PHYSICS ANSWER KEY & SOLUTION

SECTION - A

PHYSICS						
Que.	**1**	**2**	**3**	**4**	**5**	**6**
Ans.	1	4	3	1	2	4

SOLUTION SECTION 'A'

Ans :- 2
1. Negative
2. 400 nm to 800 nm.
3. One
4. Critical Angle
5. Decreases
6. $\frac{h}{2\pi}$

Ans :- 3
1. False
2. True
3. True
4. True
5. True

Ans :- 4 1-iii, 2-i, 3-ii, 4-v, 5-vi, 6-iv

Ans :- 5
1. $B\alpha\frac{1}{R}$
2. The drift velocity of electrons is grater than that of holes.
3. 10^{-14} m
4. Coherent sources
5. J.J.Thomson

SOLUTION SECTION 'B'

Ans :- 6 (i) In an a.c. circuit containing only inductance the current laging behing by 90^o with voltage.

(ii) In an a.c. circuit containing only containing only capacitance the current leads by 90^o with voltage.

OR

In a.c circuit, when the average consumed power is zero, then that current is called wattless current. By using choke coil in A.C. circuit wattless current can be obtained practically.

Ans :- 7 In this position, magnetic moment of each pieces will be M' = $m'\times 2l$

But $m' = \frac{m}{2}$

$\therefore$ $M' = \frac{m}{2}\times 2l = ml = \frac{M}{2}$

Therefore magnetic moment will become half of its initial value.

OR

A current carrying solenoid has its magnetic moment, just like a bar magnet Magnetic moment M= NIA

Here N = 800 ; A = $2.5\times10^{-4}\,m^2$, I = 3.0 A

$\therefore \quad M = 800\times3.0\times2.5\times10^{-4}\,JT^{-1}$

$= 0.60\,JT^{-1}$

Ans :- 8 (i) Microwaves : in radar

(ii) Infrared rays : Radiation purpose in some diseases.

(iii) Ultraviolet rays : for killing germs.

(iv) $\gamma-$ Rays : for treatment of cancer.

OR

Given : $\upsilon_1 = 7.5MHz = 7.5\times10^6\,Hz,\ \upsilon_2 = 12MHz = 12\times10^6\,Hz$

$$\therefore \quad \lambda_1 = \frac{c}{\upsilon_1} = \frac{3\times10^8}{7.5\times10^6} = 40m$$

$$\lambda_2 = \frac{c}{\upsilon_2} = \frac{3\times10^8}{12\times10^6} = 25m$$ **Ans.**

Ans :- 9 $$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$$

f_1 = -f and f_2 = f

$$\therefore \quad \frac{1}{F} = \frac{1}{-f} + \frac{1}{f} = 0$$

or F = 0

and power $$P = \frac{100}{f} = \frac{100}{\infty} = 0.$$

OR

(i) On the pair of medium: Refractive index of denser medium with respect to rarer medium is always greater than 1 but refractive index of rarer medium with respect to denser medium is less than 1.

(ii) Density of the medium: If optical density of any medium is more than its refractive index will also be more.

(iii) Wavelength of light: If the wavelength is less more is the refractive index and more the wavelength less is the refractive index.

(iv) Temperature of medium: On increasing temperature, it becomes optically rarer hence refractive index decreases

Ans :- 10 The negative potential of anode for which the phooelectric current becomes zero is called stopping potential or cut off potential.

OR

Given : $\lambda = 4000\text{Å} = 4000\times10^{-10}\,\text{m}$

or $\lambda = 4\times10^{-7}\,\text{m}$

Formula: $E = h\upsilon$ or $E = \frac{hc}{\lambda}$

Where h (Plank's constant) = $6.6\times10^{-34}\,\text{J sec}$

$c = 3\times10^{8}\,\text{m / sec}$

Putting the values in the formula

$$E = \frac{6.6\times10^{-34}\times3\times10^{8}}{4\times10^{-7}}$$

or $E = 4.97\times10^{-19}$ joule. **Ans.**

Ans :- 11 Energy in gorund state of hydrogen atom E_1 = -13.6 eV

Energy in n = 4 state $E_4 = \frac{-13.6}{4^2} = -0.85\text{ev}$

$\therefore$ Energy of photon = $E_4 - E_1$ = -0.85 + 13.6 = 12.75 ev

$\because$ $h\upsilon$ = E and c = $\upsilon\lambda$

$\therefore$ $h\times\frac{c}{\lambda} = E$

or $\lambda = \frac{hc}{E} = \frac{6.62\times10^{-34}\times3\times10^{8}}{12.75\times1.6\times10^{-19}}$

$\Rightarrow$ $\lambda = 973\times10^{-10}\,\text{m} = 973\text{Å}$

OR

Bohr's quanitization condition : The electron can revolve only in those orbits in which the angular momentum of electron is integral multiple of $\frac{h}{2\pi}$.

If L is angular momentum then $L = mvr = \frac{nh}{2\pi}$, where $n = 1, 2, 3...$

and h is planck's constant.

Ans :- 12 Properties of nuclear forces :

(i) Nuclear forces are attraction force,
(ii) These forces does not depend on charge,
(iii) These forces are short range forces,
(iv) The are strong forces,
(v) The nuclear forces are not central forces.

Let the mass number of a nucleus is A and radius is r then volume of nucleus be

$$V = \frac{4}{3}\pi r^3$$

$\therefore$ Density of nucleus $\rho = \frac{M}{V} = \frac{A}{\frac{4}{3}\pi r^3}$

But $r = r_0 A^{1/3}$

Putting value $\rho = \frac{A}{\frac{4}{3}\pi r_0^3 A} = \frac{3}{4\pi r_0^3}$

or $\rho =$ constant

Thus, it is clear that material density of a nucleus is independent of its mass number.

OR

$a + 36 + 0 = 92$

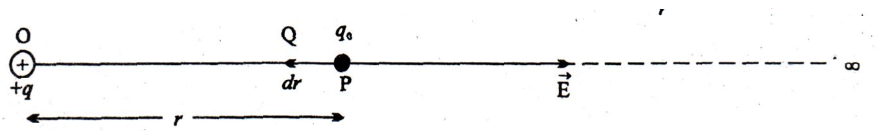
$\therefore$ $a = 56$ **Ans.**

and $141 + b + 3 = 236$

$\therefore$ $b = 92.$ **Ans.**

SOLUTION SECTION 'C'

Ans :- 13 Consider a point charge q placed at origin O. Potential at P has to be found out.Let the medium between charge 'q' and P has dielectric constant ε_r.



Electric field at P due to charge q is .

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

The electric field $\vec{E}$ points away from the charge q. A force $\vec{F}=-q_0\vec{E}$ has to be applied on the charge so that it can be brought near to q. The small work required to move the test charge q_0 from P to Q through a small distance dr is given by

$$dw = f.dr$$
$$dw = q_o\,Edr$$

The total work done in moving the charge q_o from infinity to point P will be obtain by integrating the above equation as

$$\int_0^w dw = r\int_\infty^w -q_0 Edr$$

$$\Rightarrow \quad (W)_0^w = -q_0\int_\infty^r Edr$$

$$\Rightarrow \quad W - 0 = -q_0\int_\infty^r \frac{q}{4\pi\varepsilon_0\varepsilon_r r^2}dr$$

$$\Rightarrow \quad W = \frac{-q_0 q}{4\pi\varepsilon_0\varepsilon_r}\int_\infty^r \frac{1}{r^2}dr = \frac{-q_0 q}{4\pi\varepsilon_0\varepsilon_r}\left(-\frac{1}{r}\right)_\infty^r$$

$$= \frac{-q_0 q}{4\pi\varepsilon_0 \varepsilon r}\left[\left(-\frac{1}{r}\right) - \left(-\frac{1}{\infty}\right)\right]$$

$$\Rightarrow \qquad W = \frac{q_0 q}{4\pi\varepsilon_0 \varepsilon_r r}$$

But electric potential is defined as work done per unit test charge

$$V = \frac{W}{q_0} = \frac{q}{4\pi\varepsilon_0 \varepsilon r}$$

$\therefore$ Potential at P is
$$V = \frac{1}{4\pi\varepsilon_0 \varepsilon r}.\frac{q}{r}$$

If medium between q and q_0 in vacuum then $\varepsilon_r = 1$

Then, $V = \frac{1}{4\pi\varepsilon_0}.\frac{q}{r}$

This is the required expression.

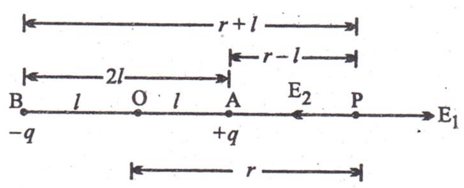
OR

Electric dipole : A system having two equal and opposite charges kept very close to each other is called electric dipole.

Derivation: Consider an electric dipole made up of charges + q and - q separated by a distance 2l apart and placed in vacuum. We have to find out the electric field at point p situated at a distance r from the centre of di pole system.

To find out the electric field intensity imagine a unit positive test charge situated at P.

Electric field intensity due to charge (+q) situated at A will be



$$\vec{E}_1 = \frac{1}{4\pi\varepsilon_0}.\frac{q}{AP^2}, (\text{along } \overrightarrow{AP})$$

$$= \frac{1}{4\pi\varepsilon_0}.\frac{q}{(r-l)^2}, (\text{along } \overrightarrow{AP})$$

$$\therefore \qquad E_1 = \frac{1}{4\pi\varepsilon_0}.\frac{q}{(r-l)^2}, (\text{in magnitude form})$$

Electric field intensity due to charge (-q) situated at B will be

$$\vec{E}_2 = \frac{1}{4\pi\varepsilon_0}.\frac{q}{BP^2}, (\text{along } \overrightarrow{PB})$$

$$= \frac{1}{4\pi\varepsilon_0}.\frac{-q}{(r+l)^2}, (\text{along } \overrightarrow{PB})$$

$\therefore \quad \vec{E}_2 = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{BP^2}$, (in magniotude form)

As AP < PB, hence repulsive effect due to charge + q will be more than the attractive effect of charge - q. Therefore, $E_1 > E_2$, but their directions are opposite.
Hence, the net electric field will be

$$E = E_1 - E_2 = \frac{1}{4\pi\varepsilon_0}\frac{q}{(r-l)^2} - \frac{1}{4\pi\varepsilon_0}\frac{q}{(r+l)^2}$$

$$= \frac{q}{4\pi\varepsilon_0}\left[\frac{1}{(r-l)^2} - \frac{1}{(r+l)^2}\right]$$

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

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

$$= \frac{q}{4\pi\varepsilon_0}\left[\frac{4rl}{(r^2-l^2)^2}\right]$$

$$= \frac{q}{4\pi\varepsilon_0} \cdot \frac{2.2rl}{(r^2-l^2)^2}$$

$$\therefore \quad E = \frac{2pr}{4\pi\varepsilon_0(r^2-l^2)^2}\,N/C, \qquad (\because p = 2ql) .....(1)$$

This is the esxpression for the electric field which is directed from A to P.
For samll and strong dipoles, $r >> 2l \Rightarrow r >> l \Rightarrow r^2 >>> l^2$

$\therefore \quad r^2 - l^2 \approx r^2$

Hence, eqn. (1) becomes

$$E = \frac{1}{4\pi\varepsilon_0}\frac{2pr}{(r^2)^2} = \frac{1}{4\pi\varepsilon_0}\frac{2p}{r^3}\,N/C$$

This is the required expression.

Ans :- 14 The resistance offered by the electrolyte of the cell during the flow of current inside the cell is called its internal resistance.

The following factors affect the internal resistance:

(i) Distance between the electrodes: As the distance increases, the internal resistance increases.

(ii) Area of the immersed electrodes: As the area increases, the internal resistance decreases.

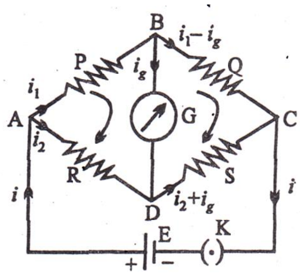
(iii) Concentration of the electrolyte : As the concentration is more, the internal resistance is more.

(iv) Temperature: The increase of temperature, decreases the internal resistance.

OR

Principle of Wheatstone bridge : Four resistances P, Q, R and S are connected to form a quadrilateral ABCD. A cell E is connected across the diagonal AC and a galvanometer across BD. When the current is flown through the circuit and galvanometer does not give any deflection, then the bridge is said to be balanced. In this condition,

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



This is the principle ofWheatstone bridge.

Formula derivation: Let the current us divided into two parts i_1 and i_2, flowing through P, Q and R, S respectively. In the position of equilibrium, the galvanometer shows zero deflection, i.e., the potential of B and D will be equal.

In the closed mesh ABDA, by Kirchhoff's second law, we get

$$i_1P - i_2R = 0$$

or $$i_1P = i_2R$$

Similarly, in the closed mesh BCDB, we have

$$i_1Q - i_2S = 0$$

or $$i_1Q = i_2S$$

Dividing eqn. (1) by eqn. (2), we get

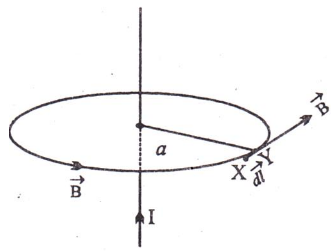
$$\frac{i_1P}{i_1Q}=\frac{i_2R}{i_2S}$$

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

This is Wheatstone bridge principle or principle of balance.

Ans :- 15 **Ampere's circuital law :** Ampere's circuital law states that the line integral of magnetic field $\vec{B}$ around any closed path is equal to μ_0 times the total current I enclosed by the path.

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



Proof : Consider an infinitely long straight conductor carrying current I. The magnetic lines of force are produced around the conductor as concentric circles.

The magnetic field duc to this current-carrying infinite conductor at a distance a is given by

$$B = \frac{\mu_0}{4\pi}\frac{2I}{a}, \qquad \text{...(1)}$$

(from Biot-savart law)

Consider a circle of radius a. Let XY be a small element of length dl. $\vec{dl}$ and $\vec{B}$ are in the same direction because direction of $\vec{B}$ is along the tangent to the circle.

The line integral for the closed path will be

$$\oint \vec{B}.\vec{dl} = \oint B\,dl\cos\theta = \oint B\,dl$$

$$= \oint \frac{\mu_0}{4\pi}\frac{2I}{a}dl \text{ [on putting the value of B from eqn. (1)}$$

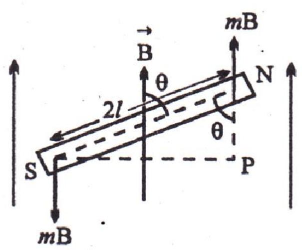
$$= \frac{\mu_0}{4\pi}\frac{2I}{a}\oint dl$$

$$= \frac{\mu_0}{4\pi}\frac{2I}{a}2\pi a. = \mu_o I \qquad \left(\because \oint dl = \text{circumference} = 2\pi a\right)$$

This proves Ampere's circuital law.

OR

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



Suppose m be the pole strength and $2l$ be the effec tive length,

Force acting on each pole will be mB. On the N-pole this force will be along the direction of field, whereas on S-pole this will be opposite to the direction of field. As two equal and opposite forces are acting on it along different line of action, hence a couple acts on it which tries to bring the magnet along the direction of magnetic field. This couple is called 'restoring couple' or 'restoring torque'.

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

$\therefore$ τ = Force × Perpendicular distance

or Torque, τ = mB x SP

Also, in Δ NPS, weget $\sin\theta = \frac{SP}{NS}$

or SP = NS sinθ = $2l\sin\theta$

$\therefore$ Putting the value of SP in eqn. (1),

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

But $\quad m \times 21 = M$ (magnctic moment)

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

1n vector form $\quad \vec{\tau} = \vec{M} \times \vec{B}$

and the direction ofr [l be perpendicular to the plane containing $\vec{M}$ and $\vec{B}$.

Definition of magnetic moment: .

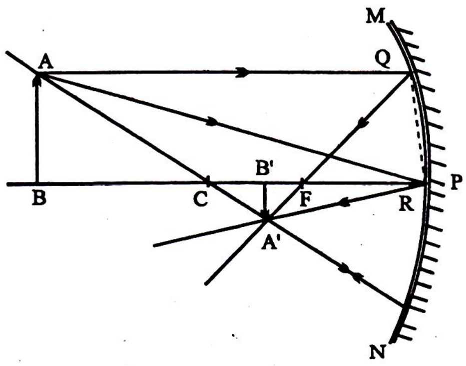
As $\quad \tau = MB\sin\theta$

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

$$\tau_{max} = M$$

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

Ans :- 16 **Focal length :** The distance between the principal focus and pole of mirror is called focal length of spherical mirror.



Let MPN is a concave minor, P is pole, F is a focus and C is its center of curvature.

If A'B' is an image of any object AB placed on principal axis, before the mirror.

Now, join AP and A'P AP is an incident ray and PA' is a reflected ray at point P.

Draw a normal on principal axis from Q.

Now , Δ A'B' F and Δ QRF are similar

$$\therefore \quad \frac{A'B'}{QR} = \frac{FB'}{RF}$$

But, $\quad QR = AB$

$$\therefore \quad \frac{A'B'}{AB} = \frac{FB'}{RF} \quad ......(1)$$

similarly, $\Delta A'B'P$ and ΔABP are similar.

$$\therefore \quad \frac{A'B'}{AB} = \frac{PB'}{RF} \quad ....(2)$$

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

$$\frac{FB'}{RF} = \frac{PB'}{PB}$$

If aperture of mirror is very small, then

$$RF = PF$$

$$\frac{FB'}{PF} = \frac{PB'}{PB}$$

or $\dfrac{PB' - PF}{PF} = \dfrac{PB'}{PB}$

But PB = -u

PB' = -v

PF = -f

$\therefore$ From eqn.(3),

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

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

or -vf = -uv + uf

or uv = vf + uf

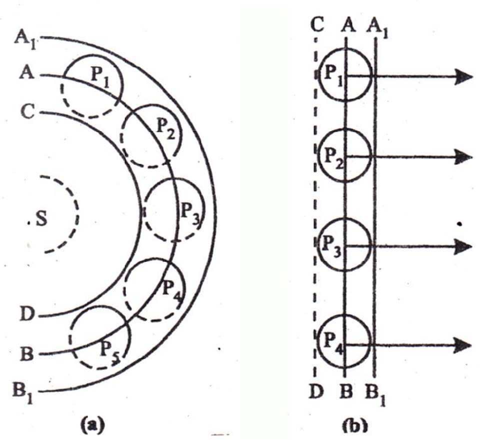
Dividing eqn. (4) by 'uvf ' on both the sides, we will get

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

or $\dfrac{1}{f} = \dfrac{1}{u} + \dfrac{1}{v}$ Proved.

OR

Huygen's secondary waveletstheory :



(i) Each point of wavefront behaves like a new source of light which emits the new wave: These are called secondary wavelets.

(ii) The secondary wavelets advances in the medium with the velocity same as that of the original waves.

(iii) The common tangential surface drawn on these secondary wavelets at any instant shows the position of new wavefront at that instant.

Let S is point type light source AB is a part of spherical wavefront. After time 't' what will be the position of this wavefront it is to be determIined.

According to Huygen's secondary wavelet theory every point of wavefront behaves like a source of light Take points P_1, P_2, P_3, P_4 .... on this wavefront.

The distance travelled by secondary wavelet in time ‘t’ with velocity ‘v’ be vt.

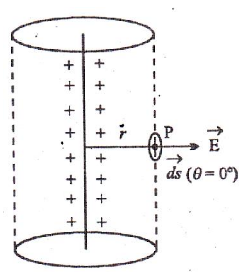
Now by taking P_1, P_2, P_3, P_4 as centre draw circles of radius vt. Now draw a comman tangential surface A_1B_1. It will show the new wavefront

SOLUTION SECTION 'D'

Ans :- 17 Gauss' law : According to Gauss' law, the net electric flux through any closed surface is $1/\varepsilon_0$ times of the total charge present inside it.

$$\therefore \quad \oint_S \vec{E}.\vec{dS} = \frac{q}{\varepsilon_0} \text{ or } \Phi_E = \frac{q}{\varepsilon_0}$$

Where ε_0 is permitivity of vacuum or air.



Let + q charge in given to a this straight wire of length ‘ l ’. then the linear charge density on wire will be

$$\lambda = \frac{q}{l}$$

or $$q = \lambda . l \qquad ......(1)$$

$\therefore$ Consider a point P at distance ‘r’ apart from the wire at which the intensity of electric field is to be obtained.

Let point P lies on a closed (Gaussian) surface. A small surface ds is taken on this surface. The electric flux linked with this cylindrical Gaussian surface will be:

$$\phi = \oint \vec{E}.\vec{ds} = \oint E.ds\cos\theta$$

$\because$ $$\theta = 0^o$$

$\therefore$ $$\phi = \oint E.ds\cos^o = \oint E.ds$$

$$\phi = E.2\pi rl$$

But by Gauss’ theorem

$$\phi = \frac{q}{\varepsilon_0}$$

By eqns. (2) and (3)

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

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

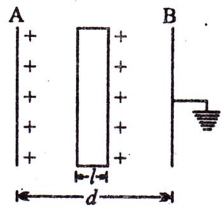
or $$E = \frac{\lambda}{2\pi\varepsilon_0 r}$$

This is required exprsion.

OR

Let A and B are parallel plates of a capacitor. The distance between the plates is d and plate of thickneas t and dielectric constant ε_0 is introduced.

Now, plate A is given charge +Q.



Let the charge density be σ.

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

intensity of field in air,

$$E_0 = \frac{\sigma}{E_0} = \frac{Q}{\varepsilon_0 \varepsilon_{1A}}$$

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

$$\text{Dielectric constant} = \frac{\text{Electric field in vacuum}}{\text{Electric field in medium}}$$

or $$\varepsilon_r = \frac{E_0}{E}$$

or $$E = \frac{E_0}{\varepsilon_r} = \frac{Q}{\varepsilon_0 \varepsilon_r A}$$

Now, potential difference between A and B,

$$V = E_0(d-t) + Et, \qquad [(d\text{-}t) \text{ is vacuum distance}]$$

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

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

$\therefore$ $$C = \frac{q}{v}$$

or $$C = \frac{Q}{\frac{Q}{\varepsilon_0 A}\left[d - t + \frac{1}{\varepsilon_r}\right]}$$

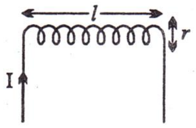
$$\therefore \qquad C = \frac{\varepsilon_0 A}{d - t + \frac{t}{\varepsilon_r}} = \frac{\varepsilon_0 A}{d - t\left(1 - \frac{1}{\varepsilon_r}\right)}$$

This is the required expression

Ans :- 18 **Expression for self-inductance of a long solenoid :** Let the length and radiusof a solenoid be l and r respectively Also n be the number of turns per unit Length.

$\therefore$ Area of cross-section, $A = \pi r^2$

and Total number of turns = n l = N.



If crrent I flows through the solenoid, then the intensity of magnetic field inside the solenoid will be given by

$$B = \mu_0 nI, \qquad \left[\because B = \frac{\mu_0}{4\pi} 2\pi nI\left(\cos 0^\circ - \cos 180^\circ\right)\right]$$

(for unit length if l >> r)

Where, μ_0 is the permeability of the medium.

$\therefore$ Magnetic flux linked with the total length of solcnoid.

$$\therefore \qquad \phi = NBA$$

($\because$ ϕ = BA or BS, for 1 turn; for Nturns, $\phi = NBA$)

$$\text{or} \qquad \phi = nl.\mu_0 nl.AS$$

But, self - inductance, $L = \frac{\phi}{I}$

$$\therefore \qquad L = \mu_0 n^2 la \qquad .....(1)$$

$$= \mu_o \left(\frac{N}{l}\right)^2 lA \qquad \left(\because n = \frac{N}{l}\right)$$

$$= \frac{\mu_0 N^2 A}{l} \qquad .....(2)$$

If the permeability of soft-iron core inside the solenoid is μ, then

$$L = \frac{\mu_0 \mu_r N^2 A}{l}$$

Equation (3)is the expression for self-inductance of a long solenoid. From this equation, it is clear that the self-inductance of a solenoid depends upon the following:

(i) Ares of cross-section of solenoid or radius of the solenoid.: The self-inductance of a solenoid increases with radius and hence with the area of cross-section.

(ii) No. of turns : Self-inductance of a solenoid increases with number of turns.

(iii) Length of the solenoid: Self-inductance of a solenoid decreases on increasing the length of the solenoid.

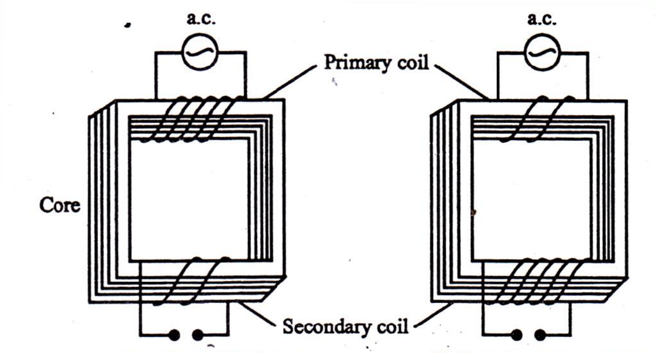
(iv) Relative permeabilitv of the core: The self-inductance of a solenoid increases placing a core of higher permeability This is the reason, that self-inductance of a solenoid with soft-iron core is greater than that of air core solenoid.

Equation (3) can be written in terms of radius as follows :

$$L = \frac{\mu N^2 \pi r^2}{l}$$

OR

Transformer : Transformer is a device which is used to convert low altenating voltage (at high current) into high alternating voltage (at low current) and vice versa.



(a) Step-down transformer (b) Step-up transformer

Construction: A transformer consists of laminated core, primary coil and secondary coil. The laminated core is obtained by piling a number of laminated rectangular strips of soft iron. Two insulated copper wires are wound on the opposite arms, in the form of coils. The coil connected to the input of a.c. is called primary coil and the other through which output is taken is called secondary coil.

Method of working and principle : Let the number of turns in primary and secondary coils are N_p and N_s respectively. If the magnetic flux linked with the primary coil at any instant is ϕ, then the e.m.f. induced in the primary coil will be .

$$E_p = -N_p \frac{d\phi}{dt} \qquad .....(1)$$

If there is no loss of flux, the secondary coil will also be linked with the same flux ϕ. So, the e.m.f. induced in the secondary coil will be

$$E_s = -N_s \frac{d\phi}{dt} \qquad .....(2)$$

Dividing equ. (2) by eqn. (1), we get

$$\frac{E_s}{E_p} = \frac{-N_s \frac{d\phi}{dt}}{-N_p \frac{d\phi}{dt}} = \frac{N_s}{N_p} \qquad .....(3)$$

If there is no loss of energy in the primary coil, then the induced e.m.f. produced in the primary coil will be nearly equal to the applied potential difference (V_p) between its ends. Similarly, because the secondary coil is open, hence the potential difference across its ends will be equal to the e.m.f. induced in it i.e., under ideal conditions

$$\frac{E_s}{E_p} = \frac{V_s}{V_p} \qquad .....(4)$$

From eqns. (3) and (4), we get

$$\frac{E_s}{E_p} = \frac{V_s}{V_p} = \frac{N_s}{N_p} = r \qquad .....(5)$$

Let I_p, and I_s be the current through primary and secondary coils respectively. Then under ideal conditions,
Instantaneous input power = Instantaneous output power
i.e., Power in primary coil = Power in secondary coil

$$I_p \times V_p = I_s \times V_s$$

or
$$\frac{V_s}{V_p} = \frac{I_p}{I_s} \qquad ......(6)$$

From eqns. (5) and (6), we get

$$\frac{V_s}{V_p} = \frac{N_s}{N_p} = \frac{I_p}{I_s} = r \qquad ......(7)$$

The quantity r in eqns. (5) and (7) is called transformation ratio.

For step-up transformer:

$$V_s > V_p, \text{ so } \frac{V_s}{V_p} > 1 \Rightarrow r > 1$$

$\therefore$
$$\frac{N_S}{N_P} > 1 \Rightarrow N_S > N_P$$

Or
$$\frac{I_S}{I_P} > 1 \Rightarrow I_p > I_s$$

So, a step-up transformer increases the voltage, but decreases the strength of current. Also, the number of turns in the secondary coil is more than that of primary coil.

For step - down transformer :

$$V_s < V_p, \text{so} \frac{V_s}{V_p} < 1 \Rightarrow r < 1$$

$$\frac{N_s}{N_p} < 1 \Rightarrow N_s < N_p$$

Also
$$\frac{I_p}{I_s} < 1 \Rightarrow I_p < I_s$$

So, a step - down tranformer decreases the voltage but increases the strength of current. The number of turns in secondary coil is less than that of primary coil.

Energy losses and their removal:

(i) **Copper loss :-** Some part of the energy is wasted in the form of heat due to the heating effect of current in primary and secondary coil because the coils have some resistance. The amount of heat produced is I^2Rt. To reduce it, thick coils are used in the primary coil of step-up transformer and in the secondary coils of a step-down transformer.

(ii) **Iron loss :-** Eddy current is produced in the iron core of the transformer, causes heating. This loss is called iron loss. To minimize this loss, the core is laminated.

(iii) **Magnetic flux leakage :-**All the magnetic flux produced by primary coil may not be transferred to the secondary coil. There fore, some energy is wasted. To minimize this loss, soft-iron core is used.
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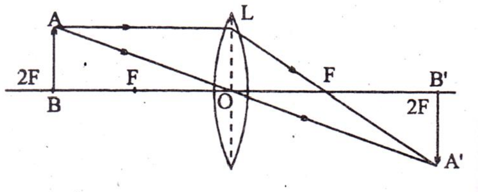
(iv) **Hysteresis loss :-** Some amount of energy is wasted because the iron core becomes magnetized during the first half and then gets demaganetized during the other half. This wastes loss of magnetic energy is called hysteresis loss. It is minimized by taking soft iron core which has thin hysteresis loop.

Ans :- 19 Let L be a convex lens and an object AB is palaced at a distance u from the lens. A'B' is the image of AB. Now OB = -u, OF = f and OB' = v.

Now Δ AOB and Δ A'OB' are similar

$$\therefore \quad \frac{AB}{A'B'} = \frac{OB}{OB'} \qquad ......(1)$$



Similary Δ LOF and Δ FA'B' are similar.

$$\therefore \frac{OL}{A'B'} = \frac{OF}{FB'}$$

But, OL = AB

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

From eqns. (1) and (2) , we get

$$\frac{OB}{OB'} = \frac{OF}{FB'}$$

$$\text{or} \quad \frac{OB}{OB'} = \frac{OF}{OB - OF}$$

$$\text{or} \quad \frac{-u}{v} = \frac{f}{v - f}$$

or -uv + uf = vf .... (3)

Dividing by uvf on both the sides in eqn. (3),

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

$$\therefore \quad \frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

This is the required formula. Proved.

OR

When two light waves of same frequency and approximately same amplitude travel in a medium in the same direction then due to the superimposition the intensity of light changes. This phenomenon is called interference

Let two waves having same frequency are propagating in same direction in same medium. Their equation are .

$$y_1 = a_1 \sin \omega t \qquad ......(1)$$

and

$$y_2 = a_2 \sin(\omega t + \phi) \qquad ......(2)$$

Where, a_1 and a_2 are their amplitudes and ϕ. is phase difference between them.

If both the wave are superimposed together then by the principle of superposition of waves,

$$\vec{y} = \vec{y}_1 + \vec{y}_2$$

or $$\vec{y} = a_1 \sin \omega t + a_2 \sin(\omega t + \phi)$$

or $$y = a_1 \sin \omega t + a_2 \sin \omega t + a_2 \cos \omega t \sin \phi$$

or $$y = (a_1 + a_2 \cos \phi) \sin \omega t + a_2 \sin \phi \cos \omega t \qquad ......(3)$$

Now let

$$a_1 + a_2 \cos \phi = R \cos \theta$$

and $$a_2 \sin \phi = R \sin \theta$$

Where, R and θ are constants -

Then from eqn. (3),

$$y = R\cos\theta \sin \omega t + R \sin \theta \cos \omega t$$

or $$y = R\sin(\omega t + \theta) \qquad ...(6)$$

Eqn. (6) shows the resultant wave. Its amplitude is R

Squaring and adding eqns. (4) and(5)

$$R_2 \cos^2\theta + R^2 \sin^2 \theta = (a_1 + a_2 \cos\phi)^2 + (a_2 \sin\phi)^2$$

or $$R^2(\cos^2\theta + \sin^2\theta) = a_1^2 + 2a_1a_2\cos\phi + a_2^2 \cos^2 \phi + a_2^2 \sin^2 \phi$$

or $$R^2 = a_1^2 + 2a_1 a_2 \cos\phi + a_2^2$$

or $$R^2 = a_1^2 + a_2^2 + 2a_1 a_2 \cos\phi$$

$\therefore$ Intensity is proportional to the R^2

$\therefore$ $$I = K(a_1^2 + a_2^2 + 2a_1a_2\cos\phi) \qquad ...(7)$$

Where K is a proportionality constant.

From eqn. (7) it is clear that the resultant intensity depends upon the phase difference between the two waves.

Condition for constructive interference : Fron eqn. (7) it is clear that for maximum intensity

$$\cos\phi = 1$$

or $$\phi = 2n\pi \qquad \text{(where, n = 0, 1,2,3,.....)}$$

At the points where the waves with same phase are superimposed, the intensity be comes maximum.

Thus $$I_{max} = K\left(a_1^2 + a_2^2 + 2a_1a_2\right)$$

$$= K (a_1 + a_2)^2$$

If the path difference for constructive interference is Δx, then

$$\Delta x = \frac{\lambda}{2\pi} \times \phi$$

$$\Delta x = \frac{\lambda}{2\pi} \times 2n\pi$$

or $$\Delta x = 2n \times \frac{\lambda}{2} = \text{even mutipe of } \frac{\lambda}{2}$$

Condition for destructive interference: From eqn. (7) it is clear that for minimum intensity

$$\cos\phi = -1$$

or $$\phi = (2n-1)\pi, \qquad \text{(where, n = 1,2,3)}$$

Hence if the waves are opposite in phase then the destructive interference takes place. If the path difference for destructive interference is Δx, then

$$\Delta x = \frac{\lambda}{2\pi} \times \phi$$

$$\Delta x = \frac{\lambda}{2\pi} \times (2n-1)\pi$$

or $$\Delta x = (2n-1)\frac{\lambda}{2} = \text{ odd multiple of } \frac{\lambda}{2}$$

Expression for intensity in the constructive interference

In eqn. (7) putting cas $\phi = 1$

$$I = K\left(a_1^2 + a_2^2 + 2a_1a_2\right) = K\left(a_1 + a_2\right)^2$$

If $a_1 = a_2 = a$, then,

$$I = k\,(a + a)^2 \text{ or } I = 4ka^2$$

Expression for intensity in the destructive interference

$$I = K\left(a_1^2 + a_2^2 - 2a_1a_2\right) = K\left(a_1 - a_2\right)^2$$

If $a_1 = a_2 = a$, then,

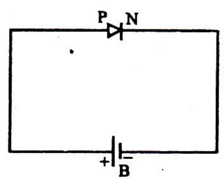
$$I = k\,(a - a)^2 = 0$$

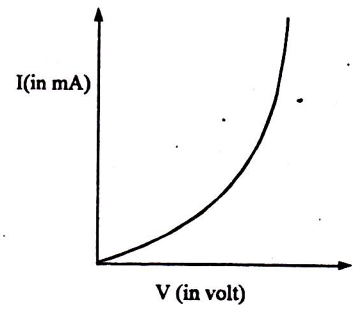
Ans :- 20 When a penta valent impurity such as antimony, arsenic, phosphorus etc. are Cintroduced into pure semiconductors, then the semiconductor formed is called as N-type semiconductor.

When a trivalent impurity such as indium, boron, aluminium etc. are introducedinto pure semiconductor, then the semiconductor formed is called as P-type semiconductor.

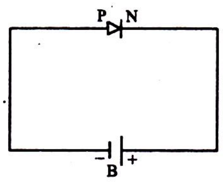
(a) Working of P-N junction in forward biis : When external voltage applied to the junction is in such a direction that it cancels the potential barrier, thus permitting the current flow, it is called forward biasing. The positive terminal of the e.m.f. source is connected to P-type and the negative terminal to N-type. Now, in this position, the holes are repelled and move towards the junction and so with the electrons also move towards the junction. For each electron hole combination, a covalent bond near the positive terminal of the battery is broken and liberated electron enters the positive terminal of the battery This action creates a new hole, which moves toward junction by the effect of applied e.m.f. At the other end, the electrons enter N-region and move towards the junction. Thus, current flows through the junction.

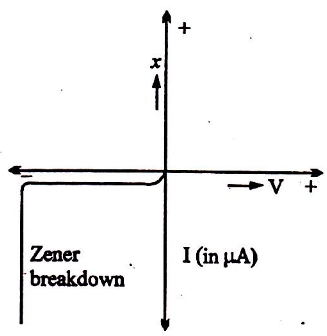
This applied voltage is called forward bias. As the voltage is increased across P and N, the current strength also increases.





(b) Working of P-N junction diode in reverse bias : When positive terminal of battery is connected to the N-end of P-Njunction and negative terminal is connected toP- end, circuit is called reverse-biased. In this condition, holes of P-region move towards negative of the battery and electrons of N-region towards positive of the battery In this way, the diode possesses neither holes nor electrons as a result current flow is very low (about zero).



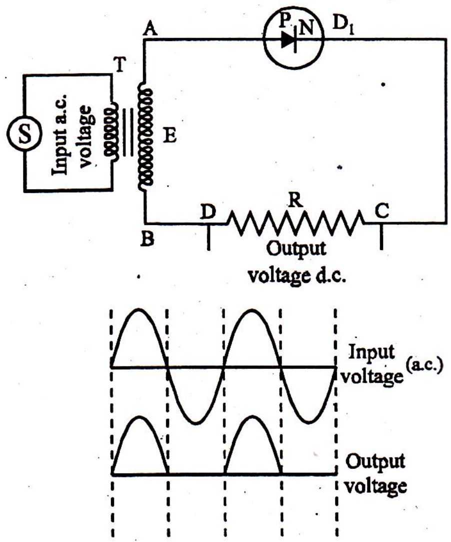


Very low current flows through the diode as shown in the figure (of the order of micro ampere) because due to thermal excitation some of the hole and electron pairs are being produced in diode. These pairs move through the junction cause flow of current of very less amount .

When reversed voltage is increased, current in the circuit remains constant (approx.) but at high value breakdown occurs as a result electron hole pairs are. produced in large amount and current increases abruptly, called Zener breakdown.

OR

Rectification : The phenomenon of conversion of a.c. to d.c. is known as rectification.



(i) Labelled diagram:

a.c. $\rightarrow$ Input a.c. voltage.

T $\rightarrow$ Step-up transformer.

PN $\rightarrow$ Junction diode.

R $\rightarrow$ Load.

(ii) Working : When an a.c. voltage is applied to the primary.coil of transformer, then an a.c. voltage is induced in the secondary coil of transformer.

Let in half cycle, A is at positive potential wr.t. that of B. Then P-N junction diode is in forward-biased. Thus, the current flows through it and conventional current flows through R, from C to D.

In the next half cycle, A is at negative potential w.r.t. B. The junction diode is in reverse-biased and no current flows through R.

The same phenomenon is repeated in the Fig. next cycle.

Therefore, only half cycle of the input a.c. wave is converted into d.c. This process is called half-wave rectification.

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