# Physics - 2020

**Full Marks : 70** **(Time: 3 Hours)** **Pass Marks : 23**

**General Instructions :**

- Group-A has 15 objective type questions each of 1 mark.
- Group-B has 8 questions, each of 2 marks.
- Group-C has 8 questions, each of 3 marks.
- Group-D has 3 questions, each of 5 marks.

## Group - A

1. Answer the following questions: 1x15=15

(i) A positively charged body has
(a) excess of electrons (b) deficit of electrons
(c) excess of protons (d) deficit of protons

Ans. (b)

(ii) If a uniform wire of resistance 16Ω is cut into four equal parts and attached in parallel combination, the equivalent resistance is
(a) 1Ω (b) 4Ω
(c) $\frac{1}{4}\Omega$ (d) $\frac{1}{16}\Omega$

Ans. (a)

(iii) Kirchhoff's point rule is a direct consequence of law of conservation of
(a) Energy (b) Linear momentum
(c) Angular momentum (d) Charge

Ans. (a)

(iv) Two long parallel wires each carrying a current of 1A in the same direction, are placed 1m apart. The force of attraction between them is.
(a) $2\times10^{-7}\,Nm^{-1}$ (b) $2\times10^{-4}\,Nm^{-1}$
(c) $1\times10^{-7}\,Nm^{-1}$ (d) $4\times10^{-7}\,Nm^{-1}$

Ans. (a)

(v) The phase difference between current and voltage in an ac circuit containing resistance only is
(a) 180° (b) 90°
(c) 60° (d) 0°

Ans. (d)

(vi) Electromagnetic waves can be deflected by
(a) electric field only (b) magnetic field only
(c) both electric and magnetic fileds
(d) none of these

Ans. (d)

(vii) If the refractive indices of water and glass are 4/3 and 3/2 respectively. The refractive index of glass with respect to water is
(a) 1/2 (b) 9/8
(c) 8/9 (d) 2

Ans. (b)

(viii) If the focal length of objective lens of an astronomical telescope is 20 cm and the length of it is 25cm, the magnification of teh telescope for normal adjustment is.
(a) 5 (b) 4
(c) 1.25 (d) 1

Ans. (c)

(ix) Huygens' wave theory of light cannot explain.
(a) Reflection of light (b) Refraction of light
(c) Total internal reflection
(d) Photoelectric effect

Ans. (d)

(x) The momentum of a photon of frequency v is.
(a) $\frac{h}{c}$ (b) hc
(c) hv (d) $\frac{hv}{c}$

Ans. (d)

(xi) If the radius of the first Bohr's orbit is r, the radius of second Bohr's orbit is.
(a) 2r (b) 4r
(c) r/2 (d) r/4

Ans. (b)

(xii) The nuclear radius is of the order of
(a) $10^{-10}$m (b) $10^{-12}$m
(c) $10^{-15}$m (d) $10^{-19}$m

Ans. (c)

(xiii) When $_7N^{14}$ nuclei are bombarded by neutrons and the resultant nuclei are $_6N^{14}$, the emitted particles will be
(a) Proton (b) Neutrino
(c) Deuteron (d) Electron

Ans. (b)

(xiv) If the forbidden energy gap in a substance is 1 eV, substance is a
(a) Conductor (b) Semiconductor
(c) Insulator (d) Superconductor

Ans. (b)

Ans. (b)

(xv) In a semiconductor, the electrical conductivity is due to

(a) electrons only (b) holes only

(c) electrons and holes both

(d) none of these

Ans. (c)

**Answer the following questions:** 2x8=16

2. **What are electric field lines? Mention any two of its properties.** 1+1

Ans. Electric field lines:-

Electric field lines are curved or straight imaginary lines in the electric field such that the tangent at any point on the filed lines gives the direction of the electric field at that point.

**Properties of electric field lines:-**

Electric field lines are imaginary line

Two electric field lines cannot cross each other.

3. **An infinite line chagre produces an electric field of $1\cdot8\times10^{5}NC^{-1}$ at a distance of 2 cm. Calculate the linear charge density.**

Ans. Given,

$d = 0.02m$

$E = 1.8\times10^{5}NC^{-1}$

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

$$\lambda = 2\pi\varepsilon_0 dE = \frac{4\pi\varepsilon_0 dE}{2}$$

$$= \frac{0.02\times1.8\times10^{5}}{2\times9\times10^{9}}$$

$$= 0.2\mu C/m$$

4. **What are the factors on which the resistance of a conductor depends? Give the corresponding relation.** 1+1

Ans. Factor on which the resistance of a conductor depends:-

(i) Resistivity

(ii) Temperature

(iii) Length

(iv) Cross section Area.

(v) Nature of its material

The corresponding relation is-

$$R = \rho\frac{l}{A}$$

5. **Define diamagnetic and paramagnetic materials.** 1+1

Ans. Diamagnetic Materials:-

The materials which are weakly magnetised in a direction opposite to the direction of applied magnetic field are known as diamagnetic material's

Paramagnetic Materials

The materials which are weakly magnetised in the direction of applied magnetic field are known as paramagnetic materials.

6. **Define coefficient of self induction and coefficient of mutual induction.** 1+1

Ans. Coefficientof self induction:-

Co-efficient of self induction is the magnetic flux linked with a coil, when a unit current flow through it.

Co-efficientof mutual induction:

The co-efficient of mutual induction of a pair of coils is the magnetic flux linked with one of the coil when a unit current passes through the other coil.

7. **Name six types of electromagnetic waves in ascending order in terms of their wavelength.** 2

Ans. Six type of electromagnetic wave in ascending order is .

(i) Gamma Ray

(ii) X-Ray

(iii) Ultraviolet Ray ,

(iv) Visible light

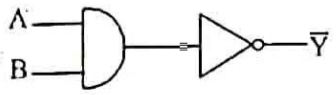
(v) Infrored

(vi) Microwave

(vii) Radio wave

8. **The output of an AND gate is connected to the input of a NOT gate. Draw the logic circuit of this combination of gates and write the truth table.** 1+1

Ans. Cricuil diagram:-



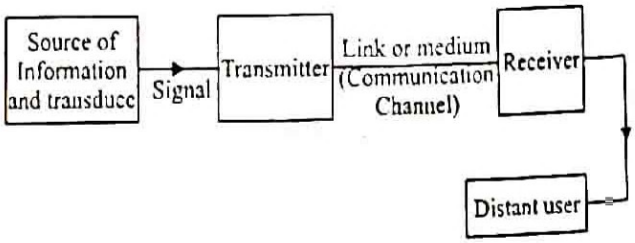

Truth table:

| A | B | y = A. B | $\overline{y}$ |
|---|---|---|---|
| 0 | 0 | 0 | 1 |
| 0 | 1 | 0 | 1 |
| 1 | 0 | 0 | 1 |
| 1 | 1 | 1 | 0 |

9. **What do you understand by communication system? What are its essential elements?** 1+1

Ans. Communication System :- Communication is processing and faithful transfer of the information or signal from one place to other using some special method.

Element of Comminicaton System:-

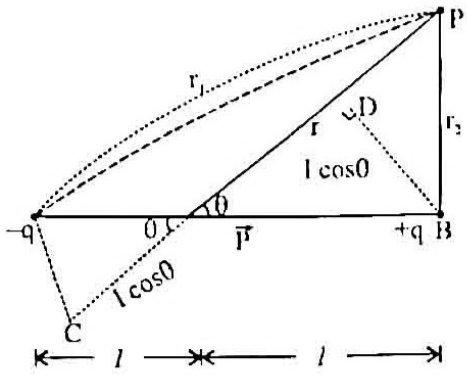


## Group-C

**Answer the following questions:** 3x8=24

**10. Derive an expression for the electric potential at a point in axial position duet to an electric dipole.** 3

**Ans.** Consider any point P at a distance r from the centre (O) of the electric dipole AB. Let OP make an angle Q with the dipole moment $\vec{p}$. Let $r_1$ and $r_2$ be the distances of point P from -q charge and +q charge of the dipole respectively (figure).




Step 1 Potential at P due to -q charge

$$v_1 = \frac{1}{4\pi\varepsilon_0}\frac{(-q)}{r_1}$$

Potential at P due to +q charge

$$v_2 = \frac{1}{4\pi\varepsilon_0}\frac{q}{r_2}$$

$\therefore$ Using principle of superposition, potential at P due to the dipole

$$V = V_1 + V_2$$

or, $$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r_1} + \frac{1}{4\pi\varepsilon_0}\frac{q}{r_2}$$

or, $$V = \frac{q}{4\pi\varepsilon_0}\left[\frac{1}{r_2} - \frac{1}{r_1}\right] \quad ...(i)$$

Step 2: Draw a perpendicular from A which meets the line OP at C when procduced backward. Also draw BD perpendicular on OP.

Then $r_1 = AP = CP = OP + OC = r + l\cos\theta$

($\because$ from $\Delta AOC$, $UC = l\cos\theta$)

and $r_2 = BP = DP = OP - OD = r - l\cos\theta$

($\because$ from $\Delta BOD$, $OD = l\cos\theta$)

Step 3: Sabstituting the values of $r_1$ and $r_2$ in eqn. (i), we get,

$$V = \frac{q}{4\pi\varepsilon_0}\left(\frac{1}{(r - l\cos\theta)} - \frac{1}{(r + l\cos\theta)}\right)$$

$$= \frac{q}{4\pi\varepsilon_0}\left[\frac{r + l\cos\theta - r + l\cos\theta}{r^2 - l^2\cos^2\theta}\right]$$

$$V = \frac{q}{4\pi\varepsilon_0}\left(\frac{2l\cos\theta}{r^2 - l^2\cos^2\theta}\right)$$

$$= \frac{q\,2l\cos\theta}{4\pi\varepsilon_0(r^2 - l^2\cos^2\theta)}$$

Since, $q \times 2l = p$, where p is dipole moment.

$$\therefore \quad V = \frac{P\cos\theta}{4\pi\varepsilon_0(r^2 - l^2\cos^2\theta)}$$

Step 4: If the point of obervation P is far away from the centre of the electric dipole (i.e., $r >> l$),

the eqn. (ii), becomes $$V = \frac{P\cos\theta}{4\pi\varepsilon_0 r^2}$$

Since $p\cos\theta = \vec{p}.\hat{r}$, where $\hat{r}$ is unit vector directed along OP.

then, $$V = \frac{\vec{p}.\hat{r}}{4\pi\,\epsilon_0\, r^2}$$

**11. State the principle of potentiometer. Compare the electromotive force of two cell using potentiometer. 1+2**

**Ans.** Principle of Potentiometer:- It works on the principle that potential difference across any part of a uniform wire is directly proportional to the length of that portion, when a constant current flows through the wire.

Comparison of e.m.fs of two cells using potentiometer:- The circuit diagram of the potentiometer used to compare the e.m.f.s of two cell under comparison.

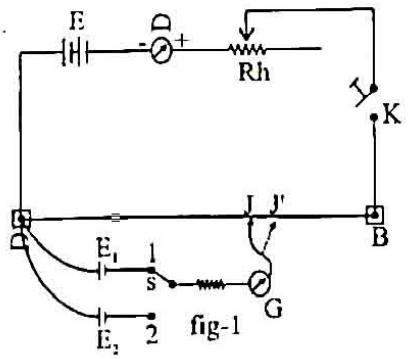



fig-1

Step:1 When suritch $s_1$ is connected to the circuit

$$E_1 = V_{AJ} \quad ...(i)$$

According to the principle of the potentiometer,

$V_{AJ} \propto l_1$ or $V_{AJ} = kl_1$ ...(ii)

Hence eqn. (i) become

$E_1 = kl_1$

Step :2 When suritch $s_2$ is connecte to the circuit

$E_2 = V_{AJ}$ ...(iii)

If $l_2$ be the length between A and J', then

$V_{AJ'} \propto l_2$ or $V_{AJ'} = kl_2$

Hence eqn. (iii) becomes

$E_2 = kl_2$ ...(iv)

Dividing (ii) by(iv), we get,

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

Knowing the value of $l_1$ and $l_2$, we can find $\frac{E_1}{E_2}$

**12. An object is placed at a distance of 60 cm from a concave lens of focal length 15cm. Determine the magnification of the lens.**

**Ans.** Given,

$4 = 60\,cm$

$6 = 15\,cm$

By uisng lens formula,

$$\frac{1}{6} = \frac{1}{v} - \frac{1}{4}$$

$$\frac{1}{15} = \frac{1}{v} + \frac{1}{60}$$

$$\Rightarrow \frac{1}{v} = \frac{1}{15} - \frac{1}{60} = \frac{1}{20}\,cm$$

$v = 20\,cm$

Magnification, $m = \frac{v}{4} = \frac{-20}{60} = \frac{-1}{3}$

$\therefore \quad M = \frac{1}{3}$

**13. What do you understand by the term 'interference of light'? Mention the necessary conditions for sustained interference. 1½+1½**

**Ans.** Interference of light:- The phenomenon of redistricbution of light energy due to the super-posttion of light waves from two conerent source is known as interference of light.

The necessary conditions for sustained interference is-

(i) The two ources of light must be coherent source.

(ii) The two sources of light sould be narrow sources.

(iii) The distance between the two sources should be small.

(iv) The amplitude of two interfering waves should either be equal or nearly equal or nearly equal.

(v) The distance between the screen and slits should be as large as possible.

**14. What is photoelectric effect? Define threshold frequency and stopping potential. 1+1+1**

**Ans.** Photoelectric Effect:- The phenomenon of emission of electrons from preferably metal surface exposed to light energy of suitable frequency is known as photoelectric effect.

Threshold frequency (V0):- The minimum frequency of incident light which causes photo emission with zero K.E. of photoelectrons. The corresponding wavelength of lightis called threshold wavelength.

Stopping Potential (Vo):- The negative value of potential given to the anode which repels all the electrons emitted by the cathode to reach the anode is called stopping potential.

**15. Mention Rutherford's nuclear atomic model. What are its drawbacks? 2+1**

**Ans.** Rutherford Atomic Model:-

(i) Entire positive charge and almost the all mass of the atom is concentrated in a small central core called nucleus.

(ii) The nucleus is surrounded by a suitable number of electrons so that the atom is electrically neutral.

(iii) The electron revolve around the nucleus in various orbits. The necessary centripetal force is provided to them by the electrostatic force of attraction between the electrons and the nucleus.

**Drawbacks :**

(i) It could not explain about the stability of an atom i.e., how both positive and negative charges could remains so close together.

(ii) It couldn't explain the results of experiments such as alpha ray scattering experiment, carried out be other scientists.

**16. Define semiconductor. Explain different types of semiconductor. 1+2**

**Ans.** Semiconductor:-

The solid having resistivity or conductivity in between metals and insulator are termed as semiconductor.

Type of semiconductor

(i) Elemental semiconductor

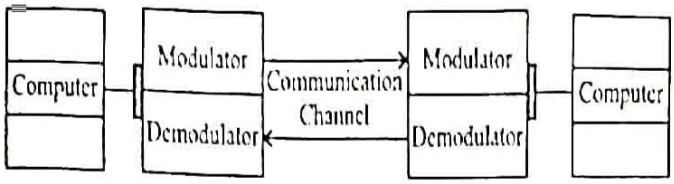
(ii) Compound semiconductor

**17. Define Modem. With the help of a block diagram diagram explain the function of modem between two computers. 1+2**

**Ans.** Modem:- The device which can transfer data from one computer to another commuter at a distant place, is known as modem.

It acts both as modulator and demodulator. The term 'Modem' is extracted from these two types of functions of the devices.

Working of the modem may be expressed as follows.

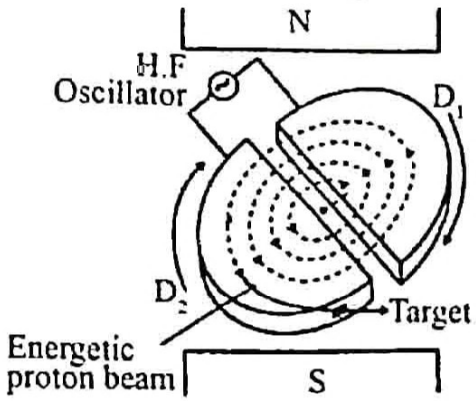



## Group-D

**Answer the following questions :** 5x3=15

**18. With the help of a diagram describe the principle, construction and working of a cyclotron.** 1+1+3

Ans.




Principle: A cyclotron is device to accelerate positively charged particles to a very high energy level. It works on the principles that a positively charged particle becomes capables of being accelerated at a high energy level when it crosses an electric field again and again under the effect of a very strong magnetic field.

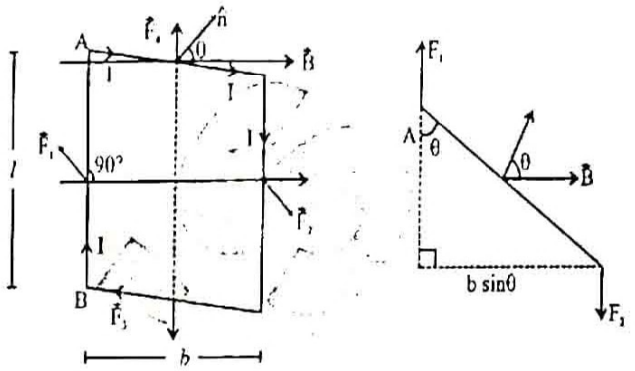
Construction: $D_1$ and $D_2$ are two semicircular dies with small gap between them. The dees are connected to a source which produces high frequency alternating electric field between the dees. The dees are placed between the poles of an electromagnet. The magnetic field so produced is perpendicular to the plane of the dees.

Working: the positively charged particle is placed between the centre of the gap of dees. ..... and the positively charged is produced b/w these dees. The particle in accelerated towards the D which is negatively charged. This polarity changes of the dees and the particle is accelerated again and attracted by the other dees. The particle covers a circular path and the velocity of the particle increases, energy time the particle moves from one dees to the other. When the radius of the circular path covered by the particle becomes equal to radius of the dee, the particle is taken out from the dees and hit the target.

**OR / अथवा**

**Derive an expression for the torque acting on a current carrying rectangular coil placed in a uniform magnetic field.** 5

Ans.




Consider a rectangular conducting coil. ABCD of length l and b placed in a uniform magnetic field $\vec{B}$. Let I be the current flowing in the loop in clockwise direction. Let $\theta$ be the angle between the normal by the plane of the loop and the magnetic field $\vec{B}$.

We know, force acting on a conductor of the length l caring current I in the magnetic field is give by.

$$\vec{F} = I\left(\vec{l} \times \vec{B}\right)$$

$\therefore$ Force acting on the arm AB on the loop $\vec{B}$.

$$\vec{F}_1 = I\left(\vec{l} \times \vec{B}\right) \quad \text{...(i)}$$

Direction of $\vec{F}$ is perpendicular to the arm AB and directed inside of the sheet of paper.

Similarly, force acting on the arm CD of the coil,

$$\vec{F}_2 = I\left(\vec{l} \times \vec{B}\right)$$

or $F_2 = BIl$ ...(ii)

$\vec{F}_2$ is perpendicular to the length of arm CD and is directed outside the sheet of the paper.

Farce, $\vec{F}_3$ acting on the arm BC and force, $\vec{F}_4$ acting on the arm DA of the loop are equal, oppasite and act along the same line, hence they cancel each other.

Therefore, only two force $\vec{F}_1$ and $\vec{F}_2$ act on the coil. It form a couple and try to ratate the coil clockwise.

The magnitude of the tarque I due to force $\vec{F}_1$ and $\vec{F}_2$ is given by,

T = magnitude of either farce x lever arm

$= F_1 \times DN$

$= BTl \times b\sin\theta$

$= I(l\,b)B\sin\theta$

$= IAB\sin\theta$ (Sice, lb = A, area of loop)

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

In vetor from, $\vec{\tau} = I(\vec{A}\times\vec{B})$

**19. (a) Derive an expression for average or mean value of alternating current for half cycle. 2½+2½**

**(b) Derive an expression for root mean square value of alternating current for one full cycle. 2½+2½**

**Ans.** (a) Derivation of expression mean value of a.c for half cylce:

Let an a.c be represented by, $I = I_0 \sin wt$

The charge sent by the a . c I in time dt is given by,

$dq = I\,dt = I_0 \sin wt\,dt$

$\therefore$ The charge sent by a.c in the half cycle i.e., t = 0 to t = T/2 is given by

$$\int dq = \int_0^{T/2} I_0 \sin wt\,dt$$

$$q = I_0 \int_0^{T/} \sin wt\,dt = I_0\left[-\cos\frac{wt}{w}\right]_0^{T/2}$$

$$= \frac{-I_0}{W}[\cos wt]_0^{T/2} = \frac{I_0}{2\pi/T}\left[\cos\frac{2\pi}{T}t\right]_0^{T/2} \quad \left[\therefore w = \frac{2\pi}{T}\right]$$

$$= -\frac{I_0}{2\pi}\left[\cos\frac{2\pi}{T}\times\frac{I}{2} - \cos 0\right]$$

$$q = -\frac{I_0 T}{2\pi}(-1-1) = \frac{I_0 T}{\pi} \qquad ...(i)$$

Let $I_{av}$ be the mean value of a.c. over positive half cycle, then charge sentby it in the T/2 is givn by,

$$q = I_{av}\frac{T}{2} \qquad ...(ii)$$

A/c to definitions, eqn (i) = eqn (ii)

$$I_{av}\times\frac{T}{2} = \frac{I_0 T}{\pi}$$

$$\text{or } I_{av} = \frac{2I_0}{\pi} = 0.631 I_0$$

(b) Derivation of an expression for RMS value of an alternating current for one full cycle:

Let an a.c. $I = I_0 \sin wt$ flow through a conductor of resutence R for time dt.

Then, heat produced in the conductor is given by,

$dH = I^2 R\,dt$

or $dH = I_0^2 R\sin^2 wt\,dt$

Now heat produced in the conductor, when current flows for time period T i.e., from t = 0 to t = T is given by,

$$\int dH = \int_0^T I_0^2 R\sin^2 wt\,dt$$

$$\text{or} \quad H = I_0^2 R\int_0^T \sin^2 wt\,dt$$

$$\therefore H = \frac{I_0^2 R}{2}\int_0^T \frac{(1-\cos 2wt)\,dt}{2} \quad \left(\because \sin^2 wt = \frac{1-\cos 2wt}{2}\right)$$

$$= \frac{I_0^2 R}{2}\int_0^T dt\int_0^T \cos 2wt\,dt = \frac{I_0^2 R}{2}\left[[t]_0^T - [\sin 2wt]_0^T\right]$$

$$= \frac{I_0^2 R}{2}\left[(T-0) - \frac{1}{2w}\left[\sin 2\times\frac{2\pi}{T}t\right]_0^T\right]$$

$$= \frac{I_0^2 R}{2}\left[T - \frac{1}{2w}\sin 2\times\frac{2\pi}{T}\times T - \sin 0\right]$$

As $\sin 0 = \sin 4\pi = 0$

$$H = \frac{I_0^2 R}{2}T \qquad ...(i)$$

Let Irms be the raot mean square value of ac which flows through the conductor of resistance R for time T.

$\therefore \quad H = I_{rms}^2 RT \qquad ...(ii)$

A/c to definition rms, value of a.c., equ. (i) = equ. (ii)

$$\therefore \quad I_{rms}^2 RT = \frac{I_0^2 RT}{2} \quad \text{or } I_{rms} = \frac{I_0}{\sqrt{2}} = 0.707 I_0$$

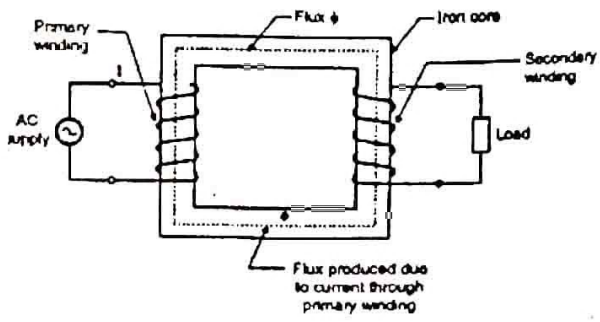
**OR**

**What is a transformer? Describe the principle, construction and working method of a transformer.**

**Ans.** Transformer is a device used to convert low a.c. voltage at higher current into high a.c. voltage at low current and vice-versa.

**Principle:**

A transformer is based on the principle of mutual induction. An emf induced in a coil, when it changing current flows though its nearby coil.



Construction :- It consists of the separate coils of insulated wire wound on same iron care one of the coil connected to a.c. input is called primary (p) and the other winding giving output is called secondary (s) coil.

The primary coil is connected to a source of a.c. voltage (Ep). The primary coil along with a source of a.c. voltage is called primary ckt. The output a.c valtage (Es) is taken across the secondary coil and the load is connected to this winding. The secondary coil along with load is called secondary ckt.

Working:- A 'c to for aday's low emf induction, the induced emf in the primary coil is

$$E_p = -N_p \frac{d\theta}{dt} \qquad ...(i)$$

and induced emf in the secondary coil is

$$E_s = -Ns\frac{d\phi}{dt} \qquad ...(ii)$$

Dividing from (ii) i we get

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

Where, $\frac{N_s}{N_p} = k$, transformater ratio or turne ratio

Then, $\frac{E_s}{E_p} = \frac{N_s}{N_p} = k$

k > 1 for stepdown transformer

k > 1 for stepup transformer.

**20. Derive the lens maker's formula for a thin lens: 5**

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

**Ans.** Consider a lens made of a material of absolute refractive index n2. This lens is placed in a medium of absolute refractive index n2. The lens is bounded by two spherical refracting surface $xP_1y$ and $xP_2y$. $C_1$ and $C_2$ be their centre of curvature and $R_1$ and $R_2$ be their radii of curvature respectively. C is the optical centre of the lens.

Let O be a point object lying in the rarer medium on the principal axis of the refracting surface $xP_1y$. The incident ray OA after refraction at A bend towards the normal AC, and meets the principal axis at image of the object O.

Since, object lies in the rarer medium, so we have

$$-\frac{\mu}{u} + \frac{\mu_2}{v_1} = \frac{\mu_2 - \mu_1}{R_1} \qquad ...(i)$$

In fact, the ray AB refracted by the first surface $xP_2y$ i refracted at B by the surface $xP_2y$ and it finally meets the principle axis at I. The point $I_1$ act as virtual object placed in the denser medium for the spherical surface $xP_2Y$. Now it is the situation, when object is placed in the denser medium and image is formed in the rarer medium.

$$\therefore \quad -\frac{\mu_1}{u} + \frac{\mu_2}{v} = \frac{\mu_1 - \mu_1}{R} \qquad ...(ii)$$

Adding equ. (i) and (ii), we get,

$$-\frac{\mu_1}{u} + \frac{\mu_2}{v} = \mu_2 - \mu_1\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\text{or, } \frac{\mu_1}{u} + \frac{\mu_2}{v} = \left(\frac{\mu_2}{\mu_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\text{or } -\frac{1}{u} + \frac{1}{v} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

where $\mu = \frac{\mu_2}{\mu_1}$

**OR**

**What do you understand by the term 'interference'? Describe Young's double slit experimentand discuss the formation of fringes. 1½+2+1½**

**Ans.** Interference of light:- The phenomenon of redistribution of light energy due to superposition of light waves from two coherent source is known as interference of light.

Young's Double shit experiment:- As per Huygens's principle, slit S send wave front in all direction. In this fig., dotted ares represent the troughs and solids one represent the creates of the waves. Slits S1 and S2 become the source of secondary wavelets which are in phase and of same frequency when they reach point O on the screen because path S1O and S2O are equal. In this case, crease of one wave falls on the crest of the other wave and through of one waves falls on the fraught of the other. The constructive interference is represented by dote (.) in the fig., This effect become maximum at point O, so it known as central maxima.

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