly charged thin shell—

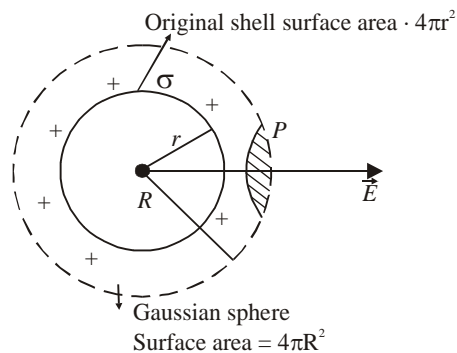
If point lies outside the shell.

Let us consider a thin spherical shell of radius “r”. Its surface charge density “σ”. Its charge distribution is uniform. By defⁿ of surface charge density

$$\sigma = \frac{\text{charge}}{\text{surface area}}$$

$$\sigma = \frac{q}{4\pi r^2} \therefore \Rightarrow q = 4\pi r^2 \sigma \dots(1)$$

We want to find electric field at point P which is outside the shell. It is R distance away from centre of Original shell.



By Gauss Law $\phi = \frac{q}{\epsilon_0}$

$$\phi = \frac{4\pi r^2 \sigma}{\epsilon_0} \dots(2)$$

By basic defⁿ of flux

$$\phi = \oint \epsilon \cdot ds$$

$$\phi \Rightarrow \oint \epsilon ds \cos \theta$$

$$\phi \Rightarrow \oint \epsilon \cdot ds \cos \theta$$

($\therefore \vec{\epsilon}$ and ds are in same direction)

$$\phi = \oint \epsilon \cdot ds$$

$$\phi = \epsilon \oint ds$$

$$\phi = \epsilon \cdot 4\pi r^2$$

By eqⁿ (ii) and (iii)

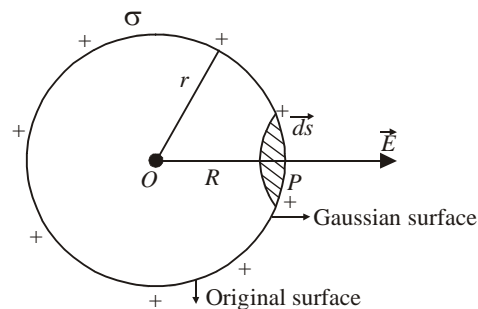
$$\frac{4\pi r^2 \sigma}{\epsilon_0} = \epsilon \cdot 4\pi R^2$$

$$\boxed{\frac{\sigma}{\epsilon_0} \cdot \frac{r^2}{R^2} = \epsilon}$$

...(4)

Eqⁿ 4 is general eqⁿ for electric field due to uniformly charged thin shell. If point P lies outside the shell

Case-II If point P lies on the surface of shell.



In this case radius of original shell and Gaussian sphere are equal

i.e. $r = R$

Using in eqⁿ-4

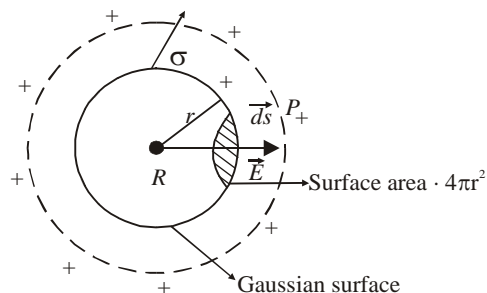
$$\epsilon = \frac{\sigma}{\epsilon_0} \cdot \frac{r^2}{R^2} = \frac{\sigma}{\epsilon_0}$$

$$\therefore \boxed{\epsilon = \frac{\sigma}{\epsilon_0}}$$

...(5)

Eqⁿ 5 is general expression for electric field when point is on the surface of shell.

Case-III. If point lies inside the uniformly charged shell.



According to Gauss Law

$$\phi = \frac{q}{\epsilon_0}$$

...(6)

Where q is enclosed surface charge but Gaussian surface enclose no charge.

$$q = 0$$

...(7)

$$\phi = \frac{0}{\epsilon_0} = 0 \quad \epsilon = 0$$

...(8)

Inside the thin spherical shell electric field is zero.

14. Explain the application of p-n junction diode as rectifier.

Ans.—APPLICATION OF p-n JUNCTION DIODE AS RECTIFIER

A device which converts alternating current (a.c.) into direct current (d.c.) is known as rectifier.

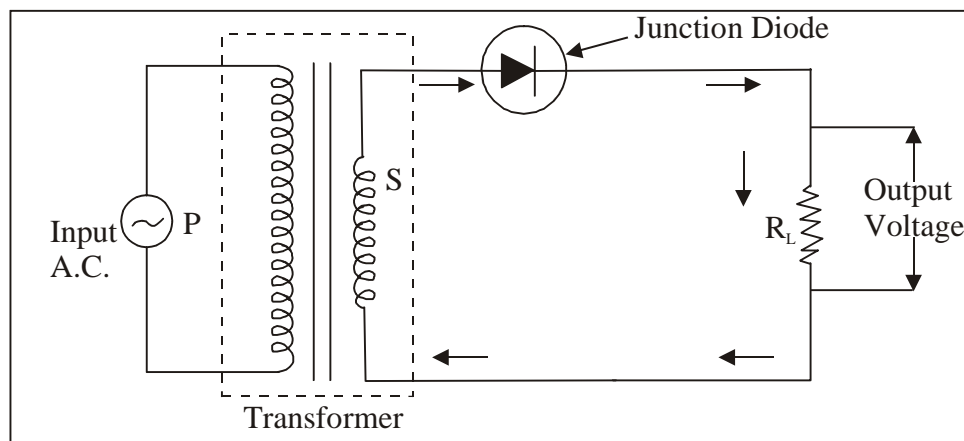
The process of converting a.c. into d.c. is known as rectification.

Principle—Junction diode conducts only when forward biased and it does not conduct when reverse biased. This fact makes the junction diode to work as a rectifier.

Junction diode as a half wave rectifier.

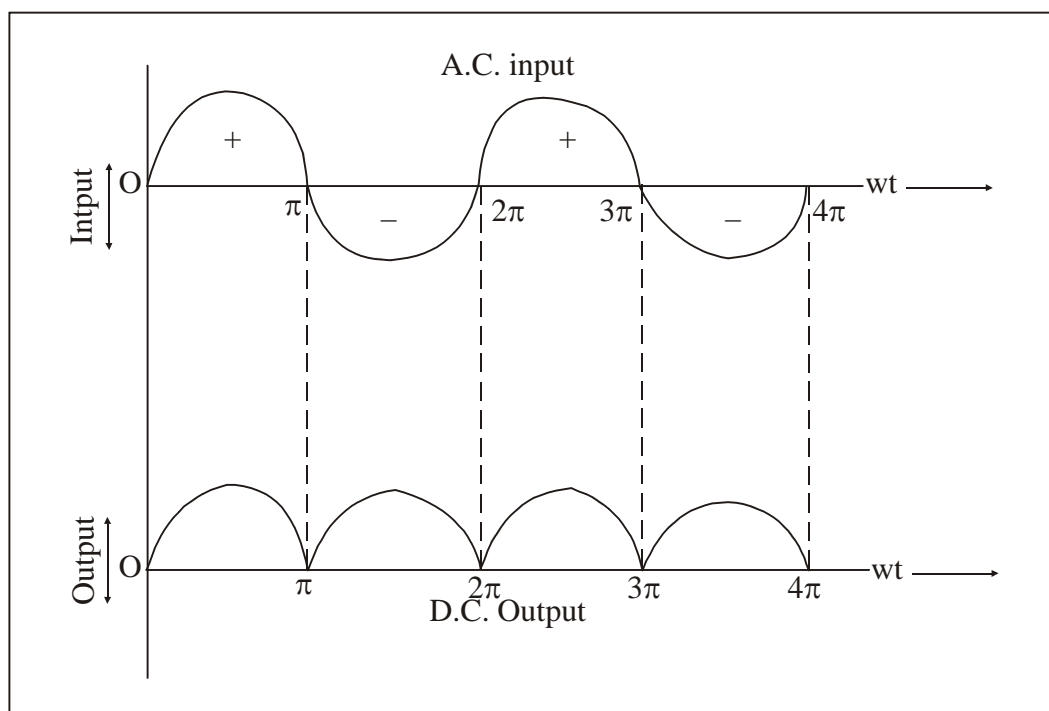
The rectifier which converts only one half of a.c. into d.c. is called half wave rectifier.

The circuit diagram of half wave rectifier.



Working—When positive half cycle of input a.c. signal flows through the primary coil, induced e.m.f. is set up in the secondary coil due to mutual induction. The direction of induced e.m.f. is such that the upper end of the secondary coil becomes positive and lower end becomes negative. Since upper end of secondary coil is connected to p-region and end is connected to the n-region of the junction diode, so the junction diode is forward biased during the positive half of input a.c. Thus the junction diode conducts and flow of current starts in the direction shown by arrows. The output voltage which varies in accordance with the input half cycle is obtained across the load resistance R_L .

When negative half cycle of a.c. input flows through the primary coil, again induced emf is set up across the secondary coil due to mutual induction. Now the direction of induced emf is such that upper end of the secondary coil becomes negative and lower end becomes positive. So the junction diode is reverse biased. Hence the junction diode does not conduct and therefore. We got no output across the load resistance during negative half of input and corresponding output voltage are shown in figure.



Since only half of the portion of the wave (input signal) is obtained as output in the form of d.c., so the junction diode is called a half wave rectifier.

Disadvantae

1. Since the output signal is discontinuous, so the efficiency of half wave rectifier is small.
2. The output is not d.c. but it is a fluctuating for pulsating (d.c.) which contains a.c. components or expression for output d.c. voltage

output d.c. voltage = mean load current \times load resistance

$$\text{i.e. } V_{d.c.} = I_{d.c.} \times R_L$$

But $I_{d.c.} = \frac{\pi_0}{\pi}$, where I_0 is the maximum value of the secondary half wave current.

$$V_{d.c.} = \frac{\pi_0}{\pi} \times R_L$$

15. Explain with the help of neat & labelled diagram the principle of Davison & Germer experiment.

Ans.—Davission and Germer Experiment—

Davission and German experiment established the wave nature of electron. They use the deflection effect of electron radiation scattered by the crystals.

Following are the important components of experimental set up—

1. Electron gun
2. Nickel crystal
3. Movable detector or collection.

1. Electron Gun—The main function of electron gun is the supply of electron. Electron is supplied by the filament made up of Tungsten. For controlled emission of tungsten, filament is coted with Barium oxide. The filament acts as an Emitter. Electron gun is heated with low tesnion wire.

2. Nickel crystal—It behaves like linear scale. All electrons emitted by electron gun is collected by the

Nickel crystal and scattered in all the direction.

3. Movable Dectors or collector—The main function of collector is to collect all the electron scattered by the Nickel crystal. It is connected Galvanometer, So that catching of electron can be detected.

Experiment set up—

It is observed when ϕ is 50° the emission of electron is maximum. The corresponding voltage is observed 54 volt.
For Linear scale,

$$\theta + \phi + \theta = 180^\circ \quad \dots(1)$$

$$2\theta + \phi = 180^\circ \quad \dots(2)$$

$$\text{But, } \phi = 50^\circ \quad \dots(3)$$

$$\therefore 2\theta + 50^\circ = 180^\circ$$

$$2\theta = 180^\circ - 50^\circ = 130^\circ$$

$$\boxed{\theta = 65^\circ}$$

According to De-Broglie eqn :

$$\lambda_{\text{expt}} = \frac{1227}{\sqrt{V}} \text{ \AA} \quad \dots(5)$$

$$\text{But, } V = 54 \text{ volt} \quad \dots(6)$$

$$\lambda_{\text{expt}} = \frac{12.27}{\sqrt{54}} \text{ \AA}$$

$$\lambda_{\text{expt}} = \frac{12.27}{7.348} = 1.669$$

$$\boxed{\lambda_{\text{expt}} = 1.67}$$

...(7)

Theoretical value :

According to Bragg's law,

$$n\lambda = 2d\sin\theta$$

...(8)

$$\text{for } n = 1$$

...(9)

$$\lambda_{\text{theory}} = 2d\sin\theta$$

...(10)

For Nickel crystal,

$$d = 0.91 \text{ \AA}$$

$$\theta = 65^\circ$$

...(11)

Using in eqⁿ (10)

$$\lambda_{\text{theory}} = 2 \times 0.91 \times \sin 65^\circ$$

$$= 2 \times 0.91 \times 906$$

$$= 1.648 \text{ \AA}$$

$$= 1.66 \text{ \AA}$$

$$\boxed{\lambda_{\text{theory}} = 1.66 \text{ \AA}}$$

...(12)

Since, theoretical value of wavelength and experimental value of wavelength are nearly same. Hence, wave nature of electron can be established by Davisson and Germer.

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. A wire is stretched 50%, Calculate % change in its resistance.

Ans.—When a wire is stretched then its volume will remain same, and we know the relation—

$$\frac{R_2}{R_1} = \left(\frac{L_2}{L_1} \right)^2$$

Here, it is given that the wire is stretched 50%, So,
 We can write—

$$L_2 = L_1 + \frac{50}{100} L_1$$

$$= \frac{150L_1}{100}$$

$$L_2 = 1.5L_1$$

$$\frac{R_2}{R_1} = \left(\frac{1.5L_1}{L_1} \right)^2$$

$$\frac{R_2}{R_1} = 2.25 \therefore R_2 = 2.25 R_1$$

$$\begin{aligned} \text{Change in resistance, } R &= R_2 - R_1 \\ &= 2.25 R_1 - R_1 \\ &= R_1 (2.25 - 1) \\ &= R_1 \times 1.25 \end{aligned}$$

$$\% \text{ Change in resistance} = \frac{\text{change in resistance}}{\text{original resistance}} \times 100$$

$$= \frac{R_1 \times 1.25}{R_1 \times 100} \times 100$$

$$= 125\%$$

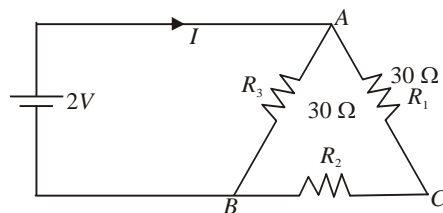
2. Express the relationship between commercial unit of energy and S.I. unit of energy. Express the general formula of Joule's heating effect of current.

Ans.—Relationship b/n commercial unit of energy & S.I. unit of energy can be given by—

$$\boxed{1\text{kwh} = 3.6 \times 10^6 \text{J}}$$

Expression of Joule's heating effect of current, $\boxed{H = I^2 R t}$

3. What will be the value of current 'I' in the circuit which is shown here under—



Ans.—As per the circuit, we can write—

$$R_1 \text{ \& } R_2 \text{ are in series, So } R_s = R_1 + R_2 \\ = 30 \Omega + 30 \Omega = 60 \Omega$$

Then,

$$\frac{1}{R_p} = \frac{1}{R_3} + \frac{1}{R}$$

$$\frac{1}{R_p} = \frac{1}{30} + \frac{1}{60}$$

$$\frac{1}{R_p} = \frac{2+1}{60} \text{ or, } \frac{1}{R_p} = \frac{3}{60}$$

$$\therefore \frac{1}{R_p} = \frac{60}{3} = 20\Omega$$

$$V = IR \therefore I = \frac{V}{R} = \frac{2}{20} = \frac{1}{10} = 0.1$$

$$\boxed{I = 0.1A}$$

4. Define Astigmatism. Which lens is used to remove the defect of Astigmatism.

Ans.—**Astigmatism**—It is that defect of the eye due to which a person cannot focus on both horizontal and vertical lines simultaneously.

A cylindrical lens is used to remove the defect of astigmatism.

5. Define mirage. What is its cause.

Ans.—**Mirage**—It is an optical illusion due to which we see a layer of water at a short distance ahead of us in a desert on a very hot day, when actually there is no water at all.

It is produced by the total internal reflection of light caused by atmospheric refraction.

6. The image of a candle is formed on a screen by a convex lens. If half of the lens is blackened then what will be the size of the image?

Ans.—The ray coming from any point of the candle meets at the same point after refraction through half the portion, where it meets in case of the full lens. So, the full image is formed but the intensity of the image decreases.

7. What change will occur when a lens is dipped in water?

Ans.—When a lens is dipped in water then its power decreases and so the focal length increases but the geometrical nature of the lens does not change.

8. State properties of photons.

Ans.—Properties of photons are as follows—

1. A photon travels with a speed of light in vacuum,
 2. A photon has zero rest mass.
9. In a parallel plate capacitor with air between the plates, each plate has an area of $6 \times 10^{-3} \text{ m}^2$ and the distance between the plates is 3mm. Calculate the capacitance of the capacitor.

Ans.—As we know that,

$$C = \frac{\epsilon_0 A}{d}$$
$$= \frac{8.85 \times 10^{-12} \times 6 \times 10^{-3}}{3 \times 10^{-3}}$$

$$\boxed{C = 17.70 \times 10^{-12} \text{ F}}$$

10. Define work function and threshold frequency related to Einstein's photoelectric effect.

Ans.—Work function—The minimum amount of energy required to take out an electron from the surface of metal, is called its work function.

Threshold frequency—Photo-electrons are not emitted from the surface of a metal if the frequency of the incident light is less than a particular minimum value. This minimum frequency is called threshold frequency.

11. State two uses of Photo diode.

Ans.—Two uses of **Photo diodes** are as follows—

1. They are used as photo detectors to detect intensity of radiation.
2. They are used as light operated switches.

Model Set (Class-XII) 2017
SECTION-II (NON-OBJECTIVE TYPE QUESTIONS)

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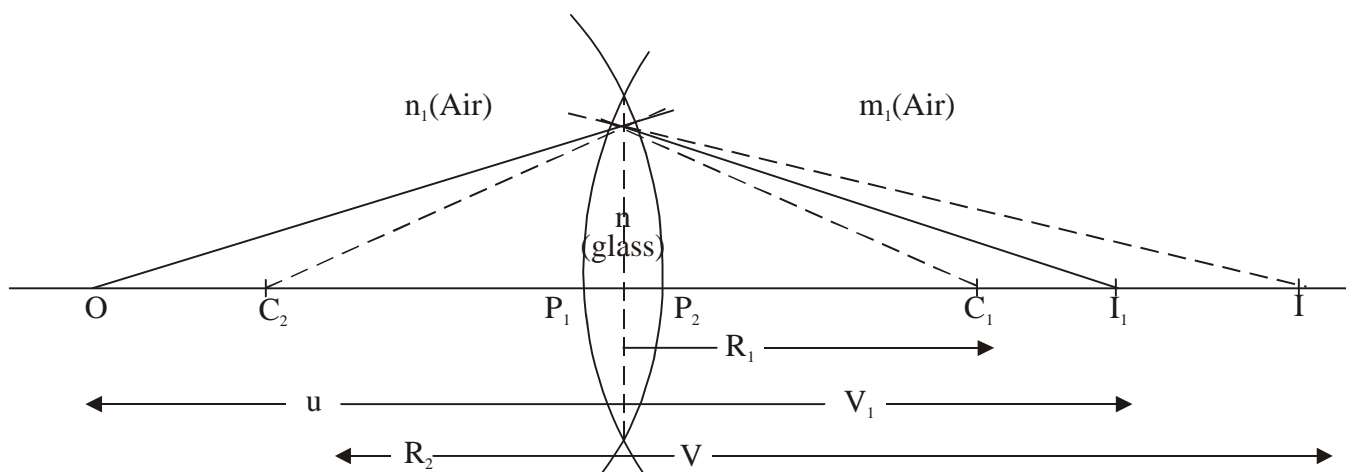
Question Nos. 12 to 15 are of long answer type. Answer must be explanatory and in your own language.
 Each question carries 5 marks. $4 \times 5 = 20$

LONG QUESTIONS

12. State and explain Lens maker's formula.

Ans.—This equation is used for manufacturing lens. Therefore it is called lens maker's equation.
 Following are the important assumptions made for lens maker's formula.

1. The spherical must be very thin
2. The distance from pole to optical centre must be very-very small.
3. The angle made by object, image and normal must be very-very small.



For refracting surface XAY

$$\frac{n_2}{v_1} = \frac{n_1}{u} = \frac{n_2 - n_1}{R_1} \quad \dots(1)$$

$$\left[\begin{array}{l} V_1 = P_1 I_1 \\ u = -P_1 O \\ R_1 = P_1 C_1 \end{array} \right] \quad \dots(2)$$

Using in equation (1)

$$\frac{n_2}{P_1 I_1} + \frac{n_1}{P_1 O} = \frac{n_2 - n_1}{P_1 C_1} \quad \dots(3)$$

$\therefore P_1$ is very-very close to "C"

$$\left[\begin{array}{l} P_1 I_1 = C I_1 \\ P_1 O = CO \\ P_1 C_1 = CC_1 \end{array} \right] \quad \dots(4)$$

$$\therefore \boxed{\frac{n_2}{CI_1} + \frac{n_1}{CO} = \frac{n_2 - n_1}{CC_1}} \quad \dots(5)$$

For refracting surface XP_2Y

$$\frac{n_1}{V} - \frac{n_2}{V_1} = \frac{n_1 - n_2}{R_2} \quad \dots(6)$$

$$\left. \begin{aligned} V &= P_2I \\ V_1 &= P_2I_1 \\ R_2 &= -P_2C_2 \end{aligned} \right] \quad \dots(7)$$

$$\frac{n_1}{P_2I} - \frac{n_2}{P_2I_1} = \frac{n_1 - n_2}{P_2C_2}$$

$$\frac{n_1}{P_2I} - \frac{n_2}{P_2I_1} = \frac{n_2 - n_1}{P_2C_2}$$

$\therefore P_2$ is very-very close to "C".

$$\left. \begin{aligned} P_2I &= CI \\ P_2I_1 &= CI_1 \\ P_2C_2 &= CC_2 \end{aligned} \right] \quad \dots(9)$$

$$\therefore \boxed{\frac{n_1}{CI} - \frac{n_2}{CI_1} = \frac{n_2 - n_1}{CC_1}} \quad \dots(10)$$

adding eqⁿ (5) and (10)

$$\frac{n_2}{CI_1} + \frac{n_1}{CO} = \frac{n_2 - n_1}{CC_1}$$

$$\frac{n_1}{CI} - \frac{n_2}{CI_1} = \frac{n_2 - n_1}{CC_1}$$

$$n_1 \left[\frac{1}{CI} + \frac{1}{CO} \right] = (n_2 - n_1) \left[\frac{1}{CC_1} + \frac{1}{CC_2} \right]$$

$$\frac{1}{CI} + \frac{1}{CO} = \left(\frac{n_2 - n_1}{n_1} \right) \left[\frac{1}{CC_1} + \frac{1}{CC_2} \right]$$

$$\frac{1}{CI} + \frac{1}{CO} = \left(\frac{n_2}{n_1} - 1 \right) \left[\frac{1}{CC_1} + \frac{1}{CC_2} \right]$$

$$\frac{1}{CI} + \frac{1}{CO} = (n - 1) \left[\frac{1}{CC_1} + \frac{1}{CC_2} \right] \quad \dots(11)$$

Using proper sign-convention,

$$\left. \begin{aligned} CI &= v \\ CO &= -u \\ CC_1 &= R_1 \\ CC_2 &= -R_2 \end{aligned} \right] \quad \dots(12)$$

$$\therefore \frac{1}{v} - \frac{1}{u} = (n-1) \left[\frac{1}{R_1} - \frac{1}{R_2} \right] \quad \dots(13)$$

According to lens equation

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \quad \dots(14)$$

$$\therefore \boxed{\frac{1}{f} = (n-1) \left[\frac{1}{R_1} - \frac{1}{R_2} \right]} \quad \dots(15)$$

Equation (15) is called lens maker's equation,

$$\text{But, } \frac{1}{f} = P \quad \dots(16)$$

$$\therefore \boxed{P = (n-1) \left[\frac{1}{R_1} - \frac{1}{R_2} \right]} \quad \dots(17)$$

- 13.** State and explain interference of light. Find conditions for constructive & destructive interference. Also find its expression.

Ans.—Interference of Light—Interference is the superposition of two light waves due to which non-uniform distribution of energy takes place in the medium. Due to interference of two light waves redistribution of energy takes place in the medium. The points at which intensity of light is maximum is called constructive interference while at some points in the medium at which intensity is minimum is called destructive interference. Constructive interference is also called Bright fringes. Destructive interference is also called Dark fringes.

The constructive pattern of constructive interference and destructive interference pattern of light. If interference pattern is permanent on the screen then it is called sustained interference pattern. Following are the important conditions for sustained interference pattern—

1. The two light source emits light wave continuously.
2. The two light source must be very-very close to each other.
3. The light wave should be of nearly same wave length.
4. The intensity of light of two source must be nearly same.
5. The two light source must be in same phase or constant phase.
6. The light source must be narrow.

CONDITIONS FOR CONSTRUCTIVE AND DESTRUCTIVE INTERFERENCE

Let us consider two light waves represented by the equations—

$$y_1 = A_1 \sin \omega t \quad \dots(1)$$

$$y_2 = A_2 \sin (\omega t + \delta) \quad \dots(2)$$

By definition of interference,

$$\begin{aligned} y &= y_1 + y_2 \\ &= A_1 \sin \omega t + A_2 \sin (\omega t + \delta) \end{aligned}$$

$$\begin{aligned}
&= A_1 \sin wt + A_2 [\sin wt \cdot \cos \delta + \cos wt \cdot \sin \delta] \\
&= A_1 \sin wt + A_2 \sin wt \cdot \cos \delta + A_2 \cos wt \cdot \sin \delta \\
&= [A_1 + A_2 \cos \delta] \sin wt + (A_2 \sin \delta) \cdot \cos wt \quad \dots(4)
\end{aligned}$$

Let us consider,

$$A_1 + A_2 \cos \delta = A \cos \theta \quad \dots(5)$$

$$A_2 \sin \delta = A \sin \theta \quad \dots(6)$$

Using in eqⁿ (4)

$$y = A \cos \theta \sin wt + A \sin \theta \cdot \cos wt$$

$$y = A [\sin wt + \cos \theta + \cos wt \cdot \sin \theta]$$

$$\boxed{y = A \sin(wt + \theta)} \quad \dots(7)$$

eqⁿ (7) is the general eqⁿ for superposed wave which is periodic in nature.

Taking square of eqⁿ (5) and (6) and then adding.

$$(A_1 + A_2 \cos \delta)^2 = A^2 \cos^2 \theta$$

$$A_2^2 \sin^2 \delta = A^2 \sin^2 \theta$$

$$\begin{aligned}
A_1^2 + A_2^2 \cos^2 \delta + 2A_1A_2 \cos \delta + A_2^2 \sin^2 \delta \\
= A^2 [\cos^2 \theta + \sin^2 \theta]
\end{aligned}$$

$$A_1^2 + 2A_1A_2 \cos \delta + A_2^2 [\cos^2 \delta + \sin^2 \delta] = A^2$$

$$A_1^2 + 2A_1A_2 \cos \delta + A_2^2 = A^2 \quad \dots(8)$$

$$\text{But } A^2 = I \quad \dots(9)$$

$$\therefore \boxed{I = A_1^2 + A_2^2 + 2A_1A_2 \cos \delta} \quad \dots(10)$$

→ Conditions for constructive interference or bright fringes—

For constructive interference, intensity must be max^m,

$$\text{For } I_{\max}, \cos \delta = \max^m = 1 \quad \dots(11)$$

General value,

$$\delta = 2\pi n \quad \dots(12)$$

By definition of periodic function.

$$\text{Path difference} = \frac{\lambda}{2\pi} \times \text{phase difference} \quad \dots(13)$$

$$x = \frac{\lambda}{2\pi} \times \delta \quad \dots(14)$$

$$x = \frac{\lambda}{2\pi} \times 2\pi n$$

$$\boxed{x = n\lambda} \quad \dots(15)$$

eqⁿ (15) is the required conditions for constructive interference.

→ Conditions for destructive interference or dark fringes—

For destructive interference, intensity must be minimum,

$$\text{For } I_{\min}, \cos \delta = \min^m = -1 \quad \dots(16)$$

General value,

$$\delta = (2n + 1)\pi \quad \dots(17)$$

By defⁿ of periodic function,

$$\text{Path difference} = \frac{\lambda}{2\pi} \times \text{phase difference} \quad \dots(18)$$

$$x = \frac{\lambda}{2\pi} \times \delta \quad \dots(19)$$

$$x = \frac{\lambda}{2\pi} \times (2n+1)\pi$$

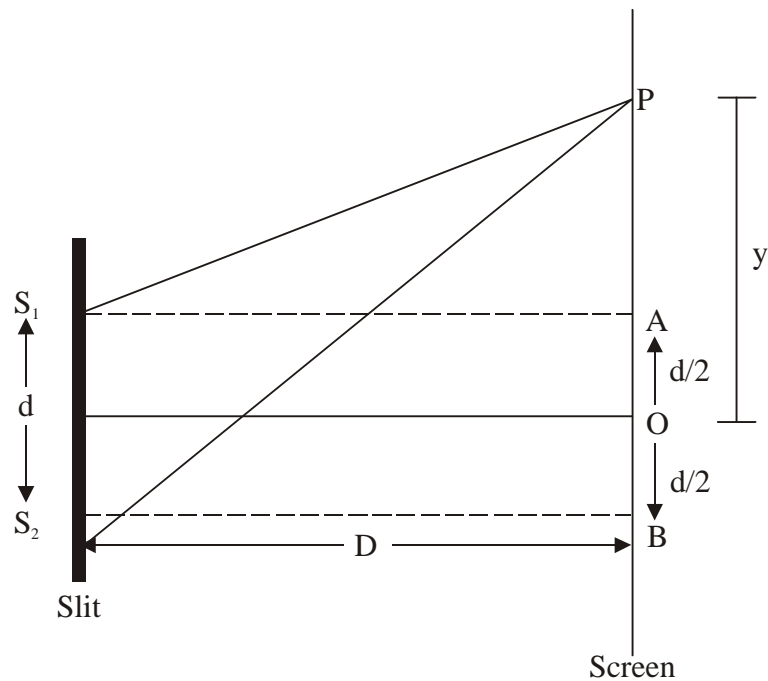
$$x = \frac{\lambda}{\pi} \times (2n+1)$$

...(20)

This is the required condition for destructive interference.

14. Discuss theory of interference fringe and find its expression.

Ans.—Theory of Interference fringes



Let us consider two light sources are placed at S_1 and S_2 . The distance between two light source is 'd'. The screen is 'D' distance away from the slit or source of light. O is the mid point of S_1 and S_2 therefore,

$$AP = (y - d/2) \quad \dots(1)$$

$$BP = (y + d/2) \quad \dots(2)$$

$$\text{In } \Delta S_2PB -$$

$$(S_2P)^2 = (S_2B)^2 + (BP)^2 \quad \dots(3)$$

$$(S_2P)^2 = D^2 + (y + d/2)^2 \quad \dots(4)$$

$$\text{In } \Delta S_1PA -$$

$$(S_1P)^2 = (S_1A)^2 + (AP)^2 \quad \dots(5)$$

$$(S_1P)^2 = D^2 + (y - d/2)^2 \quad \dots(6)$$

Subtracting (6) from (4)

$$(S_2P)^2 - (S_1P)^2 = D^2 + (y + d/2)^2 - [D^2 + (y - d/2)^2]$$

$$(S_2P + S_1P)(S_2P - S_1P) = D^2 + y^2 + \frac{d^2}{4} + yd - D^2 - y^2 - \frac{d^2}{4} + yd$$

$$(S_2P + S_1P)(S_2P - S_1P) = 2yd \quad \dots(7)$$

$$(S_2P + S_1P) \cdot x = 2yd$$

Using approximation method,

$$\left. \begin{array}{l} S_2P \approx D \\ S_1P \approx D \end{array} \right] \quad \dots(8)$$

$$(S_2P + S_1P)(D - D) = 2yd$$

$$x \times 2D = 2yD$$

$$\boxed{x = \frac{yd}{D}} \quad \dots(9)$$

For constructive interference,

$$x = n\lambda \quad \dots(10)$$

$$n\lambda = \frac{yd}{D}$$

$$y = \frac{n\lambda D}{d} \quad \dots(11)$$

It is the general value of n^{th} -fringe.

$$\boxed{y_n = \frac{n\lambda D}{d}} \quad \dots(12)$$

For $n = 1$

$$y_1 = \frac{\lambda D}{d}$$

For $n = 2$

$$y_2 = \frac{2\lambda D}{d}$$

For $n = 3$

$$y_3 = \frac{3\lambda D}{d} \quad \dots(13)$$

\therefore For destructive interference,

$$x = (2n + 1) \cdot \frac{\lambda}{2} \quad \dots(14)$$

$$\text{But } x = \frac{yd}{D}$$

$$\therefore \frac{yd}{D} = (2n + 1) \frac{\lambda}{2}$$

$$y = \frac{(2n + 1)\lambda D}{2d} \quad \dots(15)$$

It is the general value of n^{th} fringe—

$$y_n = \frac{(2n + 1)\lambda D}{2d} \quad \dots(16)$$

For $n = 1$

$$y_1 = \frac{3\lambda D}{2d}$$

For $n = 2$

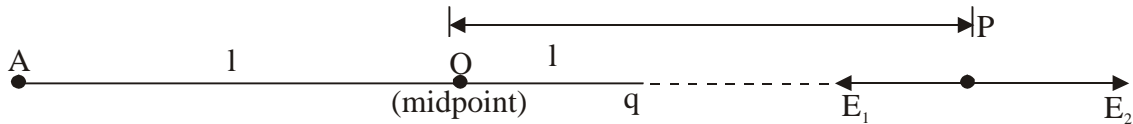
$$y_2 = \frac{5\lambda D}{2d}$$

For $n = 3$

$$y_3 = \frac{7\lambda D}{2d} \quad \dots(17)$$

15. Find the electric field on the axial line of electric field.

Ans.—Electric field on the axial line of electric dipole.



Let us consider an electric dipole of length “ $2l$ ”. Negative charge ($-q$) is placed at “A”. Positive charge ($+q$) is placed at “B”. Axial line is a st. line which passes through both $-ve$ charge + ve charge.

We want to calculate electric field on axial line of electric dipole at point “P”. Which is “ r ” distance away from the mid-point of the electric dipole.

\vec{E}_1 is the electric field due to ($-ve$) charge which is acting inward. \vec{E}_2 is the electric field due to ($+ve$) charge which is acting outward.

$$AP = (r + l) \quad \dots(1)$$

$$BP = (r - l) \quad \dots(2)$$

$$E_1 = \frac{1}{4\pi\epsilon_0} \times \frac{q}{(AP)^2} \quad \dots(3)$$

Using in eqn. (1)

$$E_1 = \frac{1}{4\pi\epsilon_0} \times \frac{q}{(r + l)^2} \quad \dots(4)$$

$$E_2 = \frac{1}{4\pi\epsilon_0} \times \frac{q}{(BP)^2} \quad \dots(5)$$

Using eqn (2)

$$E_2 = \frac{1}{4\pi\epsilon_0} \times \frac{q}{(r - l)^2} \quad \dots(6)$$

Since $E_2 > E_1$

Total electric field at point ‘p’—

$$E = E_2 - E_1 \quad \dots(7)$$

$$= \frac{1}{4\pi\epsilon_0} \times \frac{q}{(r - l)^2} - \frac{1}{4\pi\epsilon_0} \times \frac{q}{(r + l)^2}$$

$$= \frac{1}{4\pi\epsilon_0} \left(\frac{q}{(r - l)^2} - \frac{q}{(r + l)^2} \right)$$

$$= \frac{q}{4\pi\epsilon_0} \left(\frac{(r + l)^2 - (r - l)^2}{(r + l)^2} \right)$$

$$= \frac{q}{u\pi\epsilon_0} \left[\frac{r^2 + l^2 + 2rl - r^2 - l^2 + 2rl}{(r-l)^2} \right]$$

$$= \frac{1}{u\pi\epsilon_0} \frac{2 \cdot (2lq)r}{(r^2 - l^2)^2} \quad \dots(8)$$

But, $2lq = p$... (9)

$$= \frac{1}{u\pi\epsilon_0} \frac{2pr}{(r^2 - l^2)^2} \quad \dots(10)$$

Eqn. (10) is the general eqn. for electric field on the axial line of electric dipole.

Spl. Case— If $r \gg l$... (11)

In this case “l” can be neglected.

$$l = 0 \quad \dots(12)$$

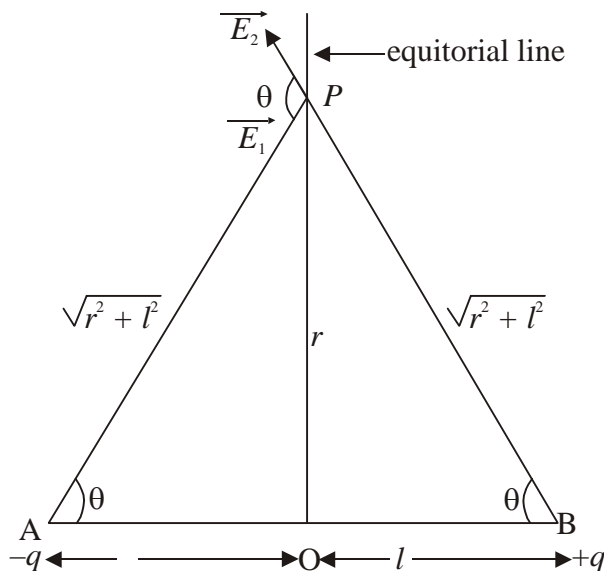
Using in eqn. ... (10)

$$E_{\text{axial}} = \frac{1}{u\pi\epsilon_0} \times \frac{2pr}{(r^2 - 0)^2}$$

$$E_{\text{axial}} = \frac{1}{u\pi\epsilon_0} \times \frac{2pr}{r^4}$$

$$\boxed{E_{\text{axial}} = \frac{1}{u\pi\epsilon_0} \times \frac{2pr}{r^3}} \quad \dots(13)$$

Q. Electric field on the equatorial line of an electric dipole—



Let us consider an electric dipole of length $2l$. Negative charge ($-q$) is placed at ‘A’. Positive charge ($+q$) is placed at B.

Equatorial line is a st. line which is perpendicular to the line and passes through mid point of the electric dipole.

We want to calculate electric field at point ‘p’ which is placed on equatorial line and ‘r’ distance away from the mid-point of the electric dipole. \vec{E}_1 is the electric field due to $-ve$ charge which is acting inward. \vec{E}_2 is the electric

field due to +ve charge which is acting outward.

$$\left. \begin{aligned} PA &= (r^2 + l^2)^{1/2} \\ PB &= (r^2 + l^2)^{1/2} \end{aligned} \right] \quad \dots(1)$$

$$\therefore E_1 = \frac{1}{4\pi\epsilon_0} \times \frac{q}{(PA)^2} \quad \dots(2)$$

Using eqn. (1)

$$E_1 = \frac{1}{4\pi\epsilon_0} \times \frac{q}{(r^2 + l^2)^{1/2}}$$

$$\therefore \boxed{E_1 = \frac{1}{4\pi\epsilon_0} \times \frac{q}{r^2 + l^2}} \quad \dots(3)$$

$$E_2 = \frac{1}{4\pi\epsilon_0} \times \frac{1}{(PB)^2} \quad \dots(4)$$

Using in eqn (1)

$$E_2 = \frac{1}{4\pi\epsilon_0} \times \frac{1}{(r^2 + l^2)^{1 \times 2 \times 2}}$$

$$\therefore \boxed{E_2 = \frac{1}{4\pi\epsilon_0} \times \frac{1}{(r^2 + l^2)}} \quad \dots(5)$$

Since E_1 & E_2 are equal.

$$\therefore E_1 = E_2 \text{ (say)} \quad \dots(6)$$

Total electric field at point 'p' :

$$E = \sqrt{E_1^2 + E_2^2 + 2E_1E_2 \cos 2\theta} \quad \dots(7)$$

Using eqn. (7)

$$E = \sqrt{x^2 + x^2 + 2xx \cos 2\theta}$$

$$= \sqrt{2x^2 + 2x^2 \cos 2\theta}$$

$$E = \sqrt{2x^2(1 + \cos 2\theta)} \quad \dots(8)$$

$$\text{But, } (1 + \cos^2\theta) = 2\cos^2\theta \quad \dots(9)$$

$$E = \sqrt{2x^2 \cdot 2\cos^2\theta}$$

$$E = \sqrt{4x^2 \cos^2\theta}$$

$$E = 2x \cos\theta \quad \dots(10)$$

In ΔAPO

$$\cos\theta = \frac{OA}{OP}$$

$$\cos\theta = \frac{l}{(r^2 + l^2)^{1/2}} \quad \dots(11)$$

Using eqn. (11) & (6) in eqn. (10)

$$E = 2x \cos\theta$$

$$E = 2 \times E_1 \times \frac{l}{(r^2 + l^2)^{1/2}}$$

$$E = 2 \times \frac{1}{4\pi\epsilon_0} \times \frac{q}{(r^2 + l^2)^{1/2}} \times \frac{l}{(r^2 + l^2)^{1/2}}$$

$$E = \frac{1}{4\pi\epsilon_0} \times \frac{q}{(r^2 + l^2)^{1+1/2}}$$

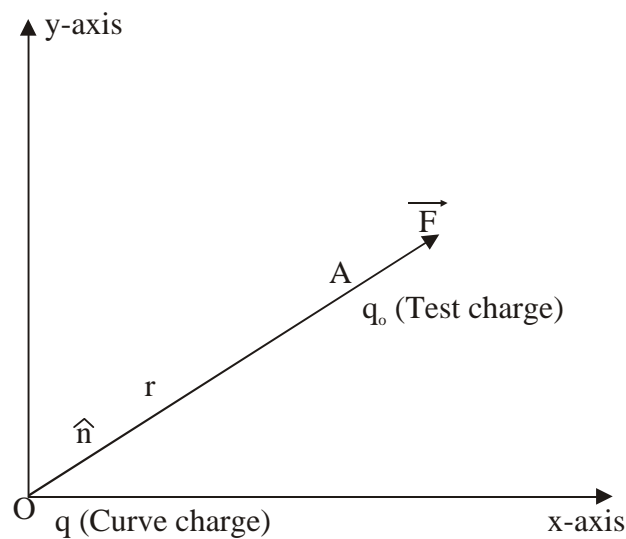
$$E = \frac{1}{4\pi\epsilon_0} \times \frac{2lq}{(r^2 + l^2)^{3/2}} \quad \dots(12)$$

$$\text{But, } 2lp = p \quad \dots(13)$$

$$\therefore \boxed{E = \frac{1}{4\pi\epsilon_0} \times \frac{p}{(r^2 + l^2)^{3/2}}} \quad \dots(14)$$

Eqn (14) is the general expression for electric field on the equatorial line of electric dipole.

Q. Electrical field due to a point charge—



Electric field can be defined as force acting per unit test charge. Force between source charge test charge—

$$F = \frac{1}{4\pi\epsilon_0} \times \frac{qq_0}{r^2} \quad \dots(1)$$

By defⁿ of electric fields

$$E = \frac{F}{q_0} \quad \dots(2)$$

Using eqn. (1)

$$E = \frac{1}{4\pi\epsilon_0} \times \frac{qq_0}{r_2q_0}$$

$$\therefore \boxed{E = \frac{1}{4\pi\epsilon_0} \times \frac{q}{r^2}} \quad \dots(3)$$

Its unit vector form—

$$\vec{E} = \frac{1}{4\pi\epsilon_0} \times \frac{q}{r^2} \hat{n} \quad \dots(4)$$

The direction of electric field and unit vector is in the same direction. By defⁿ of unit vectors

$$\hat{n} = \frac{\vec{r}}{r} \quad \dots(5)$$

Using in eqn. (4)

$$\vec{E} = \frac{1}{4\pi\epsilon_0} \times \frac{q}{r^2} \times \frac{\vec{r}}{r}$$

$$\boxed{\vec{E} = \frac{1}{4\pi\epsilon_0} \times \frac{q}{r^3} \times \vec{r}} \quad \dots(6)$$

Eqn. (6) is the vector form of electric field.

By defⁿ of displacement or position vectors

$$\vec{r} = x\hat{i} + y\hat{j} + z\hat{k} \quad \dots(7)$$

$$\therefore \left(\frac{\vec{r}}{r} \right) = \sqrt{x^2 + y^2 + z^2}$$

$$r = (x^2 + y^2 + z^2)^{1/2}$$

$$\therefore r^3 = (x^2 + y^2 + z^2)^{1/2 \times 3} \quad \dots(8)$$

Using eqn. (7) & (8) in eqn. (6)

$$\boxed{\vec{E} = \frac{1}{4\pi\epsilon_0} \times \frac{qx\hat{i} + y\hat{j} + z\hat{k}}{(x^2 + y^2 + z^2)^{3/2}}} \quad \dots(9)$$

Eqn. (9) is the standard eqn. for electric field is vector form—

Taking its x, y & z – components :

$$\left[\begin{aligned} E_x &= \frac{1}{4\pi\epsilon_0} \times \frac{q}{(x^2 + y^2 + z^2)^{3/2}} x \\ E_y &= \frac{1}{4\pi\epsilon_0} \times \frac{q}{(x^2 + y^2 + z^2)^{3/2}} y \\ E_z &= \frac{1}{4\pi\epsilon_0} \times \frac{q}{(x^2 + y^2 + z^2)^{3/2}} z \end{aligned} \right] \quad \dots(10)$$