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consider a metal rod A on an insulating stand as shown in fig. 1

When the charged glass rod as rubbed with silk is brought near one end of the rod A then it attracts some of free electrons on the nearer side producting a deficiency of electron on the for side.

Hence, nearer side becomes (+ vely) charged if rod A is touched with the finger then the charge flow to the earth through body and (-ve) charge remains on it's original position. The induced charge is opposite to that on the rod is called Bound charge.

Faraday's ice pail experiment:- The transferring of charge from one conductor to other hollow conductor by internal contact was studied by faraday's in the place of a hollow conductor, he used a metal pail in which the supply of ice for laboratory was usually kept and hence, this experiment is still refferred as faraday ice-pail experiment.

At first a hollow can C is kept on the disc D of uncharged gold lef electroscope [fig (i)] then a (+ vely) charged metal ball A on an insulating handle H is inserted inside the can C. [fig. 2(ii)]. The (+ vely) charged ball A induces (-ve) charge on the inner surface of the can and (+ve) charge on it's outer surface [of Disc(D) the rod R and the leaves < < form a part]

V.V

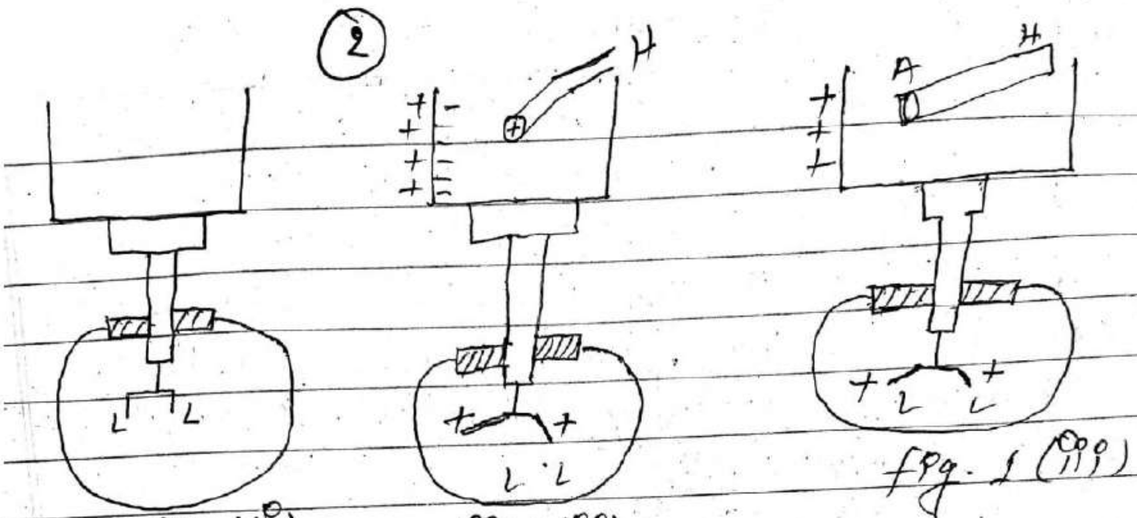


fig. 1(i) fig. 1(ii) fig. 1(iii)

So, the leaves LL diverge due to the force of repulsion between the like charged. The ball A can be removed around inside the can C without affecting the divergence when the ball is withdrawn, the leaves collapse indicating that the induced (-ve) and (+ve) charges neutralise each other.

The (+very) charged ball A is inserted again inside the can C so that the leaves LL diverge and touched with inner surface fig. 1 (iii). The divergence of the leaves remain uncharged when the ball is withdrawn the leaves remain diverged and if the ball is tested its found to lost all of it's charge indicating that the +ve charge of the ball has neutralised by induced -ve charge.

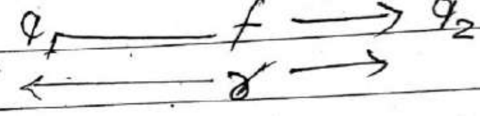
* Conclusion :-

i) When a charged body is inserted inside hollow conductor it includes equal and opposite charge on inner surface of conductor and equal and same charge on the outer surface of conductor.

iii) The net charge inside a hollow conductor is always zero

(*) Coulomb's law in electrostatic :- The force of attraction or repulsion between two point charges is directly proportional to product of their magnitude and ~~the~~ inversely proportional to the square of their seperation.

that is



$$f \propto \frac{q_1 \cdot q_2}{r^2}$$

$$f = K \frac{q_1 \cdot q_2}{r^2} \quad \text{(I)}$$

where K is proportionality constant whose value depend upon the medium in which charge are situated. In vaccum (air)

$$K = \frac{1}{4\pi\varepsilon_0} \quad \text{(2)}$$

where ε_0 is permittivity of free space, whose value is $\varepsilon_0 = 8.85 \times 10^{-12}\ C^2/Nm^2$
or, $8.85 \times 10^{-12}\ f/N$

$$K = \frac{1}{4\pi \times 8.85 \times 10^{-12}}\ Nm^2/C^2$$

$$= 9 \times 10^9\ Nm^2/C^2$$

Thus in vaccum, coulomb's law can be written as

$$f = \frac{1}{4\pi\varepsilon_0} \frac{q_1 \cdot q_2}{r^2} \quad \text{(3)}$$

In other medium beside the air with permittivity ϵ the coulomb's law can be expressed as

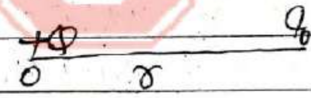
$$f = \frac{q_1 q_2}{4\pi \epsilon_0 \epsilon_r r^2} \quad \text{--- (4)}$$

where $\epsilon_r = \epsilon/\epsilon_0$ is called relative permittivity or dielectric constant.

(*) Electric field intensity (E)

→ The electric field intensity at a point in electric field is defined as the force per unit charge experienced by a test positive charge placed at that point. that is

$$E = \frac{f}{q_0} \quad \text{--- (I)}$$



Suppose we have to find the electric field intensity E at a point p at distance r due to a point charge '+Q' situated at origin. We consider a test charge q_0 at a point p. then by coulomb's law.

$$f = \frac{Q q_0}{4\pi \epsilon_0 r^2}$$

$$\frac{f}{q_0} = \frac{Q}{4\pi \epsilon_0 r^2} \quad \text{--- (II)}$$

from equation (I) and (II)

$$E = \frac{Q}{4\pi \epsilon_0 r^2}$$ which is required expression

V^{1000}

(5)

Electric potential :-

The electric potential at point in electric field is defined as the amount of workdone per unit charge in bringing at test positive charge from infinity to that point, that is

$$V = \frac{W}{q_0} \quad \text{—(I)}$$

Suppose we have to find the electric potential (V)

fig.1

due to a point charge +q situated at origin at a point p at distance r from O as shown in fig.1 for this, we consider a test positive charge q_0 at a point A at distance x from the origin. Then by coulomb's law, the force experienced by a test positive charge is given by

$$f = \frac{q\, q_0}{4\pi\epsilon_0 x^2} \quad \text{—(II)}$$

If B is another point closer to point A at distance dx from A then the small work done 'dw' in bringing test positive charge from A to B is given by

$$dw = -f\,dx = -\frac{q\, q_0}{4\pi\epsilon_0 x^2}\,dx \quad \text{—(III)}$$

(6)

where, -ve sign shows that the force and displacement are in opposite direction Then the total work done in bringing test positive charge from R at infinity to point P at distance r from the origin is given by

$$W = \int_{R\,at\,\infty}^{P\,at\,r} dw = \int_{R}^{P} dw$$

$$= \int_{\infty}^{r} \frac{-Qq_0}{4\pi\varepsilon_0 r^2}\, dx$$

$$= -\frac{Qq_0}{4\pi\varepsilon_0} \int_{\infty}^{r} x^{-2}\, dx$$

$$= \frac{-Qq_0}{4\pi\varepsilon_0} \left[\frac{x^{-2+1}}{-2+1}\right]_{\infty}^{r}$$

$$W = \frac{-Qq_0}{4\pi\varepsilon_0} \left[\frac{x^{-1}}{-1}\right]_{\infty}^{r}$$

$$= \frac{Qq_0}{4\pi\varepsilon_0} \left[\frac{1}{x}\right]_{\infty}^{r}$$

$$= \frac{Qq_0}{4\pi\varepsilon_0} \left[\frac{1}{r} - \frac{1}{\infty}\right]$$

$$= \frac{Qq_0}{4\pi\varepsilon_0} \left[\frac{1}{r} - 0\right]$$

$$W = \frac{Qq_0}{4\pi\varepsilon_0 r}$$

$$\frac{W}{q_0} = \frac{Q}{4\pi\epsilon_0 r} \quad \text{(iv)}$$

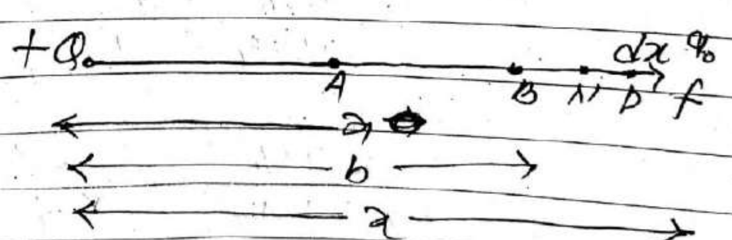
from eqn. (i) and (iv)

$$V = \frac{Q}{4\pi\epsilon_0 r}$$ which is required expression.

1000

Potential difference between two points

The potential difference between two points in an electric field may be defined as the amount of work done in moving a unit positive charge from one point to another point against electric force. We have to find the expression of potential difference between two points A and B V_{BA} for this we consider a point charge $+Q$ at ~~again~~ origin. Let test positive charge q_0 at point P at distance x from O



then from coulomb's law

$$f = \frac{Q q_0}{4\pi\epsilon_0 x^2} \quad \text{(I)}$$

This force f remains constant over distance $PN = dx$, then the small work done.

$$dw = -f\,dx \quad \text{--- (11)}$$

-(ve) sign shows that the force and distance are in opposite direction.

Now, the total work done W in bringing test positive charge q_0 from point B at distance b to a point A at distance a from origin is given by

$$W = \int_B^A dw = \int_b^a -f\,dx = -\int_b^a \frac{Qq_0}{4\pi\varepsilon_0 x^2}\,dx$$

$$= -\int_b^a \frac{Qq_0}{4\pi\varepsilon_0} x^{-2}\,dx$$

$$= \frac{-Qq_0}{4\pi\varepsilon_0}\int_b^a x^{-2}\,dx$$

$$= \frac{-Qq_0}{4\pi\varepsilon_0}\left[\frac{x^{-2+1}}{-2+1}\right]_b^a$$

$$= \frac{-Qq_0}{4\pi\varepsilon_0}\left[-\frac{1}{x}\right]_b^a$$

$$= \frac{Qq_0}{4\pi\varepsilon_0}\left[\frac{1}{x}\right]_b^a$$

$$W = \frac{Qq_0}{4\pi\varepsilon_0}\left[\frac{1}{b} - \frac{1}{a}\right]$$

$$\frac{W}{q_0} = \frac{Q}{4\pi\varepsilon_0}\left[\frac{1}{b} - \frac{1}{a}\right]$$

$$\therefore V_{BA} = \frac{Q}{4\pi\varepsilon_0}\left[\frac{1}{b} - \frac{1}{a}\right]$$

V.V. I

* Gauss's law or Guss's Theorm :-

This theorm state that the total electric flux passing through the close surface is equal to $\frac{Q}{\epsilon_0}$, where Q is the total charge and ϵ_0 is the permittivity of free space.

proof :-

consider a point charge $+Q$ at the centre 'O' of a sphere of radius r and surface area A as shou in fig. Let E be the electric field intensity at any point p on the surface of sphere. then the total electric flux.

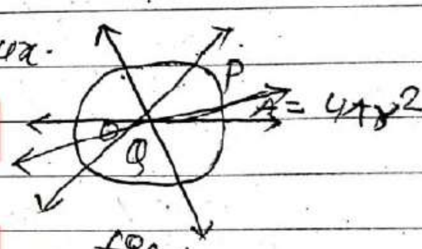


fig-1

$$\phi = E A$$

$$\phi = E \cdot 4\pi r^2 \quad \text{--- (I)}$$

we have also, the electric field intensity

$$E = \frac{Q}{4\pi\epsilon_0 r^2} \quad \text{--- (II)}$$

substituting eqn (II) in eqn (I) we have

$$\phi = \frac{Q}{4\pi\epsilon_0 r^2} \cdot 4\pi r^2$$

$$\phi = \frac{Q}{\epsilon_0} \quad \text{proved}$$

* State Gauss's theorem in electrostatics, use this theorem to calculate the electric field intensity due to solid charged sphere at a point inside it.

→ Gauss's theorem

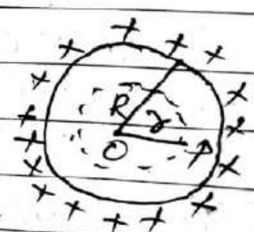
It state that the total electric flux passing through the close surface is equal to $\frac{Q}{\epsilon_0}$

that is $\phi = \frac{Q}{\epsilon_0}$

* electric field intensity at a point inside the charged sphere

Consider a point P inside the surface of charged sphere of radius R with uniform charge distribution +q as shown in fig-1

We draw a Gaussian sphere of radius r through point P concentric to charged sphere since Gaussian surface doesnot contain any charge. So,



$q = 0$

The electric flux $(\phi) = EA$

$= E \cdot 4\pi r^2$ —— (I)

from Gauss's theorem

$\phi = \frac{q}{\epsilon_0}$ —— (II)

from eqn. (I) and (II)

$E 4\pi r^2 = \frac{q}{\epsilon_0}$

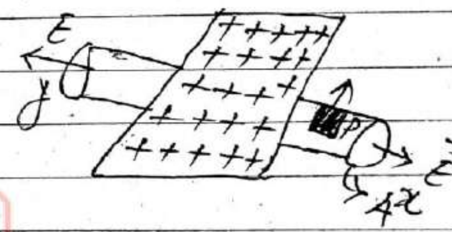
$$E = \frac{q}{4\pi\epsilon_0 r^2} = \frac{0}{4\pi\epsilon_0 r^2} \quad [\because q=0]$$

$$\therefore E = 0$$

Thus, the electric field intensity at a point inside the charged sphere is zero

(#) Electric field due to an infinite plane sphere of charge.

→ consider an infinite plane sheet with uniform surface charge density σ. To find electric field, we drawn a gaussian surface in the form of cylinder of cross sectional area A.



The flux through end x is

$$\phi_1 = \oint_x E\, ds \cos\theta$$

$$= E \oint_x ds \cos 0^\circ$$

$$\phi_1 = EA$$

The flux through the end y is

$$\phi_2 = \oint_y E\, ds \cos\theta$$

$$= E \oint_y ds \cos 0^\circ = E \oint_y ds = EA$$

The flux through the surface perpendicular to gaussian surface

$$\phi_3 = \oint_p E\, ds \cos\theta = E \oint_p ds \cos 90^\circ = 0$$

then the total flux $\phi = \phi_1 + \phi_2 + \phi_3$

$= EA + EA + 0$

$= 2EA$ —— (I)

from Gauss's theorem

$\phi = \frac{q}{\varepsilon_0} = \frac{\sigma A}{\varepsilon_0}$ —— (II)

from eqn. (I) and (II)

$2EA = \frac{\sigma A}{\varepsilon_0}$

$\boxed{E = \frac{\sigma}{2\varepsilon_0}}$ which is required expression.

Electric field intensity E at a point outside a charged plane conductor.

⇒ Let us consider a charged plane conductor having the uniform surface charge density 'σ' To find the electric field intensity ($\vec{E}$) at a distance r from the sheet we draw a gaussian surface in the form of cylinder of cross-section fig.1 area 'A' whose top face x contains the point P and other face y on the plane of conductor as shown in fig.1

Thus, surface charge density $\sigma = q/A$

the curved surface s and cross section area $A = 4\pi r^2$

The electric flux through a closed curved surface $(\phi) = \oint E\,ds\cos\theta$

$$= \oint E\,ds\cos 90^\circ$$

$$= 0 \quad \text{--- (I)} \quad [\because ds \perp E]$$

the electric flux through end x is

$$(\phi_2) = \oint E\,ds\cos\theta$$

$$= \oint E\,ds\cos 0^\circ \quad [\because ds \parallel E]$$

$$= \oint E\,ds$$

$$(\phi_2) = EA \quad \text{--- (II)}$$

the electric flux through the end y is

$$(\phi_3) = \oint E\,ds\cos\theta$$

$$= \oint E\,ds\cos 90^\circ \quad [\because ds \perp E]$$

$$= 0 \quad \text{--- (III)}$$

Total electric flux $(\phi) = \phi_1 + \phi_2 + \phi_3$

$$\phi = EA \quad \text{--- (IV)}$$

from gauss's theorem, $\phi = \frac{q}{\varepsilon_0} = \frac{6A}{\varepsilon_0}$ --- (V)

(This is not in syllabus)

Energy stored in a capacitor:-

consider a capacitor of capacitance A battery of V volt is connected to capacitor as shown in fig.1

The work done in charging the capacitor is stored in the form of electrical energy.

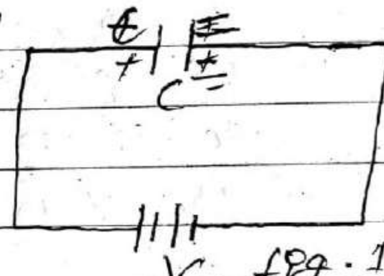


fig.1

Let dq be the charge stored in the capacitor then the small work done dW is given by

$$dW = V\,dq$$

Now, the total workdone is

$$W = \int_0^q dW = \int \frac{q}{C}\,dq \quad [\because V = \frac{q}{C}]$$

$$= \frac{1}{C}\int_0^q q\,dq$$

$$= \frac{1}{C}\left[\frac{q^{1+1}}{1+1}\right]_0^q$$

$$= \frac{1}{C}\left[\frac{q^2}{2}\right]_0^q$$

$$= \frac{1}{2C}\left[q^2\right]_0^q$$

$$= \frac{1}{2C}\left[q^2 - 0^2\right]$$

$$= \frac{q^2}{2C}$$

$$= \frac{CV^2}{2C}$$

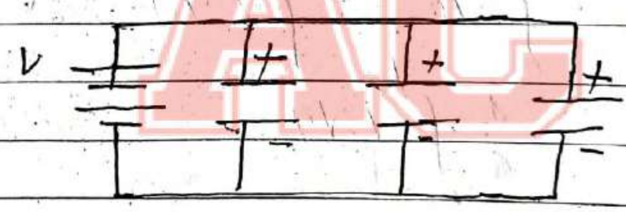
$$\boxed{\therefore W = \frac{1}{2}CV^2}$$

which is required expression.

Capacitors in parallel combination

Consider three capacitors of capacitance C_1, C_2 and C_3 are connected in parallel as shown in fig-1.
A battery of V volt is connected across this combination. The potential difference across each capacitor is V.
The charge sotred in capacitor C_1, C_2 and C_3 are

$$\left.\begin{aligned} q_1 &= C_1V \\ q_2 &= C_2V \\ q_3 &= C_3V \end{aligned}\right\} \quad (1)$$



Total charge $(q) = q_1 + q_2 + q_3$

or, $q = C_1V + C_2V + C_3V$

or, $q = (C_1 + C_2 + C_3)V$

or, $\frac{q}{V} = C_1 + C_2 + C_3$

$$\boxed{C = C_1 + C_2 + C_3}$$

where, $\frac{q}{V} = C$ is the equivalent capacitance of capacitor in parallel combination.

(*) Capacitors in series combination :-

Consider three capacitors of capacitance C_1, C_2 and C_3 are connected in series as shown in fig.1. A battery of 'v' volt of is connected across the combination.

Each capacitor has charge Q while the pot difference V_1, V_2 and V_3 across C_1, C_2 and C_3 are given by

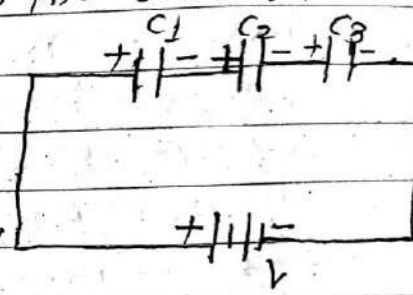


fig.1

$$V_1 = Q/C_1$$
$$V_2 = Q/C_2$$
and $$V_3 = Q/C_3$$

The total potential difference $(V) = V_1 + V_2 + V_3$

$$V = Q/C_1 + Q/C_2 + Q/C_3$$

$$\frac{V}{Q} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

$$\frac{1}{Q/V} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

where, $Q/V = C$ is the equivalent capacitance in the series combination.

Relation between current density (J) and electric field intensity (E)

If v be the pot. diff. applied to a conductor of resistance R, then the current $I = \frac{V}{R}$ — (I)

If A and l be the cross sectional area and length of conductor then.

$$R = \frac{\rho l}{A} = \frac{l}{\frac{1}{\rho}A} = \frac{l}{\sigma A} \quad \text{— (II)}$$

from eqn. (I) and (II)

$$I = \frac{V}{R} = \frac{\sigma A}{l}V$$

$$\frac{I}{A} = \frac{\sigma V}{l}$$

$$\vec{J} = \sigma\left(\frac{V}{l}\right)$$

$$\boxed{\vec{J} = \sigma E}$$ which is required relation.

Combination of resistors:-

Consider three resistors of resistance R_1, R_2 and R_3 are connected in series as shown in fig. 1 A battery of 'V' volt is connected across this combination

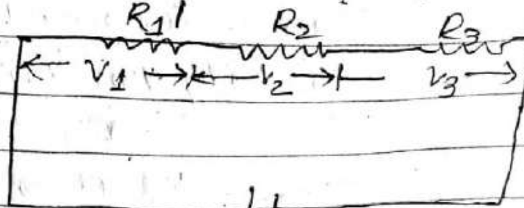


fig. 1

The same current 'I' follows in each resistences.

The potential difference across resistor R_1, R_2 and R_3 are,

$V_1 = IR_1$

$V_2 = IR_2$

and $V_3 = IR_3$

The total potential

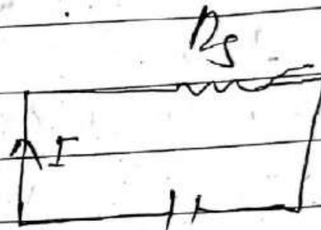


fig. 2 equivalent current

$$V = V_1 + V_2 + V_3$$
$$= IR_1 + IR_2 + IR_3$$
$$V = I(R_1 + R_2 + R_3)$$
$$\frac{V}{I} = R_1 + R_2 + R_3$$
$$\boxed{R_S = R_1 + R_2 + R_3}$$

where, $R_S = \frac{V}{I}$ is the equivalent resistance in series.

#) parallel combination of resistors :-

⇒ consider three resistors of resistances R_1, R_2 and R_3 are connected in parallel as shown in fig. 1

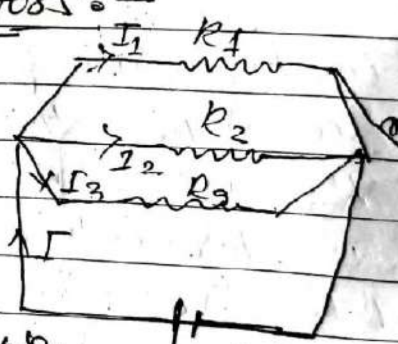


fig. 1

A battery of 'V' volt is connected across this combination. The pot. diff. each resistors is V

The current flowing through resistors R_1, R_2 and R_3

are,

$$I_1 = \frac{V}{R_1}$$

$$I_2 = \frac{V}{R_2}$$

$$I_3 = \frac{V}{R_3}$$

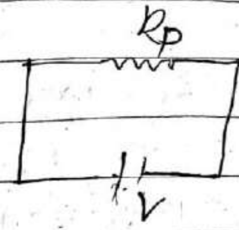


fig. 2 equivalent Current.

Total current through the circuit is

$$I = I_1 + I_2 + I_3$$

$$I = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

$$I = V\left[\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right]$$

$$\frac{I}{V} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$\frac{1}{V/I} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$\boxed{\therefore \frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

where $\frac{V}{I} = R_p$ is the equivalent resistance in parallel.

(*) Kirchhoff's law :-

for steady current flowing through a network of conductors following two laws given by Kirchhoff's law are applicable.

(1) first law [junction rule] :-

The algebric sum of the current meeting at a junction in a network of conductor is zero i.e $\Sigma I = 0$ — (I)

The current comming toward the junction is taken as the while the current moving away from the junction is taken as (−ve)

Consider current I_1, I_2 and I_3 comming toward the junction O and I_4, I_5 are current moving away from the junction.

then,

$I_1 + I_2 + I_3 + (-I_4) + (-I_5) = 0$

$I_1 + I_2 + I_3 = I_4 + I_5$

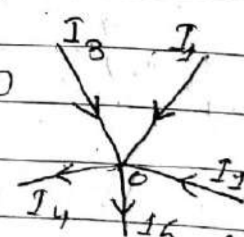


fig-1

Thus, the

incomming current = outgoing current

ii) Second law [loop rule]:-

In a closed path or loop, the algebraic sum of potential difference across various branches of loop is equal to the algebraic sum of the emfs in that loop i.e.

$$\Sigma IR = \Sigma \varepsilon \quad \text{--- (I)}$$

The current flowing in the clockwise direction is taken as (-ve) and the current flowing in the anticlockwise direction is taken as (+ve).

→ The emf of battery from (-ve) terminal to (+ve) terminal is taken as (+ve) and that of from (+ve) terminal to (-ve) terminal is taken as (-ve)

Consider a loop ABCDEFA as shown in fig 1

$$-I_1R_1 - I_2R_2 + E_1 - I_3R_3 + I_4R_4 - E_2 = 0$$

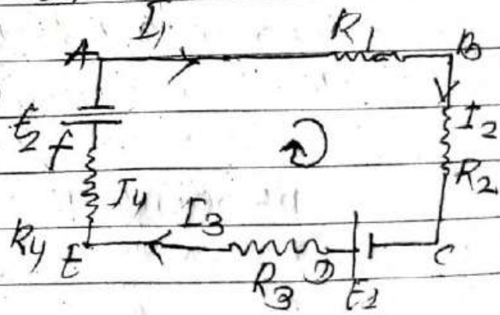


fig 1

VoVol

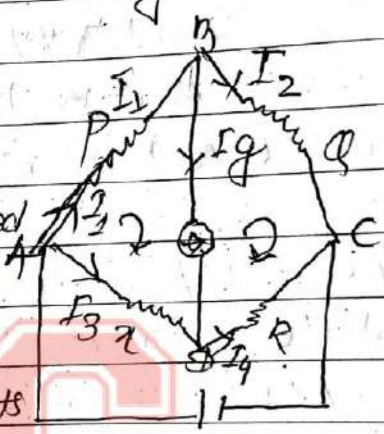
(22)

Wheat stone bridge circuit :-

If a battery is connected between two opposite point (A and C) and galvanometer is connected between two other opposite point (B and D) of a quadrilateral ABCD formed by four resistors P, Q, R and x, at balanced condition i.e $I_g = 0$ then

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

Proof



A quadrilateral ABCD formed by four resistor P, Q, x and R. A battery is connected between two opposite points A and C.

A galvanometer of resistance be is connected between two opposite point B and D. at point B

$$I_1 = I_2 + I_g \quad \text{—(I)}$$

At point D

$$I_3 + I_g = I_4 \quad \text{—(II)}$$

In loop ABDA

$$-I_1 P - I_g G + I_3 = 0 \quad \text{—(III)}$$

In loop BCDB

$$-I_2 Q + I_4 R + I_g G = 0 \quad \text{—(IV)}$$

at balanced condition i.e $I_g = 0$

from eqn. (I) and (II)

$$I_1 = I_2 \text{ and } I_3 = I_4$$

and from eqn. (III) and (IV)

$$I_3 x = I_1 P$$

$$\frac{I_3}{I_1} = \frac{P}{x} \quad \text{---(v)}$$

and,

$$I_4 R = I_2 Q$$

$$I_3 R = I_1 Q$$

$$\frac{I_3}{I_1} = \frac{Q}{R} \quad \text{---(vi)}$$

from eqn. (v) and (vi)

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

$$\boxed{\frac{P}{Q} = \frac{x}{R}}$$ proved

(#) potentiometer:- It is an instrument which measure the potential difference more accurately than voltmeter but voltmeter is usually used to measure the pot. diff. due to it's small size.

(#) principle of potentiometer:- When a constant current passes through a potentiometer of uniform cross-sectional area. The potential difference across any section of wire is directly proportional to it's

(*) Thermoelectric effect
The phenomenon in which the electric energy is produced by the means of thermal energy is called thermoelectric effect.

(#) Thermoelectricity :-
The current produced by the process of thermoelectric effect is called thermoelectricity.

Imp Variation of emf with temperature :-
Consider a Cu-Fe thermocouple in which a galvanometer (G) is connected in the copper wire. Junction A is kept at hot junction and B at cold junction.
The current flows cold from Fe to Cu, as shown in fig. 1

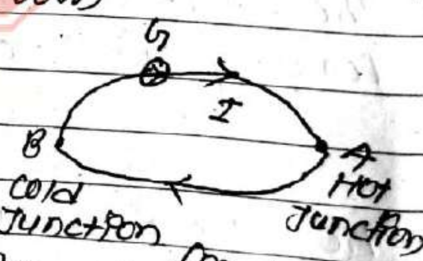


fig. 1

As the both junction are at same temperature, the galvanometer shows no deflection.
As the junction are at different temperature fig. 1. The current flow from copper to Fe.
Keeping the cold junction at constant temperature (0_c) increasing the temperature of hot junction, the thermo emf is increase up to certain temperature. The temperature at which the thermo emf is maximum

is called neutral temprature (θ_N). If the temp. of hot junction increase beyond the neutral temprature then ~~tem~~ thermo emf decrease and becomes minimum such temprature is called temprature of inversion (θ_i). The graph of thermo emf is parabolic as shown in fig. 1

Thus we have,

$$E = \alpha\theta + \frac{1}{2}\beta\theta^2 \quad \text{— (I)}$$

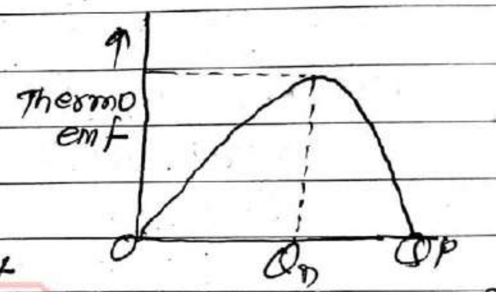


fig (II)

where α and β are constant called thermoelectric cofficent whose value depends upon the nature of conductor and temprature difference.

It is found that, $\theta_i - \theta_n = \theta_n - \theta_c$

$$\theta_i + \theta_c = 2\theta_n$$

$$\theta_n = \frac{\theta_i + \theta_c}{2} \text{ is require expn.}$$

(*) force experienced by a charge in magnetic field

force experienced by moving charge in magnetic field

→ Let 'q' be the charge moving with velocity making an angle θ with magnetic field 'B' then the force 'f' experienced by charge is

(i) Directly proportional to magnetic field 'B'

i.e. $f \propto B$ — (I)

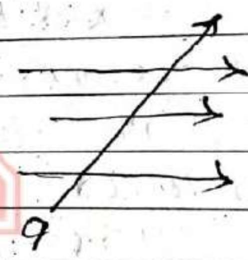
(ii) Directly proportional to velocity of charge.

i.e $f \propto v$ — (ii)

(iii) Directly proportional to magnitude of charge.
i.e $f \propto q$ — (iii)

and
(iv) Directly proportional to the sine of angle between the magnetic field and direction of motion of charge

$f \propto \sin\theta$ — (iv)



Combining these relations
$f \propto Bq\sin\theta$
$f = KBq\sin\theta$ — (v)

where K is a proportionally constant
Taking $f = 1N$, $B = 1T$, $C = 1C$, $\sin\theta = 1$ and $v = 1 m/s$
then, $1 = K$
putting $K = 1$ in eqn. (v)
$f = Bqv\sin\theta$
which is required expression

Special cases

If charge moves perpendicular to the magnetic field, then $\sin\alpha = \sin 90 = 1$

$\therefore \boxed{f_{max} = Bqv}$

i) If charge move parallel and antiparallel to magnetic field

and $f_{min} = 0$ then, $\sin\theta = 0$

*) force experienced by current carrying conductor :-

→ The force experienced by a current carrying conductor in magnetic field B is f, let I be the current in conductor and θ be the angle made by conductor with the magnetic field B.

The force is

(i) Directly proportional to the applied field B

i.e $f \propto B$ —— (I)

(ii) Directly proportional to the current in the conductor

i.e $f \propto I$ —— (II)

(III) Directly proportional to the length of conductor

i.e $f \propto l$ —— (iii)

(IV) Directly proportional to the sine of angle between conductor and field

i.e $f \propto \sin\theta$ —— (iv)

combining these all

$f \propto BIl\sin\theta$

$f = KBIl\sin\theta$ — (v)

where K is a proportionally constant putting ~~K=1~~ $B = 1T$, $I = 1A$, $l = 1m$ and $\sin\theta = 1$

then $K = 1$

putting $K=1$ in eqn. (v)

$\boxed{f = BIl\sin\theta}$ which is require expression.

(ii) If magnetic field is parallel to area vector

i.e $\theta = 0$ then

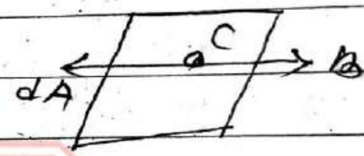
$\phi = AB$

(iii) when the magnetic field is antiparallel to be area vector.

i.e $\phi = 180^\circ$

$\phi = AB \cos 180^\circ$

$\therefore \phi = -AB$



(*) faraday's law of electromagnetic induction:

→ The magnitude of the emf E induced in a closed conducting loop is equal to the rate at which the magnetic flux through that loop changes with time.

i.e, $E = \dfrac{-d\phi}{dt}$

the negative sign indicates that opposition to the change of flux by induced emf.

If the loop contains 'N' turns, then the total induced emf.

$$E = -N\frac{d\phi}{dt}$$

suppose flux changes from initial value ϕ_1 to final value ϕ_2, then the induced emf.

$$E = \frac{N\phi_2 - N\phi_1}{t}$$

$$= \frac{N(\phi_2 - \phi_1)}{t}$$

In differential form,

$$E = \frac{Nd\phi}{dt} \quad [\text{In magnitude}]$$

*) Lenz's law :-

It state that the direction of induced current in a coil such that it always oppose the cause which produce it. thus law is used to find the direction of flow of current.

Explanation :- suppose a magnet with ~~this~~ it's north pole toward the coil is moved toward a coil. The induced emf will send a current in such direction in the coil that will proacile magnetic field from right to least so as to oppose repel the magnet when the magnet moved back, the magnetic field will be produced due to induced current from left to right.

Biot – Savart law :–

It state that the magnetic flux density 'dB' at a point at distance 'r' from a small current element of length 'dl' and carrying current I is

(I) Directly proportional to current
i.e $dB \propto I$ — (I)

(II) Directly proportional to length of current element. i.e $dB \propto dl$ — (II)

(III) Directly proportional to sine of angle of between conductor and line joining the current element and this point.

i.e $dB \propto \sin\alpha$ — (III)

(IV) Inversely proportional to the square of the distance joining the mid point of current element and that point.
i.e $dB \propto \frac{1}{r^2}$ — (IV)

Combining these all,

$$dB \propto \frac{I\,dl\,\sin\alpha}{r^2}$$

$$dB = K\frac{I\,dl\,\sin\alpha}{r^2} \quad \text{— (V)}$$

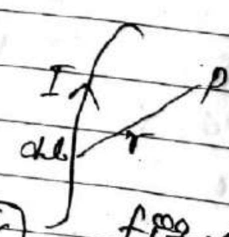


fig :1

where K is a proportional constant whose value depends up on the system of unit and in air medium

$K = \frac{\mu_0}{4\pi}$, where $\mu_0 = 4\pi \times 10^{-7}$ H/m

is called permeability of force space.

$$\therefore \boxed{dB = \frac{\mu_0}{4\pi} \frac{I\,dl \sin\theta}{r^2}}$$

which is required exp.

Application of Biot-Savart law

#) magnetic field due to circular coil :-

consider a circular coil of 'N' turns of radius 'r' carrying current I as shown in fig-1

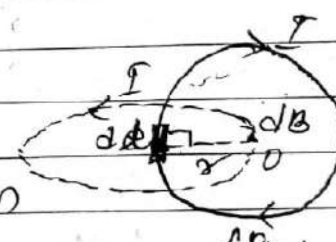


fig.1

let 'dl' be the small element and 'dB' be the magnetic flux at the centre 'O' then from Biot-Savart's law,

$$dB = \frac{\mu_0}{4\pi} \frac{I\,dl \sin\theta}{r^2} \quad \text{--- (I)}$$

Here, $\theta = 90$, $dB = \frac{\mu_0}{4\pi} \frac{I\,dl}{r^2}$ --- (II)

Total length of coil $= 2\pi r N$

Total magnetic field $(B) = \int_0^{2\pi r N} dB$

$$(B) = \int_0^{2\pi r N} \frac{\mu_0}{4\pi} \cdot \frac{I\,dl}{r^2}$$

$$= \frac{\mu_0}{4\pi} \cdot \frac{I}{r^2} \int_0^{2\pi r N} dl$$

$$= \frac{\mu_0}{4\pi} \cdot \frac{I}{r^2} \left[l \right]_0^{2\pi r N}$$

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

$$\boxed{\therefore B = \frac{\mu_0 I N}{2r}}$$

#) magnetic field due to a straight current carrying conductor :-

Consider along straight conductor AB carrying current 'I'. Let 'p' be a point at distance 'a' from the conductor.

Where the magnetic field to be calculated as shown in fig-1

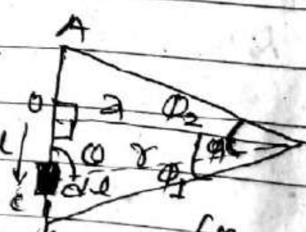


fig-1

Consider a small element 'dl' at distance 'r' from point p. according to Biot-Savart law the magnetic field at point 'p' due to a current element is

$$dB = \frac{\mu_0}{4\pi} \frac{I dl \sin\theta}{r^2} \text{ --- (i)}$$

from Δ OPC $\sin\theta = a/r = \cos\phi$ --- (ii)

$$r = \frac{a}{\cos\phi}$$

$$r = a\sec\phi \text{ --- (iii)}$$

(34)

again, $\tan\phi = l/a$ — (v)

$l = a\tan\phi$ — (iv)

differentiating (iv) w.r.t ϕ we get

$\frac{dl}{d\phi} = a\sec^2\phi\, d\phi$ — (iv)

$dl = a\sec^2\phi\, d\phi$

substituting eqn (ii), (iii) and (iv) in eqn (i) we get

$$dB = \frac{\mu_0}{4\pi} \frac{I a \sec^2\phi\, d\phi \cos\phi}{a^2\sec^2\phi}$$

$$= \frac{\mu_0}{4\pi} \frac{I\, d\phi \cos\phi}{a} \quad \text{— (vi)}$$

Now,
total magnetic field is obtained by integrating eqn (vi) from ϕ_1 to ϕ_2

$$B = \int dB = \int_{-\phi_1}^{\phi_2} \frac{\mu_0}{4\pi} \frac{I\cos\phi\, d\phi}{a}$$

$$= \frac{\mu_0}{4\pi}\frac{I}{a}\left[\sin\phi_2 + \sin\phi_1\right]$$

for ~~finite~~ infinitely long conductor $\phi_2 = \pi/2$
and $\phi_1 = \pi/2$

$$B = \frac{\mu_0 I}{4\pi a}\left[\sin\pi/2 + \sin\pi/2\right]$$

$$= \frac{\mu_0 I}{4\pi a}[1+1]$$

$$\boxed{\therefore B = \frac{\mu_0 I}{2\pi a}}$$

from eqn. (I) and (II)

$$E \alpha -\frac{dI}{dt}$$

$$E = -\frac{MdI}{dt} \quad \text{(III)}$$

where, 'M' is called the cofficent of mutual induction or mutual induction.

$$so, \quad M = \frac{E}{dI/dt}$$

when $\frac{dI}{dt} = 1 A/S$, then $M = -E$ then, $\boxed{E = M}$

thus the mutual inductance of two coil is is defined as the induced emf when the rate of flow of current is unit.

VoVo!

force between two parallel current carrying conductor
A current carrying conductor sets up a magnetic field around it. If two such conductor are very close to each other then a force acts on each wire due to magnetic field of other. Therefore, they are attached or repelled depending upon the direction of current flows in the opposite direction there is a repusive force.

consider two conductor x and y seperated at a distance 'a'. let I_1 and I_2 be the current flowing through x and y respectively shown in fig. 1 The magnetic field due to x on y is,

$$B_a = \frac{\mu_0 I_1}{2\pi a} \quad \text{(I)}$$

9827637086

the force experienced by y due to B_x

$$f_x = \frac{\mu_0 I_1 \cdot I_2}{2\pi a} \quad \text{(III)}$$

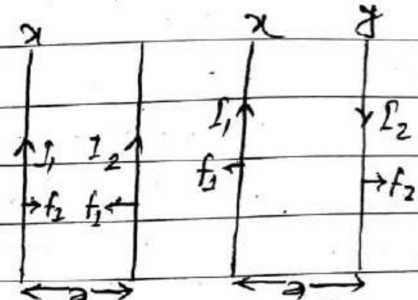


fig-1 attraction

fig-2 repulsion

similarly the magnetic field produced due ~~fig-1 attraction~~ to conductor y is force

$$B_y = \frac{\mu_0 I_2}{2\pi a} \quad \text{(iii)}$$

the force experienced by conductor x due to B_y

$$f_y = \frac{\mu_0 I_1 \cdot I_2}{2\pi a} \quad \text{(iv)}$$

thus, eqn. (ii) and (iv) ~~and~~ are the required expressi of the force experenced by conductor carrying curren

Y/O/

(*) Transformer :- A transformer is a device for converting ac current at low voletage into high voltage or viceversa. The transformer that convert low voltage to AC high voltag is known as step-up transformer while the transformer that convert ac high voltage to ac low voltage is known as step-down transformer.

principle :- It works on the principal of mutual induction i.e when a change in current take place in primary coil an induced emf is produced in the secondary coil

(*) Construction :- A transformer consist of use of soft iron in the form of

coils are ~~wounded~~ wounded upon the core toward losses of magnetic ~~the core~~ flux ϕ as shown in fig-1

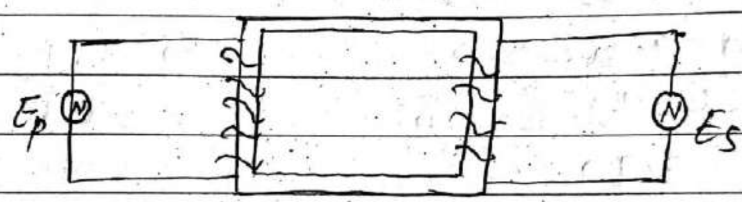


fig 1

→ If E_p and E_s are the induced emf in primary and secondary coils respectively and N_p and N_s are the number of tension in the primary and secondary coil respectively, then

$$E_p \propto N_p \text{ and } E_s \propto N_s$$

on combining we get,

$$\frac{E_s}{E_p} = \frac{N_s}{N_p} \quad \text{--- (I)}$$

the ratio $\frac{N_s}{N_p} = K$ is called the ~~transformation~~ transformation ratio of transformer.

since, the resistance of the coils is assumed zero then the potential difference V_p and V_s across the primary and secondary coils respectively are numerically equal to the corresponding emf E_p and E_s

$$\frac{V_s}{V_p} = \frac{N_s}{N_p} \quad \text{--- (II)}$$

Special cases:-

(i) when $N_s > N_p$ then $V_s > V_p$ such types of transformer is called step-up transformer.

(ii) when $N_p > N_s$ then $V_p > V_s$ such types of transformer is called step down transformer.

more over, there is no power loss for an ideal transformer.

power input in primary coil = power output in secondary coil.

$$I_p V_p = I_s V_s \rightarrow \frac{V_s}{V_p} = \frac{I_p}{I_s} \quad \text{--- (III)}$$

Thus, the current flowing in the primary and secondary coils are inversly proportional to corresponding potential difference.

(#) Ampere's law [Ampere circuital law]

→ It states that the line integral of the magnetic field intensity around a closed path in free space is equal to μ_0 times of total current enclosed by the path

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

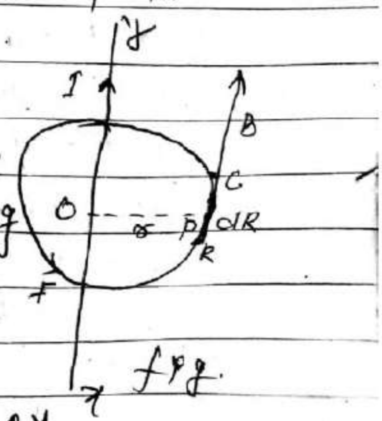


fig.

proof

consider a straight conductor carrying current 'I' in the direction as shown in fig-I Due to flow of current magnetics lines of forces are concentric circles centred on the conductor. The magnitude of magnetic field as a point P at prependicular distance

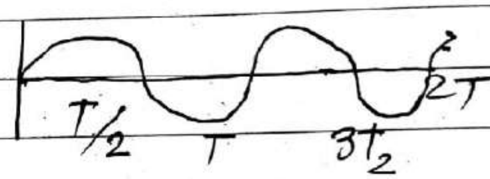
+) Alternating current of emf

→ The current or emf whose magnitude changes with the time and direction reverse perpendically is known as the alternating.

we have the emf $E = E_0 \sin\omega t$

$E >$ or $\bar{E}$ or E_{av}

$$E_{av} = \frac{\int_0^T E dt}{\int_0^T dt}$$



$$= \frac{\int_0^T E_0 \sin\omega t}{t} = E_0 \frac{\left[\frac{\cos\omega t}{\omega}\right]_0^T}{T}$$

$$= \frac{\frac{E_0}{\omega}\left[\cos\omega T - \cos 0\right]}{T}$$

$$= \frac{E_0}{\omega T}\left[\cos \frac{2\pi}{T}.T - 1\right]$$

$$= \frac{E_0}{\omega T}[1-1] = 0$$

$$E_{av} = \frac{\int_0^{T/2} E dt}{\int_0^{T/2} dt}$$

halfcycle

$$= \frac{\int_0^{T/2} E_0 \sin \omega t}{T/2}$$

$$= \frac{2}{T} \int_0^{T/2} E_0 \sin \omega t$$

$$= \frac{2}{T} \int_0^{T/2} E_0 \sin \omega t$$

$$= \frac{2}{T} E_0 \int_0^{T/2} \sin \omega t$$

$$= \frac{2E_0}{T} \int_0^{T/2} \sin \omega t$$

$$= \frac{2E_0}{T} \left[\frac{-\cos \omega t}{\omega} \right]_0^{T/2}$$

$$= (-1) \frac{2E_0}{T\omega} \left[\cos \omega t \right]_0^{T/2}$$

$$= \frac{2E_0}{T\omega} \left[\cos \omega - \cos 0 \right]_0^{T/2}$$

$$= \frac{2E_0}{T\omega} \left[\cos - \cos 0 \right]$$

$$= \frac{-2E_0}{T\omega} \left[\cos \frac{2\pi}{T} . \frac{T}{2} - \cos 0 \right]$$

$$= \frac{-2E_0}{\frac{T . 2\pi}{T}} \left[\cos \pi - \cos 0 \right]$$

$$= \frac{-2E_0}{2\pi} \left[-1 - 1 \right]$$

$$= \frac{E_0}{\pi} . 2$$

$$E_{av} = \frac{2E_0}{\pi}$$

(half cycle)

similarly (I_{av})

$$\text{half cycle} = \frac{2I_0}{\pi}$$

squareroot → Averege → root

= RMS value of current and Emf :-

The square root of average of square of the current and emf is called RMS value of current and emf

$$I_{rms} = \left[\langle i^2 \rangle \right]^{1/2}$$

$$= \left[\frac{\int_0^T i^2 dt}{\int_0^T dt} \right]^{1/2}$$

$$= \left[\frac{\int_0^T (I_0 \sin \omega t)^2 dt}{\int_0^T dt} \right]^{1/2}$$

$$= \left[I_0^2 \frac{\int_0^T \sin^2 \omega t \, dt}{T} \right]^{1/2}$$

$$= \left[\frac{I_0^2}{T} \int_0^T \left(\frac{1 - \cos 2\omega t}{2} \right) dt \right]^{1/2}$$

$$= \left[\frac{I_0^2}{2T} \int_0^T dt - \int \cos 2\omega t \, dt \right]^{1/2}$$

$$= \left[\frac{I_0^2}{2T} \left\{ T - \left(\frac{\sin 2\omega t}{2\omega} \right) \right\} \right]^{1/2}$$

$$= \left[\frac{I_0^2}{2T}\left[T - \left\{\frac{1}{2\omega}\left(\sin 2\omega T - 0\right)\right]\right]^{1/2}$$

$$= \left[\frac{I_0^2}{2T}\left[T - \left\{\frac{1}{2\omega}\left(\sin 2\omega \cdot \frac{2\pi}{\omega} - 0\right)\right]\right]^{1/2}$$

$$= \left[\frac{I_0^2}{2T}\left\{T - \frac{1}{2\omega}\left(\sin 4\pi - 0\right)\right]\right]^{1/2}$$

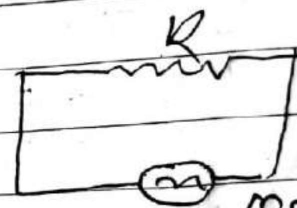
$$= \frac{I_0^2}{2T}\left(T - \left\{\frac{1}{2\omega}\left(0 - 0\right)\right\}\right)^{1/2}$$

$$= \left[\frac{I_0^2}{2T} \cdot T\right]^{1/2} = \frac{I_0}{\sqrt{2}}$$

Thus, $I_{rms} = \frac{I_0}{\sqrt{2}}$

1) AC throug resistance only:

AC through a resistance only. An ac source is connected to a resistor R is shown in fig(1). such a circuit is known as resistive circuit.

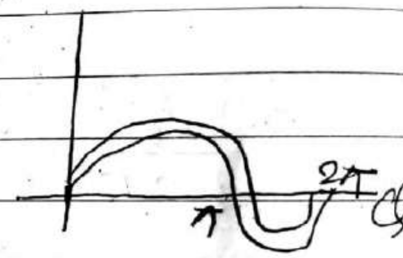


fig(a)

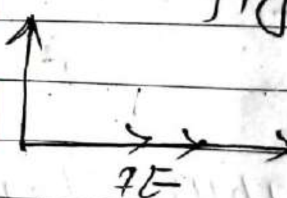
The applied alternating emf is given by $E = E_0 \sin\omega t$ —(1) fig-1)

Let 'I' be the current in the circuit at any instant of time 't', so the potential difference across the resistor

$E = IR$



fig(b)



fig(c)

V.Imp

series RL circuit :-

consider a resistor of resistance R and inductor of inductance 'L' are connected in series as shown in fig-1

let ac current $I = I_0 \sin\omega t$ passes through the circuit. then,

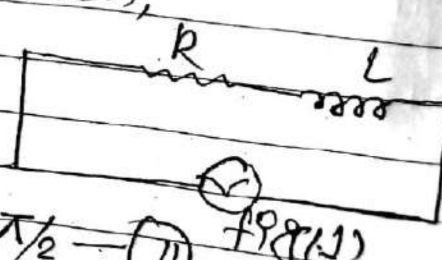
$E_R = I_0 R$

$E_R = I_0 R \sin\omega t$ —(I)

and,

$E_L = I X_L$

$= I_0 X_L \sin(\omega t + \pi/2)$ —(II)



fig(1)

the resultant (pd) (E) = $\sqrt{ER^2 + EL^2}$

$E = \sqrt{(I_0R)^2 + (I_0X_L)^2}$

$= I_0\sqrt{R^2 + X_L^2}$

$E = I_0 Z$

where, $Z = \sqrt{R^2 + X_L^2}$ is called impedence.

let, α be the angle made by the resultant pod (E) with the current then,

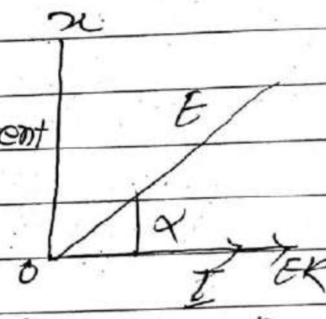


fig.2 diagram

$\tan\alpha = \frac{E_L}{E_R}$

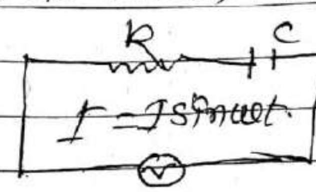
$= \frac{I_0 X_L}{R}$

$\boxed{\tan\alpha = \frac{X_L}{R}}$

1000

series R-C circuit :- consider a resistor of resistance R is connected with a capacitor of capacitance, C, connected in series as shown in fig.

let, ac current $I = I_0 \sin\omega t$ passes through the circuit then,



$E_R = IR$

$E_R = I_0 R \sin\omega t$ — (I)

$E_C = IX_C = I_0 X_C \sin(\omega t - \pi/2)$ — (II) the resultant pod (E) $= \sqrt{E^2R + E^2C}$

$= \sqrt{(I_0R)^2 + (I_0xc)^2}$

$= I_0\sqrt{R^2 + Xc^2}$

$E = I_0 z$

where, $z = \sqrt{R^2 + Xc^2}$ is the impendence

let, α be the angle made by the resultant pod (E) with the current, then

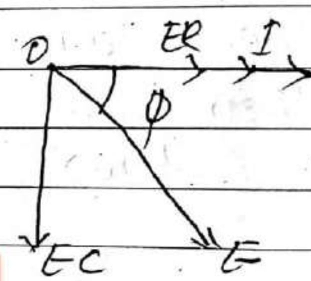


fig 1

$\tan\alpha = \frac{Ec}{ER} = \frac{I_0XC}{I_0R} = \frac{xc}{R}$

$\therefore \tan\alpha = \frac{xc}{R}$

✓1000 RLC – series circuit :– consider an inductor of inductance 'L' a capacitor of capacitance C and a resistor of resistance 'R' are connected in series as shown in fig. 1

let, ac current, $I = I_0 \sin\omega t$ passes through the circuit then,

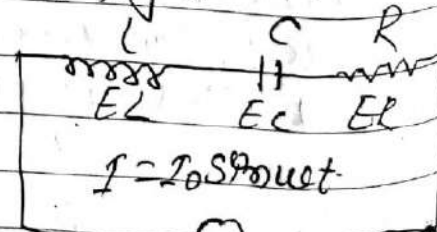


fig. 1

$E_L = (E_0)_L \sin(\omega t + \pi/2)$

$= I_0 X_L \sin(\omega t + \pi/2)$

$E_c = (E_0)_c \sin(\omega t - \pi/2)$
$= I_0 X_C \sin(\omega t - \pi/2)$

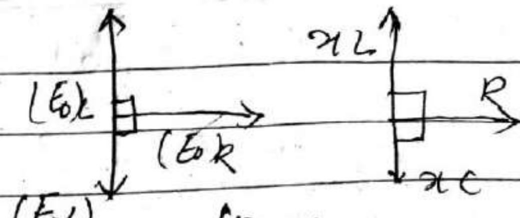


fig-2

and,
$E_R = I_0 R \sin \omega t$

case-I when $E_L > E_C$ i.e $X_L > X_C$ the the resultant pod.

$$E = \sqrt{(E_0)_R^2 + [(E_0)_L - (E_{0C})]^2}$$

then,
$$\tan\alpha = \frac{(E_0)_C - (E_0)_L}{E_0 R}$$

$$\tan\alpha = \frac{I_0 X_C - I_0 L}{I_0 R}$$

$$\boxed{\tan\alpha = \frac{X_C - X_L}{R}}$$

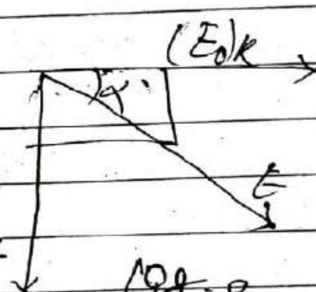


fig-3

case-(III) when $(E_{0C}) = (E_0)_L$
then,
$$E = \sqrt{(E_{0R})^2}$$
$$= \sqrt{(I_0 R)^2}$$
$$\boxed{E = I_0 R}$$

$$E = \sqrt{I_0^2 R^2 + (I_0 X_L - I_0 X_C)^2}$$

$$= I_0 \sqrt{R^2 + (X_L - X_C)^2}$$

$$E = I_0 Z \quad \text{--- (I)}$$

where,

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

is called the impendence

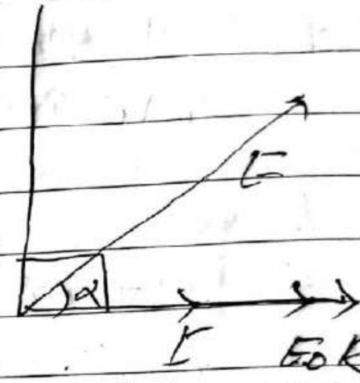


fig-2

$$\tan\alpha = \frac{(E_0)_L - (E_0)_C}{(E_0)_R} = \frac{X_L - X_C}{R}$$

Case-(II)

when, $(E_0)_C > (E_0)_L$ then the

$$E = \sqrt{E_{0R}^2 + (E_{0C} - E_{0L})^2}$$

$$= \sqrt{I_0^2 R^2 + (I_0 X_C - I_0 X_L)^2}$$

$$E = I_0 \sqrt{R^2 + (X_C - X_L)^2}$$

$$E = I_0 Z \quad \text{--- (II)}$$

where, $Z = \sqrt{R^2 + (X_C - X_L)^2}$ is called impendence. (Z)

i) Revese biasing :- When p-side of diode is connected with negative terminal and N-side is connected with positive terminal of battery such biasing is called reverse biasing.

When a diode is reverse biased

> The width of depletion layer increase
> The barrier potential ($V+V_B$) increase
> The flow of current due to minority charge carries
-> The diode offers high resistance called reverse resistance

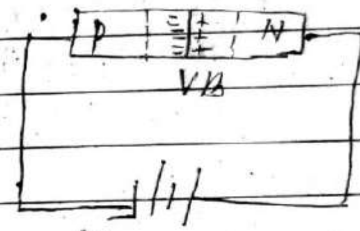


fig Reverse biasing

(*) Rectifier :-
An electronic device which converts alternating signal to unidirectional (dc) signal is called rectifiers.

Rectifires are two types :-

i> Halfwave rectifier : The rectifier which convert the half wave ac to dc is called Half wave rectifier. The circuit diagram of half wave rectifier is shown in fig. 1 it consists of a diode D connected in series with coil of transformer and load RC. Ac current is applied across the primary coil p of a transformer and a voltage in induced across the secondary coil during positive half cycle the diode 'D' is in forward and current flow through the diode. during negative half cycle, the diode is in reverse bias and no current flows through the diode. Hence only unidirectional current flows through R_L Hence the diode is half wave rectifiers.

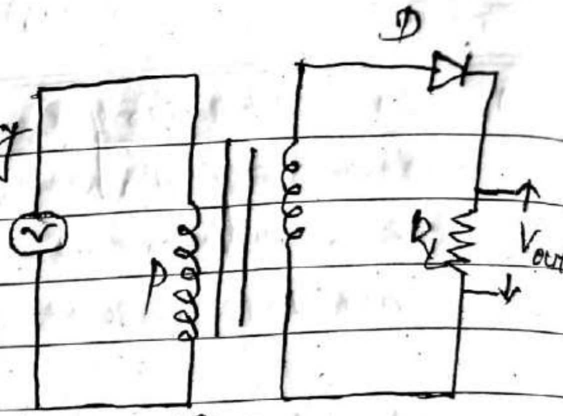


fig.I

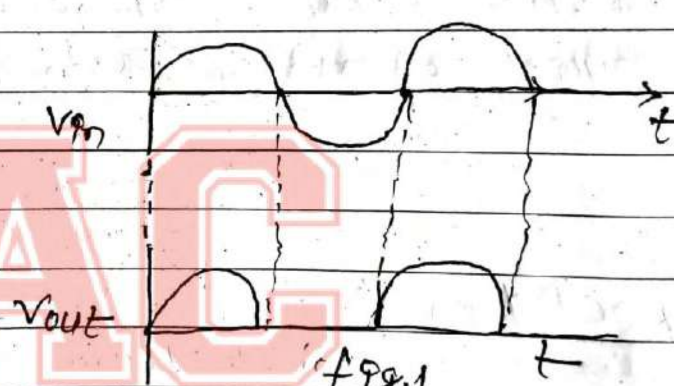


fig.1

imp full wave rectifier:-

A rectifier which converts both cycles of ac to unidirectional current is called full wave rectifier.

centretap rectifier

The circuit diagram of centre tap rectifier is shown in fig.I. It consists of two diode D_1 and D_2 connected at upper and lower ends of secondary coil of transformer. The load resistance R_L is is connected with the centre of secondary coil. When ac input is applied to primary coil, A voltage is induced in secondary coil centre tapping of secondary is connected to N-ends of diode.

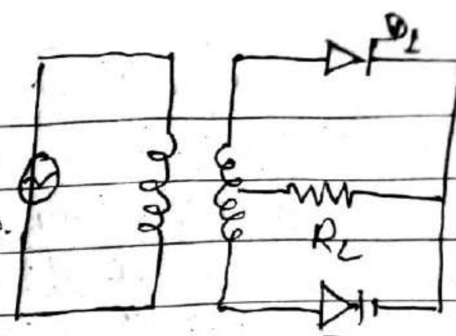


fig I

During positive half cycle, the diode is in forward bias and current flows the diode D_1 and D_2 is in reverse bias and no current flows through D_2.
During negative half cycle the diode D_1 is in reverse bias and no current flow through the diode D_1. The diode D_2 is in forward bias and current flow through the diode D_2.
Hence, unidirectional current is obtained from both the diodes so, centre tap rectifier is full wave rectifier.

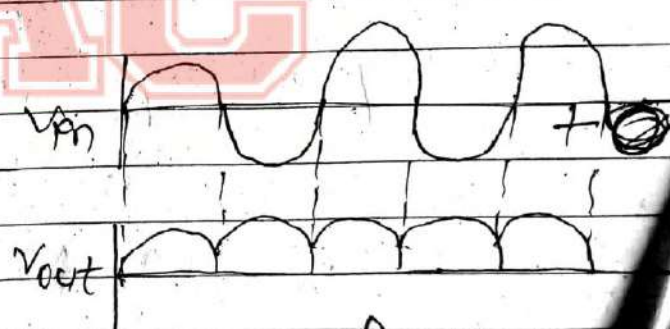


fig. II

079/12

* Photon *

(1) photon or quanta :- Each bundle or packet of electromagnetic wave which carries certain amount of energy and travel with the velocity of light is called photon or quanta.

The energy of photon is

$$E = hf = \frac{hc}{\lambda}$$

(2) photon electric effect :- when light of sufficiently smaller wave length fall on the metal surface. then the electrons emitted this phenomenon is called photon electric effect.

V.V.I

Einstein's photoelectric equation :- when light of sufficiently smaller wavelength fall on the metal surface then the electron emitted. This phenomenon is called photoelectric effect.

consider a radition having energy $E = hf$ is incident on the surface of metal. some part of this energy is used to knock out of the electrons from the surface of metal as shown in fig.1 The remaining energy is utilized in join parting kinetic energy.

The energy required to knock out on electron from the surface of metal is called workfunction (ϕ)

Thus,

Energy of radition (hf) = work function (ϕ) + K.Emax

$$hf = \phi + \frac{1}{2}mv^2_{max} \text{ ——— (I)}$$

If f_0 be the thresold frequency then,

$$\phi = hf_0 \text{ ——— (II)}$$

putting the eqn. (II) in eqn. (I)

$$hf = hf_0 + \frac{1}{2}mv^2_{max}$$

$$(hf - hf_0) = \frac{1}{2}mv^2_{max}$$

$$(hcf - f_0) = \frac{1}{2}mv^2_{max} \text{ ——— (III)}$$

Thus, the eqn. (I) and (III) are the required einstein's photo electric equation.

Unit I

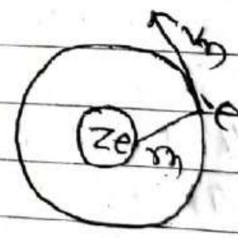
Bohar's theory of hydrogen atom:-

Consider a hydrogen atom with positive charge +ze in the nuclies. An electron with negative charge -e revolving in an orbit of radius 'r_n' with the velocity 'v_n'. from the columb's law in electrostatic the electrostatic force of attraction between nucleus and the electron is given,

$$f = \frac{ze \cdot e}{4\pi\varepsilon_0 r^2} \quad \text{--- (I)}$$

If 'm' be the mass of an electron then the centripetal force which is balanced by the electrostatic force.

$$\frac{mv_n^2}{r_n} = \frac{ze^2}{4\pi\varepsilon_0 r_n^2}$$



$$m v_n^2 r_n = \frac{1}{4\pi\varepsilon_0} ze^2 \quad \text{--- (II)}$$

fig-1

Applying Bohar's postulate

$$m v_n r_n = n\frac{h}{2\pi}$$

Squaring on both side,

$$m^2 v_n^2 r_n^2 = \frac{n^2h^2}{4\pi^2} \quad \text{--- (III)}$$

Dividing eqn (III) by eqn (II) we get

$$\frac{m^2 v_n^2 r_n^2}{m v_n^2 r_n} = \frac{\frac{n^2h^2}{4\pi^2}}{\frac{ze^2}{4\pi\varepsilon_0 r_n^2}}$$

$$mr_n = \frac{n^2h^2}{4\pi^2} \times \frac{4\pi \varepsilon_0 r_n^2}{Ze^2}$$

$$mr_n = \frac{n^2h^2\varepsilon_0}{\pi Ze^2}$$

$$\boxed{\therefore r_n = \frac{n^2h^2\varepsilon_0}{\pi m Ze^2}}$$ which is required exp. of radius of n^{th} orbit

Hydrogen atom

Vol

Bhor postulate :-

1) The electron move around the nuclies in a circular path under the action of electrostatics force of attraction. i.e. $\frac{mv^2}{r} = \frac{Z \cdot Ze}{4\pi\varepsilon_0 r^2}$

2) An electron can occupy only these orbit which the angular momentum is equal to integral multiple of $\frac{h}{2\pi}$ i.e. $mvr = n\frac{h}{2\pi}$

3) An electron revolving in an stationary orbit doesnot radiate or absorb energy at all. The electron doesnot emit energy when it jump from higher energy state to lower energy state. It absorbs the energy state to higher energy state when the electron jumps from energy state f_2 to energy state f_1 then $\boxed{hf = f_2 - f_1}$

Total energy of electron orbit of hydrogen atom

from Bohar's postulate,

$$mv_n r_n = \frac{nh}{2\pi}$$

$$v_n = \frac{nh}{2\pi m r_n}$$

$$= \frac{nh}{2\pi m \frac{n^2h^2\varepsilon_0}{\pi m z e^2}}$$

$$v_n = \frac{ze^2}{2\varepsilon_0 nh} \text{ --- (v)}$$

Kinetic energy of electron in n^{th} orbit

$$(K.E) = \frac{1}{2}mv_n^2$$

$$= \frac{1}{2}m\frac{z^2e^4}{4\varepsilon_0^2 n^2h^2}$$

$$K.E. = \frac{1}{8}\frac{mz^2e^4}{\varepsilon_0^2 n^2h^2} \text{ --- (vi)}$$

$$\text{potential energy (P.E)} = \frac{1}{4\pi\varepsilon_0}\frac{(ze)(-e)}{r_n}$$

$$= \frac{-ze^2}{4\pi\varepsilon_0 r_n}$$

$$P.E = \frac{-ze^2}{4\pi\varepsilon_0 \frac{n^2h^2\varepsilon_0}{\pi m z e^2}}$$

$$= \frac{m z^2 e^4}{4 \epsilon_0^2 n^2 h^2} \quad \text{(vii)}$$

Total energy of electron in hydrogen atom in nth orbit is

$$E = K.E + P.E$$

$$= \frac{m z^2 e^4}{8 \epsilon_0^2 n^2 h^2} - \frac{m z^2 e^4}{4 \epsilon_0^2 n^2 h^2}$$

$$\boxed{\therefore E = \frac{m z^2 e^4}{8 \epsilon_0^2 n^2 h^2}} \quad \text{(viii)}$$

which is required exp.

vol

x-ray :-

when highly energetic electrons are made to strike a metal surface the electromagnetic radiation of very short wave length of range 0.06 A° to 100 A° is produced. This is called x-ray. x-ray was discovered by W.C Roengton in 1895.

The schematic diagram of coolidge tube for production of x-ray is shown in fig 1. It consists of evaluated glass chamber containing filament 'F' and tangent 'T'. The filament is at lower potential as compared to tangent. The filament is heated by high tension DC supply. The electron emitted from filament is allowed to incident in the tangent 'T' which is placed at 45°. when the electron strikes the tangent x-ray is produced. x-ray is collected through window (w) and coolide tube is cooled by supplying water continuously.

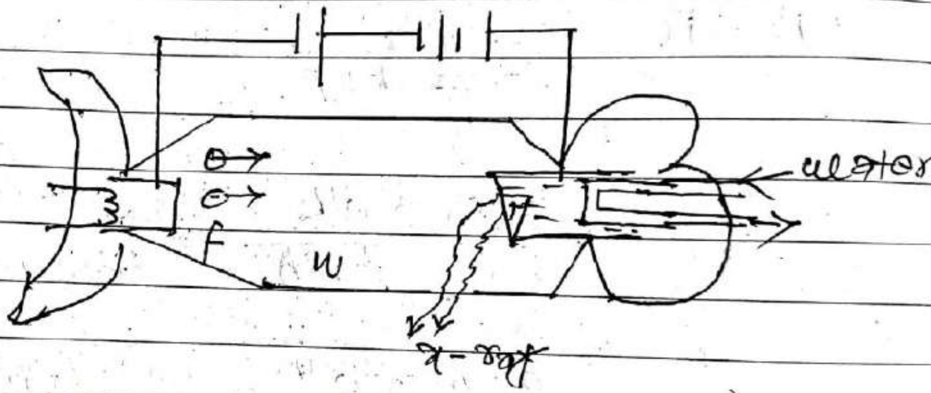


fig 1 coolide tube

V.V.I

(*) properties of x-ray :-

- x-ray has very short wave length of range 0.05A° to 100 A°
- x-ray travels in straight line with the space of light in air.
- they affect photographic ~~effe~~ plate.
- they ionize gas
- they have highly pentarating power.

use of x-ray :-

→ surgery
- Detective purpose
- engineering.
- Radiatherapy.
- scientific research
- Industry.

V° V° I

(*) Organ pipe :- The pipe which is used in musical instrument is called organ pipe.

Types of Organ pipe

⇒ There are two types of organ pipe.

i) open organ pipe.

ii) closed organ pipe.

(*) Open organ pipe :- The pipe ~~which~~ whose both ends are opened is called open organ pipe. The vibration that process the frequency in specific pattern are called mode of vibration.

When a beast of air is blown near the open end, a wave travel to other end and get reflected on encountering the free air. Thus two wave same frequency and amplitude travel in opposite directions. so a stationary wave is set up in the air in the pipe. Since air is free to vibrate at the both ends. Thus, antinodes are formed the open ends and nodes are formed between two ends.

mode of vibration

Consider an open organ pipe of length. A sound wave of velocity 'v' and wave length λ is blown to the one end of organ pipe.

first mode of vibration

In this mode, there is only one node between two antinode at the ends as shown in fig-1

The length of organ pipe is equal to half of wavelength

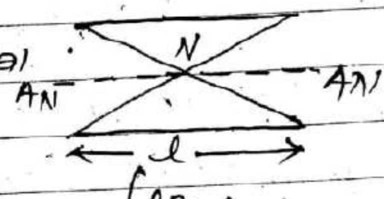


fig-1

$$l = \lambda/2$$

$$\lambda = 2l$$

then the frequency $f_1 = \frac{v}{\lambda} = \frac{v}{2\lambda}$ is first harmonic.

second mode of vibration:
In this case, two node are formed between two open ends as shown in fig.2

The length of open pipe is equal to wave length λ of the wave

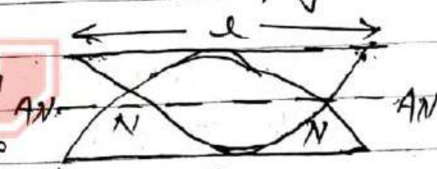


fig.2

$$l = \lambda$$

The frequency is $f_2 = \frac{v}{\lambda} = 2.\frac{v}{2\lambda} = 2f$

It is second harmonic or first overtone.

Third mode of vibration:- In this mode three nodes (N) are formed between two open ends as shown in fig-3

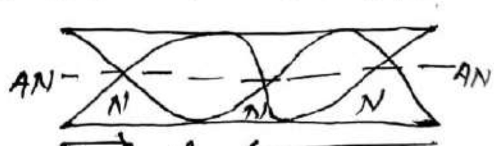


fig-3

The length of open organ pipe is equal to $\frac{3\lambda}{2}$ i.e. $l = \frac{3\lambda}{2}$

Now, the frequency, $f_3 \longrightarrow \lambda = \frac{2l}{3}$, $f_3 = \frac{v}{\lambda_3} = \frac{v}{2l/3} = 3\left(\frac{v}{2l}\right)$
$= 3f_1$

(*) closed organ pipe :- The organ pipe whose one end is opened and other end is closed is called closed organ pipe. The wave passing through one open end get reflected back and interfere with the incident wave. Hence stationary wave is formed.

Mode of vibration :- consider a closed organ pipe of length 'l'. A sound wave of velocity 'v' and wave length λ is blown at the one end.

First vibration :-
In this vibration, one antinode (AN) is formed at the open end and Node (N) is formed at the closed end as shown in fig-1

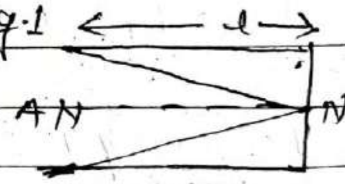


fig-1

Here, the length of pipe is equal to $\lambda/4$ i.e. $l = \lambda/4$

$\lambda = 4l$

Now, the frequency $(f_1) = \frac{v}{\lambda} = \frac{v}{4l}$

It is the first harmonic.

Second mode of vibration :- In this vibration two antinodes (AN) are formed as shown in fig 2

In this case the length 'l' of the organ pipe is equal to $3\lambda/4$

fig 2

$l = \frac{3\lambda}{4}$

$\lambda = \frac{4l}{3}$

frequency $(f_2) = \frac{v}{\lambda} = \frac{v}{\frac{4l}{3}}$

$= 3\left(\frac{v}{4l}\right)$

$= 3f_1$ is 3rd Harmonics and first overtone.

Third mode of vibration :- In this mode three Nodes(N) and three antinode (AN) are formed as shown in fig.3

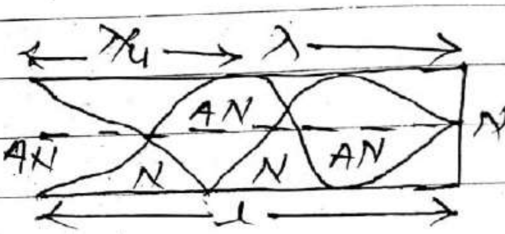


fig.3

the length of pipe is equal to $5\lambda/4$

i.e $l = \frac{5\lambda}{4}$

$\lambda = \frac{4l}{5}$

The frequency is

$$f_3 = \frac{v}{\lambda} = \frac{v}{4l/5} = 5\left(\frac{v}{4l}\right) = 5f_1$$

It is fifth harmonic and second overtone.

12) Progressive wave (Travelling wave):-
→ The wave which has same amplitude and transfer energy on a forward direction is called progressive or Travelling wave.
exg:- Sound wave.

(13) Equation of progressive wave:-
↳ let us consider a progressive wave travel from a left to right from a mean position. In this wave there arises a simple harmonic motion that is,

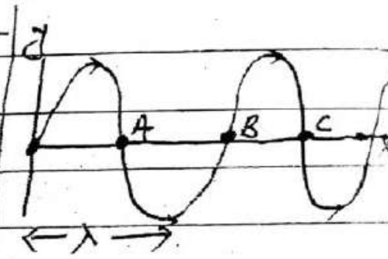


fig:- progressive wave

$$y = a\sin(\omega t - \phi) \quad \text{—(i)}$$

$$\text{or, } y = a\sin\left(\frac{2\pi}{T}\cdot t - \frac{2\pi}{\lambda}\cdot x\right)$$

$$\therefore y = a\sin 2\pi\left(\frac{t}{T} - \frac{x}{\lambda}\right) \quad \text{—(ii)}$$

again from eqn (i)

$$y = a\sin\left(\frac{2\pi v}{\lambda}\cdot t - \frac{2\pi}{\lambda}\cdot x\right)$$

$$\therefore y = a\sin\frac{2\pi}{\lambda}(vt - x) \quad \text{—(iii)}$$

again from eqn. (i)

$$y = a\sin\left(\omega t - \frac{2K}{\lambda}\cdot x\right)$$

$$\therefore y = a\sin(\omega t - kx) \quad \text{—(iv)}$$

where, $k = \frac{2\pi}{\lambda}$ = constant

$$v = d/t$$
$$\text{W.}v = \lambda/t \quad \text{—(i)}$$
$$\omega = 2\pi f$$
$$f = 1/T$$
$$\omega = 2\pi\cdot\frac{1}{T}$$
$$\therefore \omega = \frac{2\pi}{T} \quad \text{—(ii)}$$
$$v = \lambda/t$$
$$t = \lambda/v$$
$$\omega = \frac{2\pi}{\lambda/v}$$
$$\therefore \omega = \frac{2\pi v}{\lambda}$$

$\phi = \frac{2\pi}{\lambda}$

wave Right to Left

$\therefore y = a\sin(\omega t + kx)$

In general

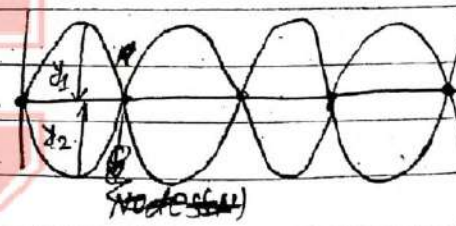
$\boxed{\therefore y = a\sin(\omega t \pm kx)}$ proved

Hence, which is the required equation from progressive

(14) principle of superimposition:-

↳ When two or more waves travel simultenously there arise a resultant displacement which is equal to vector sum of individual displacement.

i.e. $y = \vec{y_1} + \vec{y_2}$



(15) Stationary wave (Standing wave):-

↳ When two progressive wave of same amplitude frequency and wave length superimposed and forms a new wave know as stationary or standing wave.

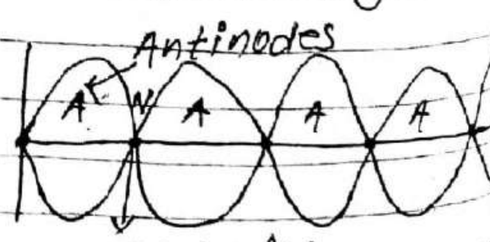


fig:- Stationary wave.

Stationary wave (Standing wave) :-

$y = y_1 + y_2$

progressive wave is given by,

$y_1 = a\sin(\omega t - kx)$ — (i)

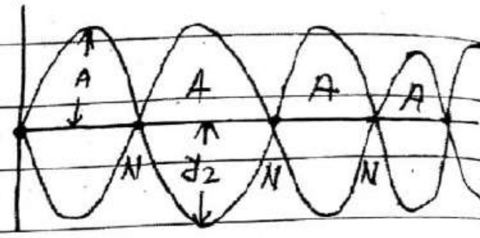


fig:- Stationary wave

y_2 be two displacement in a opposite direction

progressive wave is give by,

$y_2 = a\sin(\omega t + kx)$ — (ii)

From the principle of superimposition, we can write

$y = \vec{y_1} + \vec{y_2}$

or, $y = a\sin(\omega t - kx) + a\sin(\omega t + kx)$

or, $y = a[\sin(\omega t - kx) + \sin(\omega t + kx)]$

or, $y = a\left[2\sin\left(\frac{\omega t - kx + \omega t + kx}{2}\right) \cdot \cos\left\{\frac{\omega t - kx - (\omega t + kx)}{2}\right\}\right]$

or, $y = a\left[2\sin\left(\frac{\cancel{2}\omega t}{\cancel{2}}\right) \cdot \cos\left(\frac{\cancel{\omega t} - kx - \cancel{\omega t} - kx}{2}\right)\right]$

or, $y = a\left[2\sin\omega t \cdot \cos\left(\frac{-\cancel{2}kx}{\cancel{2}}\right)\right]$

or, $y = a[2\sin\omega t \cdot \cos(-kx)]$

or, $y = a[2\sin\omega t \cdot \cos kx]$ $(\because \cos(-\theta) = \cos\theta)$

or, $y = 2a\sin\omega t \cdot \cos kx$

or, $y = 2a\cos kx \cdot \sin\omega t$

$\therefore \boxed{y = A\sin\omega t}$ where, $2a\cos kx$ = Amplitude (A)

Hence, which is required stationary or standing wave

(16) Antinodes:- A point on stationary wave (A) with maximum Amplitude is called Antinodes.

(16) Nodes:- A point on stationary wave (N) with zero Amplitude is called nodes.

(17) Properties of sound wave
(i) Reflection of sound
(ii) Refraction of sound
(iii) Interfrance of sound – (i) Constructive interfrance
(ii) Distructive interfrance

(18) Interfrance :-
→ The non-unifor distribution of sound energy due to superposition is called interfrance of so

(19) Constructive Interfrance :-
→ The interfrance in which crest of one wave overlap with the crest of another wave and Trough is overlap with the Trough of another wave is called constructive interfrance. In this Interfrance amplitude is increase.

(20) Distructive interfrance :-
→ The interfrance in which crest of one wave overlap with the Trough of another wave and Trough is overlap with the crest of another wave is called constructive interfrance. In this interfrance amplitude is decrease.

$-dp \Rightarrow$ stress
$\frac{dv}{v} \Rightarrow$ strain

(2) Describe Newton's formula for velocity of sound in air medium and how Laplace corrected Newton's formula :-

→ Newton assume that the velocity of sound in air is slow process in this process temprature is constant with respect to surrounding. Since this process is isothermal process which is given by ⇒ $pv =$ constant.

Now Differentiating both side, we get

$d[pv] = d[\text{constant}]$

or, $pdv + vdp = 0$

or, $pdv = -vdp$

or, $p = \frac{-vdp}{dv}$

or, $p = \frac{-dp}{\frac{dv}{v}}$

$\therefore p = E$ -(i) where Elasticity $(E) = \frac{\text{stress}}{\text{strain}}$

We know velocity of sound in medium is given,

or, $v = \sqrt{E/\rho}$

or, $v = \sqrt{P/\rho}$

or, $v = \sqrt{\frac{1.013 \times 10^5}{1.293}}$ where, $P = 1.013 \times 10^5$ and $\rho = 1.293$

$\therefore v = 280$ m/s

The velocity of sound in air is 332 m/s experimentally but Newton's theoritically derive 280 m/s, so Newton's is not verified. To verify Laplace corrected the Newton's formula.

So,

$pv^{\gamma} = \text{constant}$

Differeantating both side, we get

$d[pv^{\gamma}] = d[\text{constant}]$

or, $p\gamma v^{\gamma-1} dv + v^{\gamma} dp = 0.$

or, $p\gamma v^{\gamma-1} dv = -v^{\gamma} dp$

or, $p\gamma = \dfrac{-v^{\gamma} dp}{v^{\gamma-1} . dv}$

or, $p\gamma = -\dfrac{v^{\gamma} dp}{v^{\gamma} . v^{-1} . dv}$

or, $p\gamma = \dfrac{-dp}{\frac{dv}{v}}$

or, $p\gamma = E$

We know that verocity of sound medium

$v = \sqrt{\frac{E}{\rho}} = \sqrt{\frac{p\gamma}{\rho}} = \sqrt{\frac{1.013 \times 10^5 \times 1.4}{1.293}}$ (where, $\gamma = 1.4$)

$v = 331.1$ m/s

$\boxed{\therefore v = 332 \text{ m/s}}$ → proved

Hence, which is experimentally verified.

) velocity of transverse wave in a stretched string [Dimension method]

> The velocity of transverse wave in a stretched string is given by $v = \sqrt{\frac{T}{M}}$

where, T is tension and M is mass per unit length.

(i) Tension of the string, $v \propto T^x$ — (1)

Tension of the string, $v \propto M^y$ — (2)

ii) length of the string, $v \propto l^2$ — (3)

Combining eqn (1), (2) and (3), we get

$$v \propto T^x M^y l^2$$

$$or,\ v = K T^x M^y l^2 \quad \text{— (4)}$$

Taking dimensions,

$$\left.\begin{aligned} v &= [M^0 L T^{-1}] \\ T &= [M^1 L^1 T^{-2}] \\ M &= [M^1 L^0 T^0] \\ L &= [M^0 L^1 T^0] \end{aligned}\right\} \text{— (5)}$$

puting value of eqn (4) in eqn (5)

$$v = K T^x . M^y . L^2$$

$$[M^0 L^1 T^{-1}] = [M^1 L^1 T^{-2}]^x . [M^1 L^0 T^0]^y . [M^0 L^1 T^0]^2$$

Either,

$$x + y = 0 \quad \text{— (6)}$$

$$x + 2 = 1 \quad \text{— (7)}$$

$$-2x = -1 \quad \text{— (8)}$$

from eqⁿ (8),

$-2x = -1$
$\Rightarrow x = \frac{1}{2}$

puting x in eqⁿ (6) and (7)

$\frac{1}{2} + y = 0$
$\Rightarrow y = -\frac{1}{2}$

$\frac{1}{2} + z = 1$
$\Rightarrow z = \frac{1}{2}$

Now

$$v = K T^{x} . M^{y} . l^{z}$$

$$v = K T^{1/2} . M^{-1/2} . l^{1/2}$$

$$v = K \sqrt{\frac{T}{M/l}}$$

$$\boxed{\therefore v = \sqrt{\frac{T}{M}}}$$ proved

Hence, This is the required velocity of transverse wave in a stretched string.

13) phase difference :-

→ phase difference is defined as the situation where the wave complete (light wave).

$\boxed{\text{phase difference } (\phi) = (2n-1)\pi}$

~~path difference (x) = (2n-1) λ/2~~

(13) path difference :-

→ path difference is the difference between two waves from where it started.

$\boxed{\text{path difference } (x) = (2n-1)\lambda/2}$

(14) Derive young's double slit experiment. Show that both bright and dark fringe has same fringe width.

⇒ Let 'S' be the source of monochromatic light falls on the slit A and B. Let 'd' be the distance between two slits A and B, 'D' be the distance between slit and the screen. Due to superposition of light Bright fringe and dark fringe occurs on the screen.

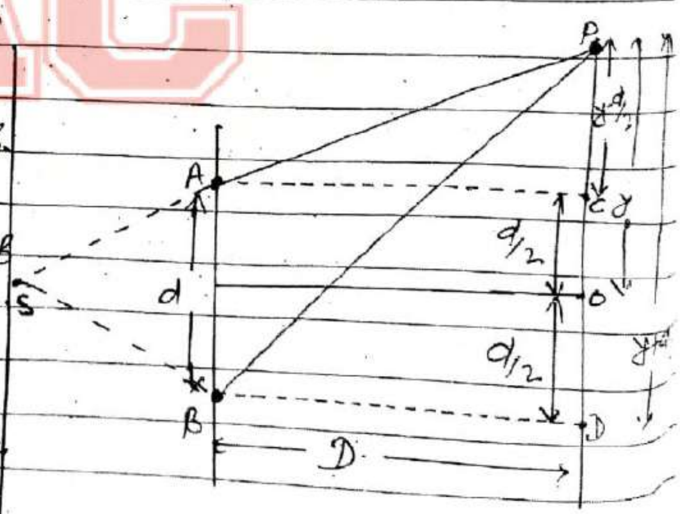


fig:- young's double slit experiment.

By using pathogorous theorem, ΔACP

or, $(AP)^2 = (y - d/2)^2 + (D)^2$ $\quad (\because AP^2 = CP^2 + AC^2)$

or, $= y^2 - 2y \cdot d/2 + d^2/4 + D^2$

$\therefore AP^2 = y^2 - yd + d^2/4 + D^2$ —— (1)

again

rt. angle ΔBDP

or, $BP^2 = (PD)^2 + (BD)^2$ $\quad (\because h^2 = p^2 + b^2)$

$= (y + d/2)^2 + (D)^2$

$= y^2 + 2 \cdot y \cdot d/2 + d^2/4 + D^2$

$\therefore BP^2 = y^2 + yd + d^2/4 + D^2$ —— (2)

for path difference $(x) = BP - AP$ —— 3

Now

Subtracting eqn (2) and (2)

or, $BP^2 - AP^2 = y^2 + yd + d^2/4 + D^2 - (y^2 - yd + d^2/4 + D^2)$

or, $(BP)^2 - (AP)^2 = \cancel{y^2} + yd + \cancel{d^2/4} + \cancel{D^2} - \cancel{y^2} + yd - \cancel{d^2/4} - \cancel{D^2}$

or, $(BP + AP)(BP - AP) = 2yd$

Suppose, $BP \simeq D$

$AP \simeq D$

then,

or, $(D+D).x = 2yd$ $\quad (\because BP-AP = x)$

or, $2Dx = 2yd$

or $x = \frac{2yd}{2D}$

$\therefore x = \frac{yd}{D}$ —— (4)

Bright fringe [constructive interference]

or $n\lambda = \frac{yd}{D}$

or, $yd = n\lambda D$

$\therefore y = \frac{n\lambda D}{d}$

[where, $n = 1, 2, 3 ---$]

$n = 1$

or, $y_1 = \frac{1 \times \lambda D}{d}$

$\therefore y_1 = \frac{\lambda D}{d}$

$n = 2$

or $y_2 = \frac{2 \times \lambda D}{d}$

$\therefore y_2 = \frac{2\lambda D}{d}$

Fringe width (β) :- The difference between two constructive bright fringe is called fringe wid

So,

$$\beta = y_2 - y_1$$

$$= \frac{2\lambda D}{d} - \frac{\lambda D}{d}$$

$$\therefore \beta = \frac{\lambda D}{d}$$

again

Dark fringe (distructive interference)

$$(2n+1)\cdot\frac{\lambda}{2} = \frac{yd}{D}$$

$$\therefore y = \left(\frac{2n+1}{2}\right)\cdot\frac{\lambda D}{d}$$

[where, $n = 0, 1, 2, 3$ ----]

$n = 0$

or $y_0 = \left(\frac{2\times0+1}{2}\right)\cdot\frac{\lambda D}{d}$

$$\therefore y_0 = \frac{\lambda D}{2d}$$

$n = 1$

or $y_1 = \left(\frac{2\times1+1}{2}\right)\cdot\frac{\lambda D}{d}$

$$\therefore y_1 = \frac{3}{2}\cdot\frac{\lambda D}{d}$$

Now

fringe width

$$\beta = y_1 - y_0$$

$$= \frac{3}{2}\frac{\lambda D}{d} - \frac{\lambda D}{2d}$$

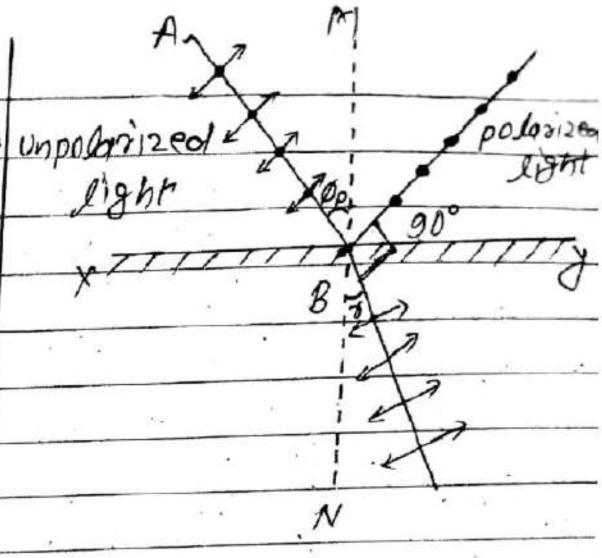
$$\boxed{\therefore \beta = \frac{\lambda D}{d}}$$

which ex...

(19) Brewster's law :-

Statement:- The tangent of the polarizing angle is equal to the refrative index of transparent medium at which light incident

i.e. $\mu = \tan \phi_p$ ($\because \phi_p$ = polarizing angle)



Let us considered a glass slab xy. AB be the unpolarized light having angle ϕ_p incidence on the glass slab and gets polarized after reflection and refraction. The angle between reflection and refraction is 90°.
The angle of incidence (and reflection) at which maximum polarized light occurs is called Brewster's angle or polarized angle.

from fig:-

$\phi_p + 90 + r = 180°$

or, $\phi_p + r = 180° - 90°$

or, $\phi_p + r = 90°$

$\therefore r = 90° - \phi_p$

By using snell's law

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

or, $\mu = \frac{\sin \phi_p}{\sin(90 - \phi_p)}$

or, $\mu = \frac{\sin \phi_p}{\cos \phi_p}$

$\boxed{\therefore \mu = \tan \phi_p}$

which is shows that refractive index is equal to the tangent of polarizing angle.

(13) Hooke's law :-

↳ With in elastic limit stress is directly proportional to the strain.

i.e.

stress α strain

or, Stress = E strain

or, $\frac{\text{Stress}}{\text{strain}} = E$ (where:- E is modulus of Elasticity (constant))

Verification of Hooke's law

Let a spring of length 'L' is suspended at a right point p as in figure. If the spring is attached by some mass at it lower end it is elongated by 'e' by reforming force f = mg.

which means,

$$F \alpha e$$
$$F = ke \quad \text{--- (1)}$$

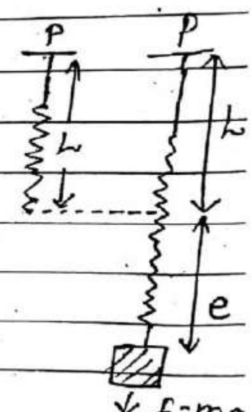


Fig :- Verification of Hooke's law

Now

dividing both sides by 'A' and multipling and dividing by 'L' on R.H.S only, we get

So,

or, $F/A = \frac{ke}{AL} \cdot L$

(where $\left(\frac{KL}{A}\right)$ is constant A is cross sectional Area and L is length)

or, $\frac{F}{A} = \frac{KL}{A} \cdot \frac{e}{L}$

so, $\frac{f}{A} \propto \frac{e}{L}$

$\boxed{\therefore \text{stress} \propto \text{strain}}$ ⇒ Hooke's law verified.

(14) Modulus of Elasticity (E)
↳ It means that $\frac{\text{stress}}{\text{strain}} = E$

(where E is modulus of Elasticity)
It's unit is N/m^2

(15) There are Three types of modulus of Elasticity (E):

(16) young's modulus of Elasticity (Y):-
↳ It is defined as the Normal stress per unit longitudinal strain.

i.e $Y = \frac{\text{Normal stress}}{\text{Longitudinal stress}}$

or, $Y = \frac{f/A}{e/L}$ $\boxed{\therefore Y = \frac{FL}{Ae}}$

(19) Energy stored in a stretched wire:-

↳ Let us consider a spring of length 'L' suspended at a rigit point 'p'. If the spring is attached by mass on its lower end. Its gets elongeter by length 'x' as in figure when deforming force $f = mg$ is applied from youns modulus of Elasticity, we have

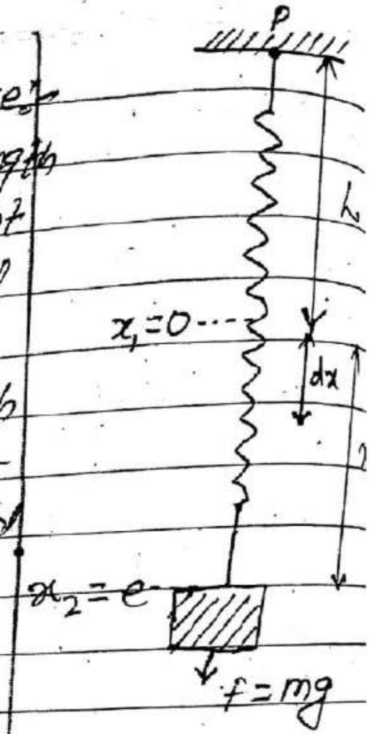


Fig:- Energy stored in a stretched wire

$$Y = \frac{fL}{Ax}$$

$$f = \frac{YAx}{L} \quad \text{——(1)}$$

If dx be the small displacement or elongation. Then small amount of work is done.

$$\boxed{\begin{aligned} dw &= \int f \cdot dx \\ &= \int \frac{YAx}{L} \cdot dx \end{aligned}}$$

$$dw = f \cdot dx$$

$$= \frac{YAx}{L} \quad \text{——(2)}$$

for total amount of work done for alongation from 0 to e we get by Integration.

dx ~~$\int_0^w f\,dx$~~

$$\int_0^w f \cdot dx$$

$$w = \int_0^e \frac{YAx}{L} \cdot dx$$

$$w = \frac{YA}{L}\left[\frac{x^2}{2}\right]_0^e$$

$$w = \frac{YA}{L}\left[\frac{e^2}{2} - \frac{0}{2}\right]$$

$$w = \frac{YA}{2L} \cdot e^2$$

$$w = \frac{YAe}{2L} \cdot e$$

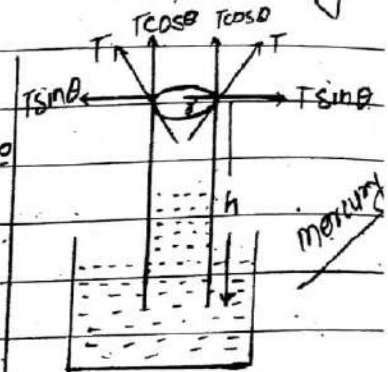
Here, work done is the required Elastic potential Energy stored in a stretched wire.

$$E = \frac{YAe}{2L} \cdot e \quad (\text{where, } x = e)$$

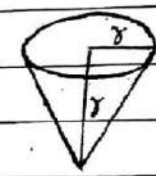
$$\boxed{E = \frac{1}{2} \times F \times e}$$

$\therefore E = \frac{1}{2} \times$ Force $\times$ elongation of length

(9) Measurement of surface Tension of liquid by ~~capa~~ capillary tube method:-



→ Let us considered a capillary tube dipped in a liquid as shown in the figure. The surface Tension resolved into two components. $T\sin\theta$ and $T\cos\theta$. θ be the angle of contact h be the height of liquid rise in capillary tube.



convex meniscus.

~~we know that, In eqli equilibrium consider.~~

we know that, In equilibrium condition,

upward force = wt. of liquid displaced —(1)

from surface tension,

$$T = \frac{F}{L}$$

$$F = T.L$$

So,

Upward force (F) $= T\cos\theta \cdot 2\pi r$ ($\because$ length of cone $= 2\pi r$)

$\therefore 2\pi r T\cos\theta$ ($\because T = T\cos\theta$)

wt. of liquid displaced $= mg$

$= V\rho g$ ($\because m = V\times\rho$)

$\therefore \pi r^2 h\rho g$ ($\because V = \pi r^2 h$)

from eq^n (1),

or, $2\pi r T \cos\theta = \pi r^2 h \rho g$

or, $2T\cos\theta = r h \rho g$

$$\boxed{\therefore T = \frac{r h \rho g}{2\cos\theta}}$$

which is required Surface Tension.

$$\boxed{\therefore h = \frac{2T\cos\theta}{r \rho g}}$$

which is height of liquid rise.

Atomic Physics

Motion of depletion of electron in electric field :-

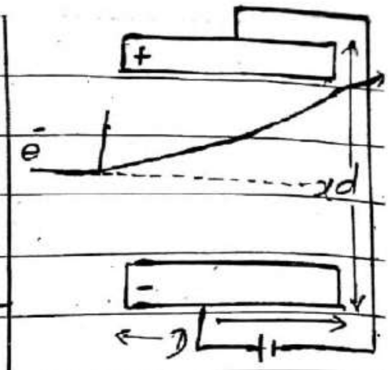


fig: motion of charged particles in electric field

) Show that motion of electron in a uniform electric field is parabolic:-

→ let us consider electron moving with a velocity 'v' in a electric field. The force experienced by a electron inside a electric field given by,

$$F = eE \quad \text{--- (1)}$$

Now, acceleration is given by,

$$F = ma$$

$$a = F/m \quad \text{--- (2)}$$

From eqn (1) and (2)

$$a = \frac{eE}{m} \quad \text{--- (3)}$$

Now, the horizontal velocity experienced by a electron at a time 't' is given by

$$t = \frac{x}{v}$$

Now, the vertical velocity due to the depletion of electron at time 't' is given by,

$$y = ut + \frac{1}{2}at^2$$

$$= 0 + \frac{1}{2}at^2$$

$= \frac{1}{2} a t^2$

$= \frac{1}{2} \frac{eE}{m} \frac{x^2}{v^2}$

$= \frac{1}{2} \frac{eE}{mv^2} (x^2)$

$\boxed{\therefore y = k x^2}$ where $k = \frac{eE}{2mv^2}$ = constant

Hence, path of electron in electric field is parabolic.

(2) Motion or depletion of electron in magnetic field:-

↳ let us consider a electron moving in a magnetic field with velocity 'v'. In this case the motion of electron is perpendicular to the magnetic field. The force experienced by a electron inside a magnetic field is given by.

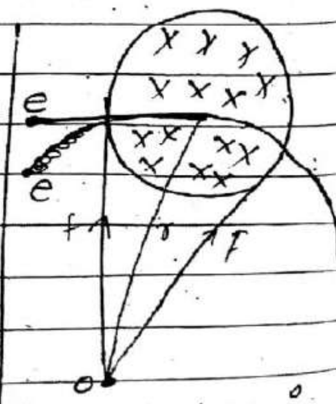


Fig:- electron in a magnetic field.

$F = B.e.v \sin\theta$ (B = magnetic field)

$F = B e v \sin 90$

$F = Bev$ — (1)

In magnetic field, the electron

moven under the centripetal force,

so,

magnetic force = centripetal force

$$Be\cancel{v} = \frac{mv^2}{r}$$

$$Be = \frac{mv}{r} \quad (\because v = \omega r)$$

$$Be = \frac{m\omega \cancel{r}}{\cancel{r}}$$

$$\omega = \frac{Be}{m} \quad \text{——— (2)}$$

which is angular velocity of electron

$$\omega = 2\pi f$$

$$f = \frac{\omega}{2\pi}$$

$$\boxed{f = \frac{Be}{2\pi m}}$$

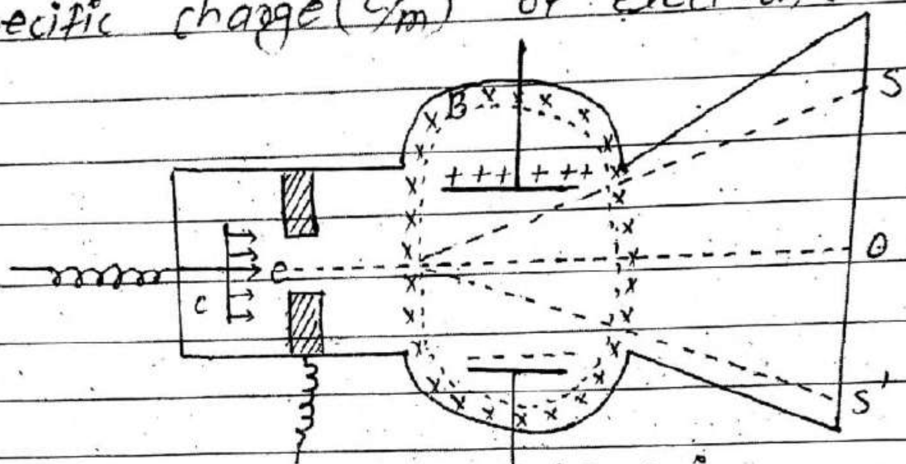
frequency of electron inside magnetic field

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

$$\boxed{T = \frac{2\pi m}{Be}}$$

Time period of electron in magnetic field.

3) J.J. Thomson experiment to determine the specific charge (e/m) of electron :-



↳ J.J. thomson explain (e/m) in a cross field region He took discharged tube for his experiment. In discharged tube cathod is conneted to negative terminal and anode is connected to positive terminal. When cathod is heated electron moven towards anode. ~~In this experiment~~ Due to hole in anode electron strikes on the screen. In this experiment magnetic field is ⊥ to electric field. He assumed three cases.

case(I):- When Electric field on electrons strike on S by parabolic path. Then electric force
$f = eE$ —— (1)

case(II):- When magnetic field on electron bends and strikes on S'. Then magnetic force
$F = Bev$ —— (2)

Case(III):- When both electric and magnetic field on electron strikes on O without diflection then,

Electric force = Magnetic force

$$\cancel{e}E = B\cancel{e}v$$

$$\therefore v = \frac{E}{B} \quad \text{——— (3)}$$

we know that,

$$E = \frac{V'}{d} \quad \text{(where, } V' \text{ is potential difference)}$$

So,

$$v = \frac{V'}{Bd} \quad \text{(which is velocity of electron)}$$

From stoping potential,

K.E. = electric potential energy

$$\text{or, } \frac{1}{2}mv^2 = eV$$

$$\text{or, } mv^2 = 2eV$$

$$\therefore \frac{e}{m} = \frac{v^2}{2V} \quad \text{——— (4)}$$

From velocity,

$$\frac{e}{m} = \frac{V'^2}{2VB^2d^2}$$

By knowing value we get,

$$\boxed{\frac{e}{m} = 1.7 \times 10^{-6}\ c/kg}$$

(4) Milikon's oil drop experiment:-

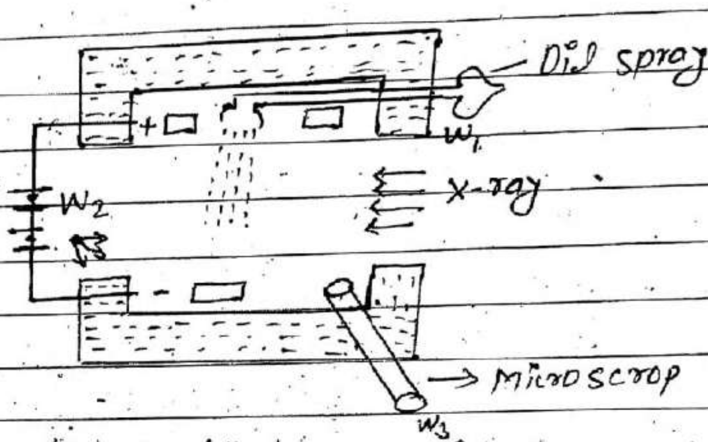
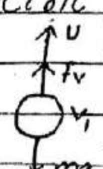


Fig:- Milikon's oil drop experimen

↳ Milikon's take a double layer wall where liquid is placed. Two metal plates is connected to battery. When oil is spray oil drop due to friction oil get charged. some oil doesnot get charged so x-ray made some oil charged. Microscope is used to see terminal velocity of oil drop. He assumed two cases.

case(I):- When electric field off under gravity.



In this case.

σ = density of air

ρ = density of oil

So, $U + F_v = mg$

or, $V\sigma g + 6\pi r\eta v_1 = V\rho g$

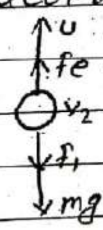
or, $\frac{4}{3}\pi r^3 \sigma g + 6\pi r\eta v_1 = \frac{4}{3}\pi r^3 \rho g$

or, $6\pi r\eta v_1 = \frac{4}{3}\pi r^3 \rho g - \frac{4}{3}\pi r^3 \sigma g$

or, $6\pi r\eta v_1 = \frac{4}{3}\pi r^3 (\rho - \sigma) g$ —— (1)

~~or, $r = \sqrt{\frac{9(\rho-\sigma)g}{2\eta v_1}}$ —— (2)~~ $\therefore r = \sqrt{\frac{9\eta v_1}{2(\rho-\sigma)g}}$ —— (2)

Case(II):- When electric field on under gravity.



So, $U + F_e = F_v + mg$

or, $\frac{4}{3}\pi r^3 \sigma g + qE = 6\pi r\eta v_2 + \frac{4}{3}\pi r^3 \rho g$

or, $qE = 6\pi r\eta v_2 + \frac{4}{3}\pi r^3 \rho g - \frac{4}{3}\pi r^3 \sigma g$

or, $qE = 6\pi r\eta v_2 + \frac{4}{3}(\rho - \sigma) g$

or, $qE = 6\pi r\eta v_2 + 6\pi r\eta v_1$ ($\because$ from eqn. (1)

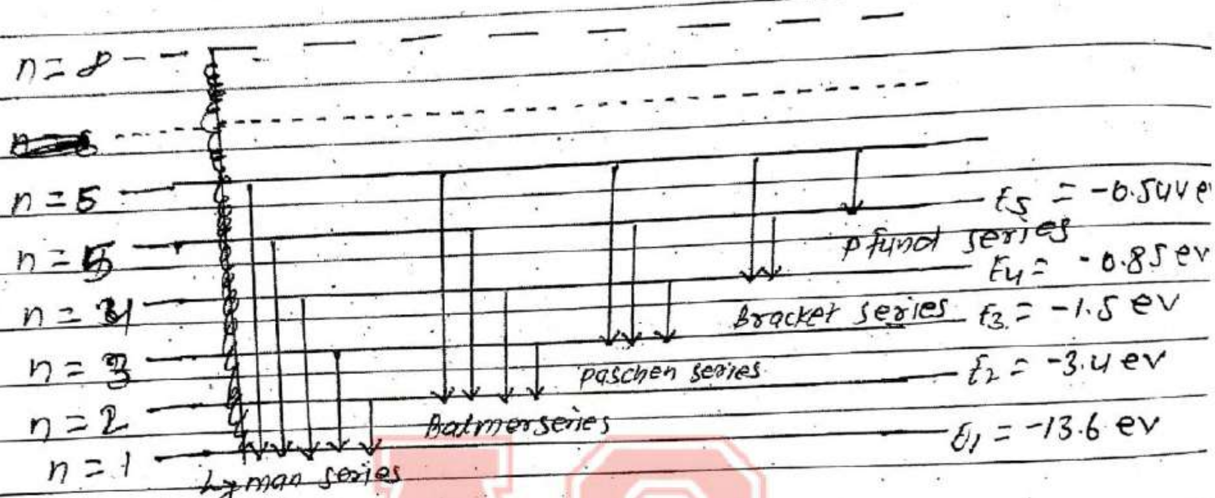
or, $qE = 6\pi r\eta (v_2 + v_1)$

or, $q = \frac{6\pi r\eta (v_2 + v_1)}{E}$

or, $q = \sqrt{\frac{9(\rho-\sigma)g}{2\eta v_1}} \cdot \frac{6\pi\eta (v_2+v_1)}{E}$ By calculating we get, $q = 1.6 \times 10^{-11} C$. charge of electron.

Energy level diagram of Hydrogen atom :-

→ The energy of an electron moving around the nucleus in the n^{th} orbit of a hydrogen atom is given by,



So, $E = \frac{-me^4}{8\epsilon_0^2 n^2 h^2}$

$\therefore E = \frac{-13.6}{n^2}$

putting the value of n = 1, 2, 3, 4, 5.

for n=1, $E_1 = \frac{-13.6}{1^2}$ eV :- -13.6 eV.

for n=2, $E_2 = \frac{-13.6}{2^2}$ eV :- -3.4 eV

for n=3, $E_3 = \frac{-13.6}{3^2}$ eV :- -1.5 eV

for n=4, $E_4 = \frac{-13.6}{4^2}$ eV :- -0.85 eV

for n=5. $E_5 = \frac{-13.6}{5^2}$ eV :- 0.544 eV

Unit-2

Current Electricity

(1) D.C. current :-

↳ It is the electric current that flow constituently in one direction.

(2) Electric current (I) :-

↳ The rate of flow of electric charge per unit time is called electric current.

i.e. $I = \frac{q}{t} = \frac{\text{charge}}{\text{time}}$

If $q = ne$

Then, $I = \frac{ne}{t}$

↳ It's unit is (A)

↳ One ampere current is defined as the flow of one coloumb charge in one sec.

(3) Ohm's law and its verification :-

↳ Ohm's law states that "The potential difference between two ends of a conductor is directly proportional to the current flowing through it

i.e. $V \propto I$

or, $V = RI$

$\therefore R = \frac{V}{I}$

where, R is Resistence V is voltage or p.d and I is current flowing.

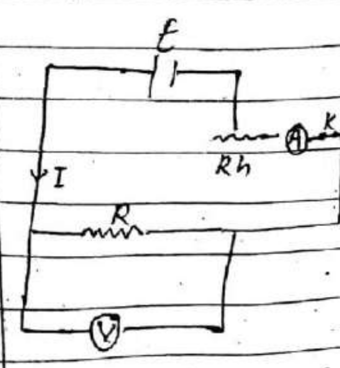


fig:- circuit diagram

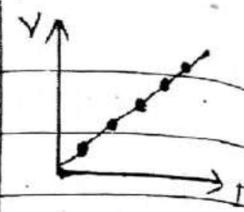


fig:- Graph between V and I

Fication:- The experiment arrangment of circuit of ohm's law is shown in the Fig.

The potential difference and current flowing through the resistance is noted by voltmeter and Ammeter increase cuirent also increase. it ~~di~~ decrease both decreses. So that Graph between V and I straight line which means potential difference is directly proportional to current.

(4) Resistance :-

↳ It is defined as the Radio of potential difference across the two ends of conductor to the current flowing through it.

$$R = \frac{V}{I}$$

↳ It's unit is ohm (Ω)

↳ It opposes the flow of current

(5) factor affecting the Resistance :-

(i) Length of wire:-

↳ Resistance is directly proportion to length of wire

$$R \propto L \quad \text{—— (i)}$$

9) Conversion of Galvanometer into Ammeter :-

→ Ammeter is device for the calculation of current flowing in the circuit. The resistance of Galvanometer 'G' is connect parallel to small resistance 'S'

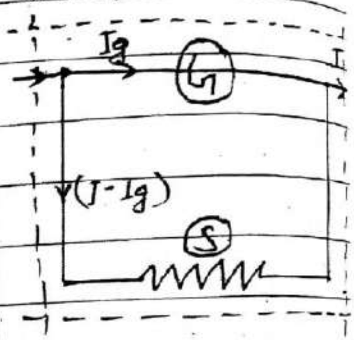


Fig :- Conversion of Galvanometer of Ammeter

Ig be the current in the Galvanometer and (I-Ig) be the current in resistance 'S'.

Since, Galvanometer and shunt are connected in parallel.

So,

$$\frac{1}{R} = \frac{1}{G} + \frac{1}{S}$$

$$\frac{1}{R} = \frac{G+S}{GS}$$

$$\boxed{R = \frac{GS}{G+R}}$$

Now

p.d across Galvanometer = p.d across shunt

$$I_g G = (I - I_g) S$$

$$\boxed{S = \frac{I_g G}{I - I_g}}$$

By knowing value of small resistance 'S' Galvanometer into Ammeter converted.

Radioactivity: The phenomenon of spontaneous emission of highly penetrating radiation α, β- and γ-ray from the element of atomic weight 'A' greater than about 206 is called radioactivitys.

Law of Radioactive disintegration

↳ This law state that the the rate of disintegeration of radioactive nuclei of atoms at any instant is directly proportional to the no. of Atoms presents at that instants.

Let N be the no. of radioactive nuclei present At any Instant of time 't'. Let dN be the number of such nuclei that ~~disintegeration~~ disintegrate $-\frac{dN}{dt}$ is directly proportional to N.

i.e. $\frac{dN}{dt} \propto N$

$$-\frac{dN}{dt} = \lambda N \quad \text{—(I)}$$

Wher λ is a proportionality constant called decay constant or disintegration constants.

eqⁿ (I) can be written as

$$\frac{dN}{N} = -\lambda dt \quad \text{—(II)}$$

Let No and N be the no. of nuclei at t=0 and t=t

Now, Integrating eqⁿ (II)

$$\int_{N_0}^{N} \frac{dN}{N} = -\int_0^t \lambda dt$$

$$[\ln N]_{N_0}^{N} = -\lambda [t]_0^t$$

$$\ln N - \ln N_0 = -\lambda(t-0)$$

$$\ln \frac{N}{N_0} = -\lambda t$$

Taking antilog on both side, we get

$$\frac{N}{N_0} = e^{-\lambda t}$$

$\boxed{N = N_0 e^{-\lambda t}}$ Which is required expressions

Relation between half-life($T_{1/2}$) and decay constant (λ)

↳ The time taken by a radioactive substance to disintegrate half of it's Atoms is called Half-life. It is denoted by $T_{1/2}$.

Let N_0 be the initial numbers of atoms in radioactive substance of decay constant λ. then after time ($T_{1/2}$), the no. of atoms left back is $N_0/2$, from the Law of radioactive disintegrations

$$N = N_0 e^{-\lambda t} \quad \text{--- (I)}$$

putting $N = N_0/2$ and $t = T_{1/2}$

then $\cancel{N_0}/2 = \cancel{N_0}\, e^{-\lambda T_{1/2}}$

$$1/2 = e^{-\lambda T_{1/2}}$$

$$e^{\lambda T_{1/2}} = 2$$

Taking log on the both sides, we gets

$$\lambda T_{1/2} = \ln 2$$

$$\boxed{\lambda = \frac{0.693}{T_{1/2}}}$$

Which is required expressions

What is the modulus of ~~electro~~ elasticity? prove that energy density $= \frac{1}{2} \times$ stress $\times$ strains.

Modulus of elasticity:- The ratio of stress to the corresponding strain that results in the body when the elastic limit is not exceeded is called modulus of elasticity. the modulus of elasticity of a material is a measure of its fitness and for most material remains constant over a range of strees.

proof of Energy density $= \frac{1}{2} \times$ stress $\times$ strains

→ conside a suspended wire of length 'L' in which a stretching force is appled on it lower end. then length of the wire will be increased. let, 'e' is the increase in length. To increase the length stretching force performs certain work. since increase from '0' to 'F'.

$$\text{Average force} = \frac{F}{2}$$

$$\text{And Work done} = \frac{F}{2} \times e = \frac{Fe}{2}$$

$$\text{But, young's modulus } (Y) = \frac{\frac{F}{A}}{\frac{e}{l}} = \frac{Fl}{eA}$$

$$\text{or, } F = \frac{YeA}{l}$$

$$\therefore \text{Work } (W) = \frac{AYe.e}{2l} = \frac{AYe^2}{2l}$$

The work performed is store in the wire as energy,

$$\therefore \text{Energy} = \frac{AYe^2}{2l} = \frac{1}{2} YA \times \frac{e^2}{l}$$

$$\text{But volume of wire} = Al$$

thus, from equation

$$\text{Energy per unit volume or energy density} = \frac{1}{2} \times \frac{F}{A} \times \frac{e}{l}$$

$$\text{But, Stress} = \frac{F}{A}$$

$$\text{And Strain} = \frac{e}{l}$$

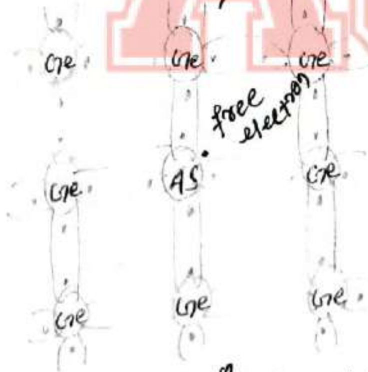
$$\therefore \text{Energy density} = \frac{1}{2} \times \text{stress} \times \text{strain.}$$

proved

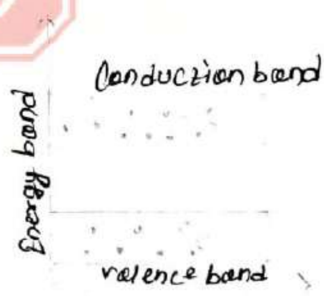
Semiconductor (96)

1. Why are semiconductor doped? [Ctevt 2065].
→

2. What is semiconductor? Explain about N-type semiconductor. [Ctevt 2063]
→ The material whose resistivity is less than insulator and more than conductor is called semiconductor. In other words, the material whose conductivity is more than insulator and less conductor is called semiconductors.
→ N-type Semiconductor: A semiconductor material doped with penta-valent Impurity such as Arsenic (As) or Indium (In) is called N-type semiconductor because it has an excess of negative charge carrier (where N stands for Negative charge carrier).
When a penta-valent impurity like arsenic (As) is added to a pure germanium (Ge) semiconductor, N-type of semiconductor is obtained as shown in fig (a). In such N-type of semiconductor, free electrons are the majority charge carriers and holes are majority charge carriers. Suppose one of the atom in a germanium crystal is replaced by a penta-valent impurity Arsenic (As) Atom is as shown in the figures.



(a). Atomic structure

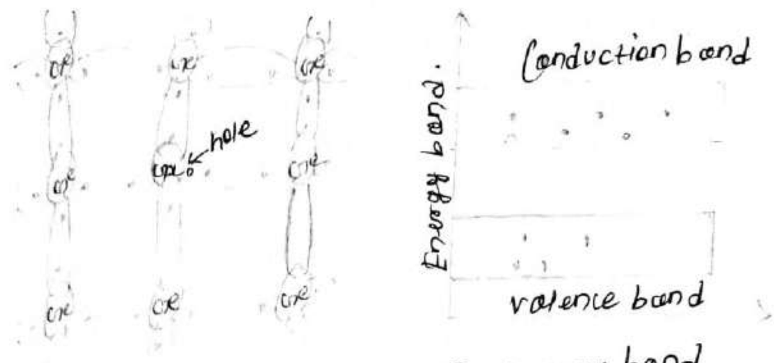


(b) Energy bands.

→ P-type semiconductors: A semiconductor material doped with tri-valent Impurity such as boron (B) or gallium (Ga) is called p-type semiconductor because it has an excess of positive charge carriers (where p stands for positive charge carriers).
If a trivalent impurity like gallium (Ga) is added in pure semiconductor, the impurity atom can provide only three valence electrons for covalent bond formations. thus, a gap is left in one of the covalent bond. this gaps acts as a hole that tends to

97 Accepts electrons. In such p-type of semiconductor, electrons are the minority charges carriers and holes are majority charge carriers. Suppose one of the atoms in a germaniums crystal is replaced by a trivalent gallium atom as shown in the figures.

97



(a) Atomic structure (b) Energy band

P-N Junctions : When a p-type semiconductor is brought in contact with a N-type semiconductor, a junction is formed called PN-Junction diode. there are two regions formed side by side in the same piece of semiconductors.

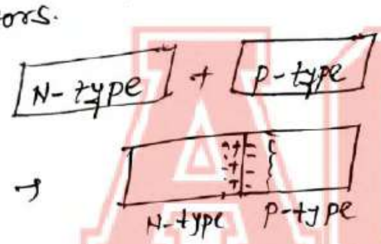


Fig. (1) PN-Junction diode.

Biasing : The connection of an external battery across the pN-junction diode is called biasing of diode

There are two types of biasing

(I) forward biasing

(II) Reverse biasing.

forward biasing : A diode is said to be forward biased if it's p-side is connected to positive terminal and N-side is connected to negative terminals of a battery as shown in figure

When diode is forward biased

→ The width of ______ layer decreases.

→ The barriers potential (V-VB) decreases.

→ flow of current due to majority charge carriers.
→ The diode offers very low resistance called forward resistances

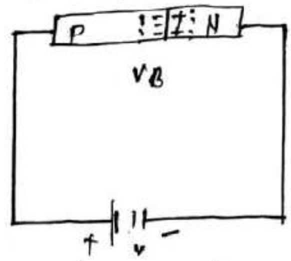


fig. ① forward biasing.

Reverse biasing: When p-side of diode is connected with negative terminal and N-side is connected with positive terminal of battery, such biasing is called Reverse biasing. When a diode is reversed biased.

→ The width of depletion layer increases.
→ The barrier potential (V+VB) increases.
→ The flow of current due to minority charge carriers.
→ The diode offers high resistance called reverse resistances.

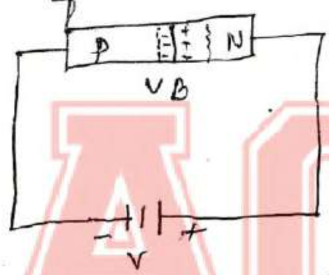


fig. ① Reverse biasing

(1). Define binding energy and write it units.

→ The energy equivalent to the mass defect is known as the binding energy of the nucleons. In other words, it is the energy equivalent to the mass defect when nucleons bind together to form an atomic nucleus.
Its unit is Joule (J)

(2) What is nuclear fissions? Give an example of nuclear reactions.

→ The process of splitting up of a heavy nucleous into two equal parts with the release of a large amount of energy is known as nuclear fissions. An example of nuclear reaction is.

$$\text{Reactions: } {}_2He^4 + {}_7N^{14} \longrightarrow {}_8O^{17} + {}_1H^1$$

$$\text{symbolically } {}_7N^{14}(\alpha,P)_8O^{17}$$

(3). Write the application of fission reaction as controlled and uncontrol chain reactions.

→ **Write application of fission reaction as controlled and uncontrolled chain reaction.**

: In nuclear fission reaction it splits into several smaller fragments. These fragments, or fission products, are about equal to half the original mass. Two or three neutrons are also emitted. The sum of the masses of these fragments is less than the original mass. This lost mass is converted into energy according to Einstein's mass energy equation. Fission can occur when a nucleus of a heavy atom captures a neutron, or it can happen spontaneously.

Nuclear chain reactions

A chain reaction is a process in which neutrons released in fission produce an additional fission in at least one further nucleus. This nucleus in turn produces neutrons, and the process repeats. The process may be controlled or uncontrolled. The nuclear reaction used in a nuclear power station is controlled one where as in atom bomb the reaction is uncontrolled.

$${}_{92}U^{235} + {}_0n^1 \longrightarrow {}_{57}La^{148} + {}_{35}Br^{85} + 3{}_0n^1 + 200\text{ Mev}$$

If each neutron releases two more neutrons, then the number of fissions doubles after each generation.

Although two to three neutrons are produced every fission, not all of these neutrons are available for continuing the fission reaction.

Controlled nuclear fission

In controlled nuclear reaction, for every 2 or 3 neutrons released, only one is allowed to strike another uranium nucleus. A neutron absorbing element is used to control the amount of free neutrons in the reaction space. Most reactors are controlled by means of control rods that are made of a strongly neutron-absorbent material such as boron or cadmium. In next method fast moving neutrons are slowed down by using moderator such as heavy water and ordinary water. Some reactors use graphite as a moderator. Once the fast neutrons have been slowed, they are more likely to produce further nuclear fissions or be absorbed by the control rod. Such controlled nuclear fission reaction is used in nuclear power station to generate current electricity.

Uncontrolled nuclear fission

In uncontrolled nuclear reaction for every 2 or 3 neutrons greater than one is allowed to strike another uranium atom and reaction soon grows uncontrolled and finally explodes with huge pressure and temperature. The method is used in atomic bomb.

1) What is the impedance of a series combination of a resistance 1000 Ω and a capacitance of 2 μf at a frequency of 50 Hz

Soln:- Given that,

Resistance (R) = 1000 Ω

Capacitance (C) = 2 μf $= 2 \times 10^{-6}$ f

frequency (f) = 50 Hz

Now, $X_C = \frac{1}{2\pi fC} = \frac{1}{2\pi \times 50 \times 2 \times 10^{-6}}$

$= 1591.55\Omega$

$\therefore$ impendance $= \sqrt{R^2 + X_C^2}$

$= \sqrt{(1000)^2 + (1591.55)^2}$

$= 1879.6$

2) In an a.c circuit, a resistor of resistance 1000 Ω and capacitor of capacitance 10 μf are connected in series with sources of 220 V and 50 Hz find the impendance of circuit and current flowing through circuit.

Soln:- Given that

Resistance (R) = 1000 Ω

capacitance (C) = 10 μf $= 10 \times 10^{-6}$ f

potential difference (V) = 220 V

frequency (f) = 50 Hz

Now

$(X_C) = \frac{1}{2\pi fC} = \frac{1}{2\pi \times 50 \times 10 \times 10^{-6}}$

$= 318.3\Omega$

Impendance (Z) $= \sqrt{(r)^2 + (X_C)^2}$

$= \sqrt{(1000)^2 + (318.3)^2}$

$= 1049.4\Omega$

$\therefore$ current (I) $= \frac{V}{Z}$

$= \frac{220}{1049.4} = 0.21$ A

(3) A 10μf Capicator is in series with a 50Ω resistance and when the combination is connected to a 220V, 50Hz line. Calculate of (i) the impedance of the circuit and (ii) the current flow is in the circuit

Soln: Given that,

Capacitance (C) = $10\mu f = 10\times10^{-6} f$

Resistance (R) = 50Ω

frequency (f) = 50 Hz

potential difference (V) = 220V

the impedance (Z) = ?

the current (I) = ?

Now,

$$(X_c) = \frac{1}{2\pi fC} = \frac{1}{2\pi\times50\times10\times10^{-6}}$$

$$= 318.31\Omega$$

(i) impedance of circuit (Z) $= \sqrt{R^2 + (X_c)^2}$

$$= \sqrt{(50)^2 + (318.31)^2}$$

$$= 322.21\Omega$$

(ii) current in the circuit $= \frac{V}{Z}$

$$= \frac{220}{322.21}$$

$$= 0.68A^0$$

What is the impedance of a series combination of resistance of 1 K Ω and a capacitance of a capacitor 2 μf at a frequency of 50 Hz

→ soln:- Given that,

Resistance (R) = 1000 Ω

Capacitance (C) = 2 μf = 2×10^{-6} f

frequency (f) = 50 Hz

Impedance of circuit (Z) = ?

Now,
$$(X_c) = \frac{1}{2\pi fc} = \frac{1}{2\pi\times50\times2\times10^{-6}}$$
$$= 1.59\times10^{3}$$

Impedance of circuit (Z) = $\sqrt{R^2+(X_c)^2}$
$$= \sqrt{(1000)^2+(1.59\times10^{3})^2}$$
$$= 1.87\times10^{3}\,\Omega$$

) A constant voltage a.c generator of 20V 50 Hz is connected with a resistor of resistance 2Ω, a coil of inductance 5 H and a capacitor of a capacitance 2 μf. Calculate the current flowing through the circuit.

→ soln:- Given that

voltage (V) = 220V

frequency (f) = 50 Hz

Resistance (R) = 2 Ω

Inductance (L) = 5 H

capacitance (C) = 2 μf = 2×10^{-6} f

Now, the impedance of LCR circuit is;
$$Z = \sqrt{R^2+\left(2\pi fL-\frac{1}{2\pi fc}\right)}$$
$$= \sqrt{(2)^2+\left(2\pi\times50\times5-\frac{1}{2\pi\times50\times2\times10^{-6}}\right)}$$
$$\therefore Z = 20.849\,\Omega$$

Current following through circuit (I) = $\frac{V}{Z} = \frac{220}{20.85}$
$$= 10.55\,A$$

(4)

(6) 40 Ω resistance, 3 mH inductor and 2 µf capacitor are in series to a 110V, 50 Hz a.c sources calculate the value current in the circuit.

→ soln:. Given that,

Resistance (R) = 40 Ω

Indunce (L) = 3 mH = 3×10^{-3} H

Capacitance (C) = 2 µf = 2×10^{-6} f

voltage (V) = 110V

frequency (f) = 50 Hz

Current in the circuit (I) = ?

we know that,

$$Z = \sqrt{R^2 + 2\pi f L - \frac{1}{2\pi f C}}$$

$$= \sqrt{(40)^2 + 2\pi \times 50 \times 3 \times 10^{-3} - \frac{1}{2\pi \times 50 \times 2 \times 10^{-6}}}$$

$$\therefore Z = 1591.10\,\Omega$$

Now

$$\text{current } (I) = \frac{E}{Z}$$

$$= \frac{110}{1591.10}$$

$$= 0.069\,A \text{ Ans}$$

5) The half life of radon is 3.82 days. After what time will the number of radon atom decrease to $\left(\frac{1}{10}\right)^{th}$ of its original value

soln:

Given that

Half-life of random $(T) = 3.82$ days

Ratio $\left(\frac{N}{N_0}\right) = \frac{1}{10}$

we have, $\lambda = \frac{0.6931}{T} = \frac{0.6931}{3.82} = 0.1814$ per ~~unit~~ day

Again we have,

$$N = N_0 e^{-\lambda t}$$

$$\text{or, } \frac{N}{N_0} = e^{-\lambda t}$$

$$\frac{1}{10} = e^{-\lambda t}$$

Taking ln on both side we have

$$\ln 10 = \lambda t$$

$$t = \frac{\ln 10}{\lambda} = \frac{2.326}{0.1814}$$

$$\therefore t = 12.7$$

Hence, the required time to decay $\left(\frac{1}{10}\right)^{th}$ is 12.7 days

6

2) The initial number of atoms in a radioactive elements is 6×10^{20} and its half life is 10 hours. Calculate the number of atom remained after 30 hours.

→ Given that

Initial number of atom $(N_0) = 6\times10^{20}$

Half-life $(T_{1/2}) = 10$ hours

Time taken $(t) = 30$ hours

Number of atoms remained $(N) = ?$

we have,

$$N = N_0 e^{-\lambda t}$$

$$N = 6\times10^{20} \times e^{-\frac{t}{T_{1/2}}}$$

$$N = 6\times10^{20} \times e^{-\frac{30}{10}}$$

$$\therefore N = 3\times10^{19} \text{ atoms.}$$

3) At a certain instant a piece of radioactive material contains 10^{12} atoms. The half life of the materials is 15 days. Calculate the rate of decay after 30 days have elapsed.

→ soln: Given that,

Initial atom $(N_0) = 10^{12}$ atoms

Half-time $(T_{1/2}) = 15$ days

Time $(T) = 30$ days

2.71

we know that,

Number of atom undecayed $\left(\frac{N}{N_0}\right) = \left(\frac{1}{2}\right)^{\frac{t}{T_{1/2}}}$

or, $N = N_0 \times \left(\frac{1}{2}\right)^{\frac{30}{15}}$

$= 10^{12} \times \left(\frac{1}{2}\right)^2$

$= 2.5\times10^{11}$ atoms

Now,

Rate of decay $\left(\frac{dN}{dT}\right) = -\lambda N$

$= -\left(\frac{0.693 \times 2.5\times10^{11}}{15\times24\times3600}\right)$

$= -133680.55$ per sec.

Hence, negative sign shows the number of atom is decreasing.

7. How long will it take to decay 20% of a radioactive substance if the half-life is 4 days

→ soln:- Given that

Half-life $(T_{1/2}) = 4$ days

Decay constant $(\lambda) = \dfrac{0.6931}{T_{1/2}}$

$= \dfrac{0.6931}{4} = 0.173$ per day

Time required $(T) = ?$

Let N_0 is the initial number of particle. Then after time 't' 20% of N_0 is decayed.

particle remain $(N) = \left(1 - \frac{20}{100}\right) N_0$

$= \left(\frac{4}{5}\right) N_0$

we have,

$N = N_0 e^{-\lambda t}$

or, $\dfrac{N}{N_0} = e^{-\lambda t}$

or, $\left(\dfrac{4}{5}\right) = e^{-\lambda t}$

or $\ln\left(\dfrac{5}{4}\right) = \lambda t$

$t = \dfrac{\ln\left(\frac{5}{4}\right)}{\lambda}$

$t = \dfrac{\ln\left(\frac{5}{4}\right)}{0.173}$

$T \approx 1.289$ days

$\therefore$ Time required $(t) = 1.289$

1) A Radioactive sources has decayed $\left(\frac{1}{128}\right)^{th}$ of initial activity in 100 days wat is half-life?

→ soln:

According to the question.

Initial activity $\left(\frac{N}{N_0}\right) = \frac{1}{128}$

time (T) = 100 days

Half-time $(T_{1/2}) = ?$

we know that,

$$N = N_0 e^{-\lambda t}$$

$$\frac{N}{N_0} = e^{-\lambda t}$$

$$\left(\frac{1}{128}\right) = e^{-\lambda t}$$

$$\ln\left(\frac{1}{128}\right) = \lambda t$$

$$\lambda = \frac{\ln\left(\frac{1}{128}\right)}{t}$$

$$\lambda = \frac{\ln\left(\frac{1}{128}\right)}{100}$$

$$\lambda = \frac{\ln\left(\frac{1}{128}\right)}{100}$$

Now,

$$\text{Half-life } (T_{1/2}) = \frac{0.693}{\lambda}$$

$$= \frac{0.693}{\ln 128} \times 100$$

$$= 14.28 \text{ days Ans}$$

5) If the half life period of radioactive substance is 2 days after how many days will $\left(\frac{1}{64}\right)^{th}$ part of the substance be left behind.

Soln: According to the questions

half-life $(T_{1/2}) = 2$ days

Ratio $\left(\frac{N}{N_0}\right) = \left(\frac{1}{64}\right)^{th}$

Time $(T) = ?$

decay constant $(\lambda) = \frac{0.693}{T_{1/2}}$

$= \frac{0.693}{2}$

$=$

We know that,

$$\frac{N}{N_0} = e^{-\lambda t}$$

$$\left(\frac{1}{64}\right) = e^{-\lambda t}$$

$$\ln\left(\frac{1}{64}\right) = \lambda t$$

$$t = \frac{\ln\left(\frac{1}{64}\right)}{\lambda}$$

$$t = \frac{\ln\left(\frac{1}{64}\right)}{0.693} \times 2$$

$$\therefore t = 12 \text{ days}$$

(6) Find the half-life period of radioactive material if its activity has decayed to $\left(\frac{1}{128}\right)^{th}$ of initial activity after 50 days.

Soln: According to the question

Time $(T) = 50$ days

Ratio $\left(\frac{N}{N_0}\right) = \left(\frac{1}{128}\right)^{th}$

Half-life $(T_{1/2}) = ?$

We know that,

$$\left(\frac{N}{N_0}\right) = e^{-\lambda t}$$

$$\left(\frac{1}{128}\right) = e^{-\lambda t}$$

$$\ln\left(\frac{1}{128}\right) = \lambda t$$

$$\ln\left(\frac{1}{128}\right) = \lambda t$$

$$\frac{\ln\left(\frac{1}{128}\right)}{t} = \lambda$$

$$\frac{\ln\left(\frac{1}{128}\right)}{50} = \lambda$$

Now

$$\text{Half-life}(T_{1/2}) = \frac{0.693}{\lambda}$$

$$= \frac{0.693}{\ln(128)} \times 50$$

$$= 7.14 \text{ days}$$

) The half-life of $_{92}U^{238}$ is 4.5×10^9 years. Calculate the activity of 1 gm sample of $_{92}U^{238}$

→ Soln: According to the questions.

Half-life of $_{92}U^{238}$ $(T_{1/2}) = 4.5 \times 10^9 \times 365 \times 24 \times 60 \times 60$
$= 1.419 \times 10^{17}$ sec.

mass = 1 gram

We know that, 238 gram of U contain 6.023×10^{23} atom (Avogadro)

$$1 \text{ gm of U} = \frac{6.023 \times 10^{23}}{238}$$

$\therefore N = 2.53 \times 10^{23}$ atom

Now Decay constant $(\lambda) = \frac{0.693}{T_{1/2}} = \frac{0.693}{1.419 \times 10^{17} \text{ sec}}$
$= 6.62 \times 10^{-18} s^{-1}$

Activity $(A) = \frac{dN}{dt} = \lambda N$
$= 6.62 \times 10^{-18} \times 2.53 \times 10^{23}$
$= 4.09 \times 10^{5}$ atom per sec.

(11)
A sodium surface ejects photo electrons when light of ... of
4.7 X 10^{14} Hz strikes it. The work function for sodium metal is
2.88 X 10^{-19} J. Find the maximum kinetic energy of the ejected
electrons. Given plank's constant = 6.62 X 10^{-34} Js

Soln:- Given that,

frequency of light (v) = 4.7×10^{14} Hz

work function (ϕ) = 2.88×10^{-19} J

plank's constant (h) = 6.62×10^{-34} Js

velocity of light (c) = 3×10^8 m/s

maximum kinetic energy of the ejected electron (K.E) = ?

we certain light frequency 'v' incident on metallic surface

$K.E = hv - \phi$

$= 6.62 \times 10^{-34} \times 4.7 \times 10^{14} - 2.88 \times 10^{-19}$

$\therefore K.E = 0.23 \times 10^{-19}$ J Ans

The ultra violet light of frequency 3×10^{15} Hz fall on a plate of molybdenum. If work function of the plate is 5ev, find the maximum kinetic energy of emmitted electrons. Given $e = 1.6 \times 10^{-19}$ C $h = 6.67 \times 10^{-34}$ Js [2061]

Soln:- Given that,

frequency of uv light (f) = 3×10^{15} Hz

$e = 1.6 \times 10^{-19}$

$h = 6.67 \times 10^{-34}$

$m = 9.1 \times 10^{-31}$ kg

$c = 3 \times 10^8$ m/s

Maximum velocity of electron (v) = ?

Now wavelength of uv light (λ) = $\frac{v}{f} = \frac{3 \times 10^8}{3 \times 10^{15}}$

$= 10^{-7}$ m

work function of molybdenum (ϕ) = 5ev

$= 5 \times 1.6 \times 10^{-19}$

we have,

$$\frac{1}{2}mv^2 = h\nu - \phi = \frac{hc}{\lambda} - \phi$$

$$\text{or } v = \sqrt{\frac{2\left(\frac{hc}{\lambda} - \phi\right)}{m}}$$

$$= \sqrt{\frac{2\left(\frac{6.67\times10^{-34}\times3\times10^{8}}{10^{-7}} - 8\times18^{-15}\right)}{9.1\times10^{-31}}}$$

$$\therefore v = 1.62\times10^{6}\ m/s$$

(C) A photo electron from cesium surface has kinetic energy of 4×10^{-19} J. the work function of cesium is 1.8 eV. What is the maximum wavelength of light which could have ejected this electron?

→ soln.: Given that

Energy of electrons ejected (E) = 4×10^{-19} J

work function (ϕ) = 1.8 eV = $1.8\times1.6\times10^{-19}$ J

$= 2.88\times10^{-19}$ J

velocity ~~city of light~~ (C) = 3×10^{8} m/s

plank's constant (h) = 6.62×10^{-34} Js

Maximum wavelength of light (λ) = ?

we know that,

$$E = h\nu - \phi$$

$$E = h\left(\frac{c}{\lambda}\right) - \phi$$

$$E = \cancel{6.62\times10^{-34}\left(\frac{3\times10^{8}}{}\right.}$$

$$E + \phi = \frac{hc}{\lambda}$$

$$\lambda = \frac{hc}{E+\phi}$$

$$\lambda = \frac{6.62\times10^{-34}\times3\times10^{8}}{4\times10^{-19} + \cancel{1.8}\ 2.88\times10^{-19}}$$

$$\therefore \lambda = 2.89\times10^{-7}\ m$$

A sodium surface ejects photoelectrons when mercury of light of frequency 4.7×10^{14} Hz strike it. The work function of sodium metal is 2.80×10^{-19} J. Find the maximum possible kinetic energy of ejected electrons? Assume; $h = 6.62 \times 10^{-34}$ Js

→ soln:- Given that

frequency of light $(\nu) = 4.7 \times 10^{14}$ Hz

work function $(\phi) = 2.8 \times 10^{-19}$ J

plank's constant $= 6.62 \times 10^{-34}$ Js

velocity of light $(c) = 3 \times 10^{8}$ m/s

Maximum kinetic energy of the ejected electrons $(K.E) = ?$

we know that,

$$(K.E) = h\nu - \phi$$

$$= 6.62 \times 10^{-34} \times 4.7 \times 10^{14} - 2.8 \times 10^{-19}$$

$$= 0.3114 \times 10^{-19} \text{ J} \quad \text{Ans}$$

e) The voltage applied to an x-ray tube is 20 KV. What is minimum wave length of x-ray produced by it? Given it $h = 6.62 \times 10^{-34}$ Js $e = 1.6 \times 10^{-19}$ C

→ soln:- Given that

potential difference applied $(V) = 20$ KV $= 20 \times 10^{4}$ V

plank's constant $(h) = 6.62 \times 10^{-34}$ Js

Charge of electron $(e) = 1.6 \times 10^{-19}$ C

velocity of light $(C) = 3 \times 10^{8}$ m/s

minimum wavelength $(\lambda_{min}) = ?$

we know that,

$$h\nu_{max} = eV$$

$$\frac{hc}{\lambda_{min}} = eV$$

$$\lambda_{min} = \cancel{\frac{eV}{hc}} \frac{hc}{eV}$$

$$\therefore \lambda_{min} = \frac{6.62 \times 10^{-34} \times 3 \times 10^{8}}{1.6 \times 10^{-19} \times 20 \times 10^{4}} = 6.21 \times 10^{-11} \text{ m}$$

Work function of molybdenum is 5ev. If UV light of wavelength 1000 A° fall upon it, find maximum velocity of ejected electron given : $h = 6.62 \times 10^{-34}$ Js, $e = 1.6 \times 10^{-19}$ C, $m = 9.1 \times 10^{-31}$ kg

Soln:- Given that,

wave length of uv light $(\lambda) = 1000 A° = 1000 \times 10^{-10} m = 10^{-7} m$

work function of molybdeum $(\phi) = 5 ev$
$= 5 \times 1.6 \times 10^{-19}$
$= 8 \times 10^{-19}$ C

plank's constant $(h) = 6.62 \times 10^{-34}$ Js

Mass of electron $(m) = 9.1 \times 10^{-31}$ kg

Maximum velocity of electron $(v) = ?$

Now,

$$\frac{1}{2} mv^2 = hv - \phi$$

or, $$v = \sqrt{\frac{2}{m}\left(\frac{hc}{\lambda} - \phi\right)}$$

$$v = \sqrt{\frac{2}{9.1 \times 10^{-31}}\left(\frac{6.62 \times 10^{-34} \times 3 \times 10^{8}}{10^{-7}} - 8 \times 10^{-19}\right)}$$

$\therefore v = 1.62 \times 10^{6}$ m/s Ans

7) Light of wave length 4×10^{-7} m falls on a sodium surface what is the maximum energy of the emitted electron? The work function of the sodium is 2.3ev and $h = 6.62 \times 10^{-34}$ Js

Soln:- wave length of light $(\lambda) = 4 \times 10^{-7}$ m

work function $(\phi) = 2.3 ev$
$= 2.3 \times 1.6 \times 10^{-19} = 3.68 \times 10^{-7}$ J

plank's constant $(h) = 6.62 \times 10^{-34}$ Js

velocity of light $(c) = 3 \times 10^{8}$ m/s

maximum energy of the emitted electron $(E) = ?$

Now $E = hv + \phi$

$= h\left(\frac{c}{\lambda}\right) + \phi$

$= \frac{6.62 \times 10^{-34} \times 3 \times 10^{8}}{4 \times 10^{-7}} + 3.68 \times 10^{-7}$

$= 8.5\ldots \times 10^{-19}$ J Ans

Calculate the frequency of light which can remove photoelectron cesium. Given work function of cesium = 1.8ev, $h = 6.64 \times 10^{-34}$ Js
$v = 6.4 \times 10^5$ m/s

Soln.: Given that

work function (ϕ) = 1.8 ev = $1.8 \times 1.6 \times 10^{-19}$

plank's constant (h) = 6.64×10^{-34} Js

velocity (v) = 6.4×10^5 m/s

velocity of light (c) = 3×10^8 m/s

frequency (f) = ?

Now,

$$\lambda = \frac{hc}{ev}$$

$$\text{or, } \frac{v}{f} = \frac{hc}{ev}$$

$$f = \frac{v \times ev}{hc}$$

$$f = \frac{6.4 \times 10^5 \times 1.8}{6.64 \times 10^{-34} \times 3 \times 10^8}$$

$$\therefore f = 5.78 \times 10^{30} \text{ Hz Ans}$$

(i) The work function of potassium is 2.3ev. If the photoelectrons are emitted with maximum velocity of 10^4 m/s. Calculate the frequency of incident radition on the metal. Given mass of electron is 9.1×10^{-31} kg and value of plank's constant is 6.62×10^{-34}

[2070]

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1) Density of air s.t.p is 1.29 kg/m³ and the value of $\gamma = \frac{C_p}{C_v} = 1.4$ of air. Calculated the velocity of sound in air at s.T.p Assume the standrad pressure is 1.013×10^5 m/s²

→ soln:- Given that

Density of air at s.T.p (ρ) = 1.29 kg/m³

value for $\gamma = \frac{C_p}{C_V} = 1.4$

velocity of sound at s.t.p (v) = ?

velocity of sound at 27°C (V_1) = ?

Standrad pressure (P) = 1.013×10^5 N/m²

Hence, using the relation; we have

$$V = \sqrt{\frac{\gamma P}{\rho}}$$

$$= \sqrt{\frac{1.4 \times 1.013 \times 10^5}{1.29}}$$

$$= 331.56 \text{ m/s}$$

i.e velocity of sound in air at s.T.p is calculated as 331.56 m/s

(b) calculate the velocity of sound in air at 27°c. Density of air at S.T.P = 1.29 kg/m3, ratio of molar heat capacities $\gamma = 1.42$

→ soln:- Given that,

Density of air at S.T.P (ρ) = 1.29 kg/m3

$\gamma = 1.42$

Normal pressure (P) = $0.76 \times 13600 \times 9.8$ N/m²

we have,

velocity of sound at 0°c (V_0) = $\sqrt{\frac{\gamma P}{\rho}}$

$$= \sqrt{\frac{1.42 \times 0.76 \times 13600 \times 9.8}{1.29}}$$

$$= 333.9 \text{ m/sec.}$$

Let, V_1 be the velocity of sound at 27°c

then, $\frac{V_1}{V_0} = \sqrt{\frac{273+27}{273}}$ = 350 m/sec.

(17) Calculate the velocity of sound in air at 27°C. $S.T.P = 129$ kg/m³ $C_P = 1.02\ KJ\,kg^{-1}K^{-1}$, $C_V = 0.72\ KJ\,kg^{-1}K^{-1}$

Soln:. Given that,

Density of air in S.T.P $(\rho) = 129$ kg/m³

$$\gamma = \frac{C_p}{C_v} = \frac{1.02}{0.72} = 1.42$$

Normal pressure $(P) = 0.76 \times 13600 \times 9.8$

We have,

velocity of sound in air at 0°C $(V_0) = \sqrt{\frac{\gamma P}{\rho}}$

$$= \sqrt{\frac{1.42 \times 0.76 \times 13600 \times 9.8}{129}}$$

Let, V_1 be the velocity of sound in air at 27°C then

$$\frac{V_1}{V_0} = \sqrt{\frac{273+27}{273}}$$

$$V_1 = \sqrt{\frac{300}{273}} \times V_0$$

$V_1 =$

$\therefore V_1 =$

d) The density of air at STP is 1.293 kg/m3 find the velocity at STP and 27°C (γ for air = 1.4)

→ soln:
Given that,

Density of air at STP (ρ) = 1.293 kg/m3

$\gamma = 1.4$

Temprature (t) = 27°C

velocity at S.T.P (V_0) = ?

velocity at 27°C (V_t) = ?

Since,

the velocity of sound in air at S.T.P is

$$V_0 = \sqrt{\frac{\gamma P}{\rho}} = \sqrt{\frac{1.4 \times 1.01 \times 10^5}{1.293}}$$

$$= 330.69 \text{ m/sec.}$$

Also, $V \propto \sqrt{T}$

Now
$$\frac{V_t}{V_0} = \sqrt{\frac{273+t}{273}}$$

$$V_t = \sqrt{\frac{273+27}{273}} \times 330.69$$

$$\therefore V_t = 346.65 \text{ m/s}$$

Thus, the velocity of sound in air,

at S.T.P = 330.69 m/s

at 27°C = 346.65 m/s

(e) velocity of sound in air at 0°C is 332 m/s. find the change in velocity per degree rise in temprature.

→ soln: Given that

velocity of sound at 0°C (273K) is 332 m/sec.

since, the velocity of sound in air is directly proportional to square root of its absolute temprature.

i.e $V \propto \sqrt{T}$

(19)

The velocity of sound at t°c and 0°c are related as;

$$\frac{v_t}{v_0} = \sqrt{\frac{273+t}{273}}$$

on taking $v_0 = 332$ m/s at NTP and $t = 1°c$ we obtain

$$\frac{v_t}{v_0} = \sqrt{\frac{273+t}{273}}$$

$$vt = \sqrt{\frac{273+1}{273}} \times 332$$

$$vt = 332.61 \text{ m/s}$$

$$v_t - v_0 = 332.61 - 332$$
$$= 0.61$$

Thus for each degree change in temprature, the velocity of sound in air changes by 0.61 m/s

1) At what tempreture will be velocity of sound is double its value at 273K ?

Soln:- Given that,

$T_0 = 273K$

$V_0 = v$

$V_1 = 2v$

$T_1 = ?$

we have,

$$\frac{v_1}{v_0} = \sqrt{\frac{t_1}{t_0}}$$

$$\frac{2v}{v} = \sqrt{\frac{t}{273}}$$

squaring on both side

$$\left(\frac{2v}{v}\right)^2 = \left(\sqrt{\frac{t}{273}}\right)^2$$

$$\frac{4}{1} = \frac{t}{273}$$

$\therefore t = 4 \times 273 = 1092K$ Ans

(2) At what tempreture, velocity of sound is $\frac{2}{3}$ of velocity of sound is $\frac{2}{3}$ of velocity of sound at 127°C

Soln:- Given that,

velocity of sound $(V_2) = 2v$

and $(V_1) = 3v$

Temprature $(T_1) = 127°C = 127+273 = 400K$

we know that, velocity of sound $(v) \propto \sqrt{T}$

Now,

$$\frac{V_2}{V_1} = \sqrt{\frac{T_2}{T_1}}$$

$$\frac{2v}{3v} = \sqrt{\frac{T_2}{400K}}$$

$$T_2 = \frac{4}{9} \times 400 = 177.78K$$ Ans

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(3) Velocity of sound in air at 0°c is 332m/s. find the change in velocity per degree rise in temperature.

⇒ Soln Given that

velocity of sound at 0°c (273K) is 332m/sec.

since, the velocity of sound is directly proportional to square root of this absolute temprature.

i.e $v = \sqrt{t}$

The velocity of sound at t°c and 0°c are related as

$$\frac{v_t}{v_0} = \sqrt{\frac{273+t}{273}}$$

$$V_t = v_0 \sqrt{\frac{273+t}{273}}$$

on taking a $V_0 = 332$ m/s at NTP and $t = 1°c$ we

$$Vt = 332 \times \sqrt{\frac{273+1}{273}}$$

$$= 332 \times \sqrt{\frac{274}{273}}$$

$$= 332.61 \text{ m/s}$$

$$Vt - V_0 = 332 - 332.6 \text{ m/s}$$

$$= 0.6 \text{ m/s}$$

since, for each degree change in temprature the velocity of sound in air changes by 0.61 m/sec.

a) find the height to which water will rise in capillary tube of 1.22mm diameter. surface tension of water is 73.5×10^{-3} N/m, angle of contact is 10° and density of water is 998.6 kg/m^3

→ Soln:- Given that,

Diameter of capillary tube(d) = 1.2mm = 1.2×10^{-3} m

Radius of capillary tube(r) = 6×10^{-4} m

surface tension(T) = 73.5×10^{-3} N/m

Density of liquid (ρ) = 998.6 kg/m^3

Angle of contact(θ) = 10°

Height rised (h) = ?

Now, Height rised in capillary(h) = $\frac{2T\cos\theta}{r\rho g}$

$$= \frac{2 \times 73.5 \times 10^{-3} \times \cos 10^{\circ}}{6 \times 10^{-4} \times 998.6 \times 10}$$

$$= 0.0242 m$$

$$= 24.2 mm$$

i.e Height to which water will rise in a capillary tube is 24.2 mm

(b) A clean glass capillary tube of internal diameter 0.06 cm is held vertically in clean water contained in a beaker. Calculat height of the water in the capillary tube. Assume angle of contact 0°. Given; surface tension = 7.2×10^{-2} N/m

→ Soln:- Diameter of capillary tube(d) = 0.06cm = 6×10^{-4} m

surface tension of water (T) = 7.2×10^{-2} N/m

Height of water (h) = ?

∴ Radius of the capillary tube(r) = 3×10^{-4} m

for water glass:

Angle of contact (θ) = 0°

Now,

The capillary ~~r~~ rise of water in the tube (h) = $\frac{2T\cos\theta}{r\rho g}$

$$= \frac{2\times 7.2\times 10^{-2}\times \cos 0^\circ}{3\times 10^{-4}\times 10^{3}\times 9.8}$$

$$= 0.48\text{ cm}$$

Hence, the water in capillary tube rise by 0.48 cm in height

A capillary tube of 0.3 mm diameter is placed vertically inside a liquid of density 1000 kg/m3, surface tension 7×10^{-2} N/m and the angle of contact 0°. Calculate the height to which liquid rise in capillary tube.

→ Soln:- Given that,

Diameter of capillary tube (d) = 3×10^{-4} m

∴ radius of capillary tube (r) = $\frac{3\times 10^{-4}\text{ m}}{2} = 1.5\times 10^{-4}$ m

density of liquid (ρ) = 1000 kg/m^3

surface tension (T) = 7×10^{-2} N/m

Angle of contact (θ) = 0°

We have,

The capillary rise of liquid in the tube

$$(h) = \frac{2T\cos\theta}{r\rho g}$$

$$= \frac{2\times 7\times 10^{-2}\times \cos 0^\circ}{1.5\times 10^{-4}\times 10^{3}\times 9.8}$$

$$= 0.093\text{ m}$$

Hence, the liquid in capillary tube rise by 0.093 m in height.

d) Find the height to which water will rise in a capillary tube of 1.2 mm diameter. Given, surface tension is 73.5×10^{-3} N/m, angle of contact 13°.

→ Soln:. Given that

Diameter of capillary tube(d) = 1.2 mm = 1.2×10^{-3}

∴ radius of capillary tube (r) = ~~1.2×10^{-3} m~~ 6×10^{-4} m

surface tension (T) = 73.5×10^{-3} N/m

Angle of contact (θ) = 13°

we have,

$$\text{Height of rise } (h) = \frac{2T\cos\theta}{r\rho g}$$

$$= \frac{2\times73.5\times10^{-3}\times\cos13}{6\times10^{-4}\times1000\times10}$$

$= \cancel{24\,mm}$

$= 0.024$ m Ans

Hence,

The water is rised in capillary tube by 0.024m

(e) Mercury in a capillary tube is depressed by 1.32m. Find the diameter of the tube. If the angle of contact of mercury is 140° and density is 13.6 gm/cm³. surface tension of Hg is given 540 dyne/cm.

→ Soln:. Given that,

height(h) = 1.32m = 1.32×10^{2} cm

Angle of contact(θ) = 140°

Density of mercury (ρ) = 13.6 gm/cm³

surface tension (T) = ~~0~~ 540 dyne/cm

d = ?

We know that,

$$h = \frac{2T\cos\theta}{r\rho g}$$

$$r = \frac{2T\cos\theta}{h\rho g}$$

$$r = \frac{2T\cos\theta}{h\rho g}$$

$$= \frac{2 \times 540 \times \cos 140^\circ}{1.32 \times 10^2 \times 13.6 \times 10}$$

$r = 0.00047$ cm

$\therefore d = 2r = 2 \times 0.00047$

$= 0.00094$ cm Ans

(7) A capillary tube of inner radius 0.25 m is dipped in a liquid of density 13.6×10^3 kg/m³, surface tension 465 dyne/cm and angle of contact is 120°. find the depression or elevation in the tube.

→ soln:- Given that

Surface tension of mercury in glass (T) = 465 dyne/cm
radius of tube (r) = 0.25 m
Density of liquid (ρ) = 13.6×10^3 kg/m³
angle of contact (θ) = 120°

Now, capillary rised of liquid in tube (h) = $\frac{2T\cos\theta}{r\rho g}$

$$= \frac{2 \times 465 \times \cos 120^\circ}{0.25 \times 13.6 \times 10^3 \times 10}$$

$= 13.95 \times 10^{-6}$ cm

$= 13.95$ mm

Here, the liquid depressed by 13.95 mm from the mercury

(26) find the height to which water will rise in capillary tube of 1.5 mm diameter. surface tension of water 72.5×10^{-3} N/m and angle of contact is 10° and density of water is 998.6 kg/m³

→ soln:-

Diameter of capillary tube (d) = 1.5 mm = 1.5×10^{-3} m

∴ Radius of capillary tube (r) = 0.75×10^{-3} m

Density of liquid (ρ) = 998.6 kg/m³

surface tension (T) = 72.5×10^{-3}

Angle of contact (θ) = 10°

Height rised (h) = ?

we know that,

Height rised in capillary tube (h) = $\frac{2T\cos\theta}{r\rho g}$

$= \frac{2\times72.5\times10^{-3}\cos10^\circ}{0.75\times10^{-3}\times998.6\times9.8}$

$= 0.01907$ m

$= 19.07$ mm

Hence, the height to which water rise is 19.07 mm. Ans

(b) A capillary tube of 0.4 mm diameter is placed vertically inside a liquid of density 1500 kg/m³, surface tension 7×10^{-2} N/m and the angle of contact 0°. Calculate the height to which the liquid rise in capillary tube.

→ soln:-

Diameter of capillary tube (d) = 0.4 mm = 0.4×10^{-3} m

Radius of capillary tube (r) = 0.2×10^{-3} m

Density of liquid (ρ) = 1500 kg/m³

surface tension (T) = 7×10^{-2} N/m

Angle of contact (θ) = 0°

we know that,

The height rised in capillary tube (h) = $\frac{2T\cos\theta}{r\rho g}$

$= \frac{2\times7\times10^{-2}\times\cos0^\circ}{0.2\times10^{-3}\times1500\times10} = 4.67\times10^{-2}$ m

(27)

A liquid rise to height of 7cm in a capillary tube of radius 0.1mm. The density of liquid is 0.8×10^3 kg/m³. If the angle of contact between the liquid and surface ~~tension~~ of tube is zero. calculate surface tension of liquid.

→ Soln:- Given that,

The height of capillary tube(h) = 7×10^{-2} m

radius of capillary tube(r) = 0.1 mm = 0.1×10^{-3} m

The density of liquid (ρ) = 0.8×10^3 kg/m³

Angle of contact (θ) = 0°

surface tension of water (T) = ?

We know that,

$$\text{surface Tension (T)} = \frac{h r \rho g}{2\cos\theta}$$

$$= \frac{7 \times 10^{-2} \times 0.1 \times 10^{-3} \times 0.8 \times 10^{3} \times 10}{2 \times \cos 0^\circ}$$

$$= 2.8 \times 10^{-2} \text{ N/m}$$

i.e. surface tension of the liquid 2.8×10^{-2} N/m Ans

J) Find the height to which water will rise in a capillary tube of 1.4 mm diameter, surface tension of water is 72.5×10^{-3} N/m and angle of contact is 10° and density of water is 1000 kg/m³

→ Soln:- Given that,

Diameter of capillary tube (d) = 1.4 mm = 1.4×10^{-3} m

∴ Radius of capillary tube(r) = 0.7×10^{-3} m

surface tension (T) = 72.5×10^{-3} N/m

Density of liquid (ρ) = 1000 kg/m³

Angle of contact (θ) = 10°

Height rised (h) = ?

Now, Height rised in capillary tube(h) = $\frac{2T\cos\theta}{r\rho g}$

$= 2 \times 72.5 \times 10^{-3} \times \cos 10^\circ$

5) Attempt any six questions from the following:

a) A charged oil drop remain stationary when situated between two parallel horizonatal plates 25mm aparts and potential difference of 1000V is applied to the plates. find the charges on the oil drop if it has mass of 5×10^{-15} kg. Assume $g = 10 m/s^2$

→ soln.:- Given that

potential difference between the plate (v) = 1000 volts

Distance between the plates (h) = 2mm = 25×10^{-3} m

mass of the oil drop (m) = 5×10^{-15} kg.

Acceleration due to gravity (g) = $10 m/s^2$

Now

$$E = \frac{V}{h} = \frac{1000}{25\times10^{-3}} = 40000 \ V/m$$

According to the question, weigh of oil-drop remains stationary

$$\text{or, } EQ = mg$$

$$\text{or, } 40000Q = 5\times10^{-15}\times10$$

$$\text{or, } Q = \frac{5\times10^{-15}\times10}{40000}$$

$$Q = 1.25\times10^{-18} C$$

The magnitude of the charges on the oil-drop is 1.25×10^{-18}C

(b) In millikens apparatus two plates seperated by 0.5 cm are charged to a potential difference of 900volt. If the drop weight 3×10^{-12} gram. find the charges which is sufficent to hold the drop at rest between the plates

→ soln.:- Given that

Radius of water drop (a) = 10^{-5} cm = 10^{-7} m

Distance between the plates (d) = 0.5 cm = 5×10^{-3} m

potential difference between plates (V) = 900V

mass of oil drop (m) = 3×10^{-12} g = 3×10^{-15} kg charge on drop (q) = ?

Now, Required electric field $(E) = \frac{V}{d}$

$= \frac{900}{5\times10^{-3}}$

$= 1.8\times10^{5}\ V/m$

for the drop to be stationary, we have,

or, $qE = mg$

or, $q = \frac{mg}{E}$

or, $q = \frac{3\times10^{-15}\times10}{1.8\times10^{5}}$

$\therefore q = 1.67\times10^{-19}C$ Ans

c) An oil drop falls through air with terminal velocity of 5×10^{-4} m/s calculate the radius of the oil drop. Given; viscosity of air $= 1.8\times10^{-5}\ NSm^{-2}$, density of oil $= 900 kgm^{-3}$, neglect the density of air

→ soln:. Given that,

Terminal velocity of oil drop $(v) = 5\times10^{-4}$ m/s

viscosity of air $(\eta) = 1.8\times10^{-5}\ NSm^{-2}$

Density of oil used $(\rho) = 900\ kgm^{-3}$

Radius of oil drop (a) = ?

we have,

Radius of oil drop $(a) = \sqrt{\frac{9V\eta}{2\rho g}}$

$= \sqrt{\frac{9\times5\times10^{-4}\times1.8\times10^{-5}}{2\times900\times9.8}}$

$= 2.142\times10^{-6}m$.

In millikan's drop experiment, a charged oil drop of density 880 kg m^{-3} is held stationary between two parallel plates 6 mm apart and held at a potential difference of 103V. when the electric field is switched off, the drop is observed to fall a distance of 2 mm in 35.7 sec. what is the radius of drop?

Soln:- Given that,

Density of oil drop (ρ) = 880 kg^{-3} (oil)

Distance between two plates(d) = 6mm = 6×10^{-3}m

potential difference(V) = 103V

$x = 2mm = 2\times10^{-3}$ m

Time taken(t) = 35.7 sec.

Radius of drop(r) = ?

Now velocity of oil drop (v) = $\frac{x}{t} = \frac{2\times10^{-3}}{35.7} = 5.6\times10^{-5}$ m/s

we know that,

$$r = \sqrt{\frac{9\eta v}{2(\rho-\sigma)g}}$$

where, $g = 9.8$ m/s^2

$\sigma = 1.29$ kg/m^3

$\eta = 1.8\times10^{-5}$ Nsm^{-2}

$$\therefore r = \sqrt{\frac{9\times1.8\times10^{-5}\times5.6\times10^{-5}}{2(880-1.29)\times9.8}}$$

$$\therefore r = 7.25\times10^{-7} \text{ m} \quad Ans$$

(e) An oil drop of density 900 kg/m³ fall with a terminal velocity of 2.9×10^{-4} m/s through air of viscosity 1.8×10^{-5} N s m^{-2}. find the radius of the oil drop ignoring density of air. what potential difference must be applied between the two plates 5 mm apart to make the oil drop at rest between the plates if the charges on the drop is $-3e$?

→ soln:- Given that,

Density of oil (ρ) = 900 kg m^{-3}

Terminal velocity of oil drop (v) = 2.9×10^{-4} m/s

viscosity of air (η) = 1.8×10^{-5} N s m^{-2}

charge of the oil drop (q) = $3e = 3\times1.6\times10^{-19} = 4.8\times10^{-19}$ C

potential difference to be applied for oil drop to keep rest (V)

Distance between the plate (d) = 5 mm = 5×10^{-3} m

we have,

$$\text{Radius of oil drop }(a) = \sqrt{\frac{9v\eta}{2\rho g}}$$

$$= \sqrt{\frac{9\times2.9\times10^{-4}\times1.8\times10^{-5}}{2\times900\times9.8}}$$

$$= 1.63\times10^{-6}\text{ m}$$

Again, for the oil drop to be at rest, weight of drop must be balanced by electric force experienced by drop.

$$Eq = mg = \frac{4}{3}\pi a^3\rho g$$

$$\text{or, } \frac{V}{d}q = \frac{4}{3}\pi a^3\rho g$$

$$V = \frac{4}{3}\frac{d}{q}\pi a^3\rho g$$

$$= \frac{4}{3}\left(\frac{5\times10^{-3}}{4.8\times10^{-19}}\right)\pi\times(1.63\times10^{-6})^3\times900\times9.8$$

$$= 1665.82\text{ V Ans}$$

(82) Electron are accelerated from rest by a potential difference of 100V. What is their final velocity? The electron beam now enters normally on the uniform electronic field of intensity 10^5 Vm^{-1}. Calculated the magnetic ~~field~~ flux density B' of uniform magnetic field applied prependicular to the electric field if the path of the beam is unchanged from its origin direction.

Soln:-

potential difference(V) = 100V

Electric field intensity (E) = 10^5 V/m

Magnetic flux(B) = ?

Now Energy gained by electron = eV

$= 1.6\times10^{-19}\times100$

$= 1.6\times10^{-17}$

$\therefore \frac{1}{2}mv^2 = eV$

or, $v^2 = \frac{2eV}{m}$

$v = \sqrt{\frac{2eV}{m}}$

$v = \sqrt{\frac{2\times1.6\times10^{-17}}{9\times10^{-31}}}$

$\therefore v = 5.96\times10^{6}$ m/s

Now according to given condition; we have;

$Bev = eE$

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

$= \frac{10^5}{5.96\times10^6}$

$= 1.67\times10^{-2}$ wb/m²

(32)

A long horizontal road having length 50cm and mass 40 gm is placed in the uniform magnetic field of strength 0.2 T perpendiculary calculate the current in the road it force acting on its just blance it weight $g = 9.8 m/s^2$

→ soln:-

length of road $(l) = 50 cm = 0.5 m$

mass of the road $(M) = 40 gm = 0.40 \times 10^{-3} kg$

strength of magnetic field $(B) = 0.2T$

Angle $(\theta) = 90°$

current $(I) = ?$

By the question, we have

force acting on road = it weight

$$BIl \sin\theta = mg$$

$$I = \frac{mg}{Bl\sin\theta}$$

$$\therefore I = \frac{40 \times 10^{-3} \times 10}{0.2 \times 0.5 \times \sin 90°}$$

$$\therefore I = 3.92A$$

(3) An electron is revolving in a uniform magnetic field of strength $1.5 \times 10^{-2} T$. The radius of the circle described is $1.2 \times 10^{-2} m$ Through what potential difference was the electron initially accelerated from the rest? Take em for electron 1.76×10^{11}

→ soln:-

strength of magnetic field $(B) = 1.5 \times 10^{-2} T$

radius of circle $(r) = 1.2 \times 10^{-2} m$

potential difference $(V) = ?$

$em = 1.76 \times 10^{11}$

1) An electron having 500 eV of energy move at right angle to uniform magnetic field flux density of 20×10^{-3} T. find the radius of its circular orbit.

Soln:-

Kinetic energy (K.E) = $\cancel{500}eV = 500\times1.6\times10^{-19} = 8\times10^{-17}$

magnetic flux (B) = 20×10^{-3} T

Mass of electron (m_e) = 9.1×10^{-31} kg

Electronic charge (e) = 1.6×10^{-19} J

Radius of circular orbit (r) = ?

we know that

$$\frac{1}{2}m_e v^2 = eV$$

$$v = \sqrt{\frac{2eV}{m_e}}$$

$$v = \sqrt{\frac{2\times8\times10^{-17}}{9.1\times10^{-31}}}$$

$$\therefore v = 13259870.88 \text{ m/s}$$

Inside the magnetic field, we have,

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

$$r = \frac{mv^{\cancel{2}}}{Be\cancel{v}}$$

$$r = \frac{9.1\times10^{-31}\times(13259870.88)^{\cancel{2}}}{20\times10^{-3}\times1.6\times10^{-19}}$$

$$\therefore r = 3.77\times10^{-3} \text{ m}$$

Ans

) An electron moving with energy 20V enters inside the magnetic field of 0.2 Tesla. Find the radius of circular path made by electron $m_e = 9.1 \times 10^{-31}$ $e = 1.6 \times 10^{-19} C$

Soln:

potential difference(V) = 20 volt

magnetic field intensity = 0.2 T

$m_e = 9.1 \times 10^{-31}$

$e = 1.6 \times 10^{-19}$

Radius of path (r) = ?

we know that

$$\frac{1}{2} m_e v^2 = eV$$

$$v = \sqrt{\frac{2eV}{m_e}}$$

$$v = \sqrt{\frac{2 \times 1.6 \times 10^{-19} \times 20}{9.1 \times 10^{-31}}}$$

$$\therefore v = 2.65 \times 10^{6} \text{ m/s}$$

Now, for uniform magnetic field

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

$$r = \frac{mv}{Be}$$

$$r = \frac{9.1 \times 10^{-31} \times 2.65 \times 10^{6}}{0.2 \times 1.6 \times 10^{-19}}$$

$$\therefore r = 7.53 \times 10^{-5} \text{ m}$$

What is the magnetic field intensity at a centre of a coil of 100 turn and radius 2.5cm carrying a current of 10A

→ Soln:-

$N = 100$ turn

$r = 2.5\,cm = 2.5 \times 10^{-2}\,m$

$I = 10\,A$

magnetic field $(B) = ?$

we know that

$$B = \frac{\mu_0 I n}{2r}$$

$$B = \frac{10 \times 100 \times 4\pi \times 10^{-7}}{2 \times 2.5 \times 10^{-2}}$$

$\therefore B = 2.51 \times 10^{-2}\,T$ Ans

(7) An electron is revolving in a uniform magnetic field of strength $1.5 \times 10^{-2}\,T$. The radius of circular path is $1.2 \times 10^{-2}\,m$ through what potential difference was the electron initially accelerated from the rest. $\frac{e}{m}$ for electron $= 1.76 \times 10^{11}$

→ Soln:-

magnetic field strength $(B) = 1.5 \times 10^{-2}\,T$

Radius of circular path $(r) = 1.2 \times 10^{-2}\,m$

$\frac{e}{m} = 1.76 \times 10^{11}$

potential difference $(V) = ?$

we know that,

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

$$\frac{Ber}{m} = v$$

$\frac{e}{m} \cdot \cancel{1.6 \times 10^{-19}} \times 1.2 \times 10^{-2} = v$

$v = 1.76 \times 10^{11} \times 1.8 \times 10^{-4}$

$\therefore v = 3.168 \times 10^{7}\,m/s$

$\cancel{\frac{1}{2} mv^2 = eV}$

again

$\frac{1}{2} mv^2 = eV$

$\frac{1}{2} mv^2 = \left(\frac{e}{m}\right) V$

or $(3.168 \times 10^{7})^2 = 2 \times 1.76 \times 10^{11} \times V$

$\therefore V = 2851.2\,V$

1) A copper wire is 2 m long and 3mm in diameter. Find the extension produced and energy stored in a wire when a 3 kg mass is hang on its end while other end is fixed at rigid support. Young's modulus for copper is $1.1 \times 10^{11} N/m^2$

→ soln: Given that

length (l) = 2m

Diameter(d) = 3mm = $r = \frac{d}{2} = \frac{3}{2} = 1.5mm = 1.5 \times 10^{-3} m$

Hanging mass (M) = 3 kg

Young modulus (Y) = $1.1 \times 10^{11} N/m^2$

gravity (g) = $10 m/s^2$

we have,

force produced due to mass(f) = mg

$= 3 \times 10$

$= 30N$

cross-section area of the wire (A) = πr^2

$= \pi (1.5 \times 10^{-3})^2$

$= 7.06 \times 10^{-6} m^2$

Now

extension produced (Δl) = $\frac{fl}{AY}$

$= \frac{30 \times 2}{7.06 \times 10^{-6} \times 1.1 \times 10^{11}}$

$= 7.73 \times 10^{-5}$

and

energy stored in wire (E) = $\frac{1}{2} f \Delta l$

$= \frac{1}{2} \times 30 \times 7.73 \times 10^{-5}$

$= 0.001 J$ Ans

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(3) find the force and energy density when 2m long and 3mm thick wire is extended by 1.4 mm (young modulus is $2\times10^{11}\ N/m^2$

→ soln:

length (l) = 2m

Thickness (d) = 3mm = 3×10^{-3} m

Δl = 1.4mm = 1.4×10^{-3} m

young modulus (y) = $2\times10^{11}\ N/m^2$

we know that,

$$(A) = \frac{\pi d^2}{4} = \frac{3.14\times(3\times10^{-3})^2}{4}$$

$$= 7.068\times10^{-6}\ m^2$$

Now

$$(y) = \frac{\frac{f}{A}}{\frac{\Delta l}{l}}$$

$$y = \frac{fl}{\Delta l A}$$

$$f = \frac{y\Delta l A}{l}$$

$$f = \frac{2\times10^{11}\times1.4\times10^{-3}\times7.068\times10^{-6}}{2}$$

$$f = 989.52\ N$$

Energy density (Ed) = $\frac{1}{2}$ stress × strain

$$= \frac{1}{2}\ \frac{f}{A}\times\frac{\Delta l}{l}$$

$$= \frac{1}{2}\ \frac{989.52}{7.068\times10^{-6}}\times\frac{1.4\times10^{-3}}{2}$$

$$= 49000\ J/m^3$$

(e) A force is 25 N is applied to the ends of wire 3m long and produces extension of 0.25 mm. If the diameter of wire is 2 mm, calculated (i) stress on wire (ii) strain (iii) young modulus.

Soln:-

force (f) = 25 N

length (l) = 3 m

Extension of wire (e) = 0.25 mm = 0.25×10^{-3} m

Diameter of wire (d) = 2mm = 2×10^{-3} m

Stress = ?

Strain = ?

young modulus (Y) = ?

we know that,

$$Area = \frac{\pi d^2}{4} = \frac{\frac{22}{7} \times 2 \times 10^{-3}}{4}$$

$$= 3.14 \times 10^{-6} m$$

$$Stress = \frac{f}{A}$$

$$= \frac{25}{3.14 \times 10^{-6}}$$

$$= 7.96 \times 10^{6} N/m^2$$

and,

$$strain = \frac{e}{l}$$

$$= \frac{0.25 \times 10^{-3}}{3}$$

$$= 1.67 \times 10^{-4}$$

$$young\ modulus (Y) = \frac{Stress}{strain}$$

$$= \frac{7.96 \times 10^{6}}{1.67 \times 10^{-4}}$$

$$= 4.77 \times 10^{10} N/m^2$$

(1) A wire of length 150cm and area of cross-section 1 mm^2 is stretched by a weight of 3kg. Determine increase in length. young modulus of material of wire is $2\times10^{11}\ N/m^2$, $g = 9.8\ m/s^2$

→ soln:-

length $(l) = 150cm = 1.5m$

Area $(A) = 1mm^2 = 1\times10^{-6} m$

Mass $(m) = 3kg$

young modoulus $(Y) = 2\times10^{11} N/m$

$g = 9.8$

Let Δl be the small increase in the length of wire

$$Y = \frac{\text{Stress}}{\text{Strain}}$$

$$= \frac{\frac{f}{A}}{\frac{\Delta l}{l}}$$

$$= \frac{fl}{A\Delta l} \quad [\because f = mg]$$

$$Y = \frac{mgl}{\Delta l A}$$

$$Y = \frac{3\times9.8\times150\times1.5}{\Delta l\times1\times10^{-6}}$$

$$\Delta l = \frac{3\times9.8\times150\times1.5}{2\times10^{11}\times1\times10^{-6}}$$

$\therefore \Delta l = 0.00011\ m$ Ans

1) The critical angle of light in certain substance is 45° what is polarizing angle?

→ soln:- Given that

critical angle (C) = 45°

polarizing angle (ϕ) = ?

from Brewster's law, we have,

$$\mu = \tan\phi$$

$$\text{or, } \frac{1}{\sin C} = \tan\phi$$

$$\text{or, } \frac{1}{\sin 45^\circ} = \tan\phi$$

$$\sqrt{2} = \tan\phi$$

$$\therefore \phi = \tan^{-1}(\sqrt{2}) = 54.7^\circ$$

(b) The critical angle of light in a certain substance is 45°. What is the polarizing angle?

→ soln:- Given that

critical angle (C) = 45°

polarizing angle (ϕ) = ?

from Brewster's law, we have

$$\mu = \tan\phi$$

$$\text{or, } \frac{1}{\sin C} = \tan\phi$$

$$\text{or, } \frac{1}{\sin 45^\circ} = \tan\phi$$

$$\sqrt{2} = \tan\phi$$

$$\therefore \phi = \tan^{-1}(\sqrt{2}) = 54.7^\circ \text{ Ans}$$

(c) The refractive index of a certain substance is 1.6. find critical angle and polarizing angle.

→ soln.: Given that

Refractive index (μ) = 1.6

critical angle (C) = ?

polarizing angle (I_p) = ?

we know that,

$$\mu = \frac{1}{\sin C}$$

or, $\sin C = \frac{1}{\mu}$

or, $C = \sin^{-1}\left(\frac{1}{1.6}\right)$

$\therefore C = 38.68°$

Similarly; we have

$$\tan I_p = \mu$$

$$I_p = \tan^{-1}(1.6)$$

$$\therefore I_p = 58°$$

(d) The critical angle of a transparent medium is 49°. what is polirazing angle?

→ soln.: Given that

critical angle(C) = 49°

polarizing angle (i_p) = ?

from Brewster law' we have

$\mu = \tan i_p$ (where i_p is polarizing angle

or, $\frac{1}{\sin C} = \tan i_p$ (where C is critical angle)

$$\frac{1}{\sin 49°} = \tan i_p$$

$$\frac{1}{1.15} = \tan i_p$$

$$\therefore i_p = \tan^{-1}\left(\frac{1}{1.15}\right) = 41° \text{ A-l}$$

(a) A policeman blown a whistle with frequency of 500 Hz. A car approaches him with a velocity 36 km/hr. calculate apparents frequency of the sound of whistle that is heared by the passengers in the car. Given; velocity of sound in air is 348 m/s

→ soln.: Given that

frequency of whistle $(f) = 50Hz$
velocity of sound $(v) = 348 m/s$
velocity of car the car $(u) = 36 km/hr$

$= \frac{36 \times 1000}{60 \times 60}$

$= 10 m/s$

Apparent frequency of the whistle heared $(f) = ?$

Here, sources is at stationary and observer the passenger is moving toward the sources, hence the frequency f) heared by the passenger is:

$f' = \frac{(u+v) \times f}{v}$

$= \frac{(348+10) \times 50}{348}$

$f' = 514.37 Hz$ Ans

(b) A car travelling at 20 m/s sound its horn which has frequency of 600 Hz what frequency is heared by stationary distant observer as car approaches.

→ soln.: Given that,

frequency of sounding car $(f) = 600 Hz$
velocity of car $(u_s) = 20 m/s$
velocity of sound $(v) = 240 m/s$

Now When car approaches close to the stationary observer let f' be the apperent frequency and give by:

$f' = \left(\frac{v}{v-u_s}\right) f = \left(\frac{340}{340-20}\right) \times 60$

$= 637.5 Hz$

(44)

c) An observer is moving towards the stationary sources. If the observer is 30% greater than actual pitch, calculate the velocity of the observer (velocity of sound 332 m/s)

→ soln:- Given that,

velocity of sound (v) = 332 m/s

change in pitch of sound ($f'-f$) = 30% of $f = \frac{30f}{100} = 0.3f$

speed of man (u) = ?

Now, Apparent frequency (f') = $\frac{vf}{v-u} = \frac{332f}{332-u}$

substituting the value in relation (1) we get

$\frac{332f}{332-u} - f = 0.3f$

or, $\frac{332f}{332-u} = 0.3f + f$

or, $\frac{332f}{332-u} = 1.3f$

or, $\frac{332}{332-u} = 1.3$

or, $u = 76.62$ m/s

Hence, the speed of the man is 76.62 m/s

The engine is continuously sounding a whistle of frequency 500 Hz. The velocity of sound is 340 m/s. What is the frequency of sound heard in the car when engine and car approaching each other and moving away from each other. (95)

→ Soln: Given that

frequency of whistle (f) = 500 Hz

velocity of sound (v) = 340 m/s

velocity of car (u) = 20 m/s

When engine and car is moving toward each other, then

$$\text{Apparent frequency } (f') = \left(\frac{v+u_0}{v+u_s}\right) \times f$$

$$= \frac{340+20}{340+20} \times 600$$

$$= 562.5 \text{ Hz}$$

Similarly, when engine and car is moving away from each other; then

$$\text{Apparent frequency } (f'') = \left(\frac{v-u_0}{v+u_s}\right) \times f$$

$$= \frac{340-20}{340+20} \times 500$$

$$= 444.44 \text{ Hz}$$

(7) Calculate the apparent frequency (46) of the horn of car approaching a stationary listner with a velocity of 12 m/s. The frequency of horn is 500 Hz and the velocity of sound 332 m/s

→ soln:- Given that

frequency of sounding car $(f) = 500\,Hz$
velocity of sound $(V) = 332\,m/s$
velocity of car $(u) = 12\,m/s$

we know that,

The apparent frequency $(f') = \left(\frac{V}{V-u}\right)f$

$$= \left(\frac{332}{332-12}\right) \times 500$$

$$= \frac{332}{\cancel{20}} \times \cancel{500}$$

$$= 332 \times 25$$

$$= 518.75\,Hz$$

(8) A car is moving with the speed of 20 m/s blown its horn at the frequency of 512 Hz. find the frequency of sound detected by a police moving toward the car from the opposite direction with velocity of 10 m/s

→ soln:- Given that

velocity of sources car $(V_s) = 20\,m/s$
frequency of sources $(f) = 512\,Hz$
velocity of observer car $(V_o) = 10\,m/s$
velocity of sound in air $(v) = 348\,m/s$ (at 20°)
frequency of sound heared by police $(f') = ?$

Now,

The apparent frequency $(f') = \left(\frac{V+V_o}{V-V_s}\right)f$

$$= \left(\frac{348+10}{348-20}\right) \times 512$$

$$= 542.75\,Hz$$

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(2) A 10 μf capacitor is charged by a 220V supply. It is then disconnected from the supply and connected to another uncharged 4 μf capacitor find (i) common potential and (ii) energy lost by the first capacitor?

Soln:

$C_1 = 10\mu f = 10 \times 10^{-6} f$

$V_1 = 220V$

$C_2 = 4\mu f = 4 \times 10^{-6} f$

$V_2 = ?$

(i) we know that, $(V) = \dfrac{C_1 V_1 + C_2 V_2}{C_1 + C_2}$

$= \dfrac{10 \times 10^{-6} \times 220 + 4 \times 10^{-6} \times 0}{10 \times 10^{-6} + 4 \times 10^{-6}}$

$= 157.14$ volt.

we have,

Energy stored in first capacitor $(E_1) = \frac{1}{2} C_1 V_1^2$

$= \frac{1}{2} \times 10 \times 10^{-6} \times 220$

$= 0.242$ J

Again,

Energy of the combination $(E_2) = \frac{1}{2} (C_1 + C_2) V^2$

$= \frac{1}{2} (10 \times 10^{-6} + 4 \times 10^{-6}) \times (0.24)^2$

$= 0.173$ J

Energy by first capacitor $= E_1 - E_2$

$= 0.242 - 0.173$

$= 0.0693$ J

4) An electric lamp is rated as 220V – 100W. What is its electric resistance? What power does it consume if it is used a circuit of 110V? 4B

→ Soln.:

Power (P) = 100W

Potential difference (V) = 220V

we have,

$$P = \frac{V^2}{R}$$

$$R = \frac{V^2}{P}$$

$$R = \frac{(220)^2}{100}$$

$$R = \frac{400\cancel{00}}{1\cancel{00}}$$

$$\therefore R = 484$$

Now, if V = 110V, then

$$P = \frac{V^2}{R}$$

$$P = \left(\frac{110}{484}\right)^2$$

$$\therefore P = 14W$$

(1) The refractive index of glass prism is 1.5 If an angle of minimum deviation is 37°, what is the angle of prism?

→ Soln:-
Refractive index of glass prism (μ) = 1.5
Angle at minimum deviation (δ_m) = 37°
Angle of prism (A) = ?

we have,

$$\mu = \frac{\sin\left(\frac{\delta_0 + A}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

or, $1.5 \sin\left(\frac{A}{2}\right) = \sin\left(\frac{A}{2}\right) \cdot \cos\left(\frac{37°}{2}\right) + \cos\left(\frac{A}{2}\right) \cdot \sin\left(\frac{37}{2}\right)$

or, $1.5 \sin\frac{A}{2} - \sin\left(\frac{A}{2}\right) \cdot \cos\left(\frac{37}{2}\right) = \cos\left(\frac{A}{2}\right) \cdot \sin\left(\frac{37}{2}\right)$

or, $\sin\left(\frac{A}{2}\right)\left[1.5 - \cos\left(\frac{37°}{2}\right)\right] = \cos\left(\frac{A}{2}\right) \cdot \sin\left(\frac{37}{2}\right)$

or, $\tan\left(\frac{A}{2}\right) = \frac{0.3173}{0.5516}$

$= 0.5752$

$\frac{A}{2} = \tan^{-1}(0.5752)$

$\therefore A = 60°$ Ans

(2) The refractive index of a glass is 1.5 and angle of prism is 60°. Find the angle of minimum deviation.

→ Soln:- Given that

Angle of prism (A) = 60°
Refractive index (μ) = 1.5
Angle of minimum deviation (δ_m) = ?

Now, we have from relation,

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

or, $\mu = \dfrac{\sin\left(\dfrac{60^\circ + \delta_m}{2}\right)}{\sin\left(\dfrac{60}{2}\right)}$

or, $1.5 = \dfrac{\sin\left(\dfrac{60^\circ + \delta_m}{2}\right)}{\sin 30^\circ}$

or,

$1.5 \sin 30^\circ = \sin\left(\dfrac{60^\circ + \delta_m}{2}\right)$

or, $\dfrac{60 + \delta_m}{2} = \sin 48.59^\circ$

or, $60 + \delta_m = 97.18^\circ$

$\therefore \delta_m = 37.18^\circ$

Hence, the angle of minimum deviation of the prism is 37.18°

(3) Angle of minimum deviation produced by a water prism is 23.4° calculate the refractive index of material of prism having refracting angle 60°.

$\Rightarrow$ Soln: Given that

Angle of minimum deviation $(\delta_m) = 23.4^\circ$
Angle of prism (A) $= 60^\circ$
Refractive index $(\mu) = ?$

We know that,

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

$$\mu = \frac{\sin\left(\frac{60 + 23.4}{2}\right)}{\sin 60/2}$$

$$\mu = 1.33$$ Ans

(4) Calculate the angle of prism with refractive index 1.5 which produces an angle of minimum deviation of 37.20°

⇒ Soln:- Given that

Angle of minimum deviation (δ_m) = 37.20°
Refractive index (μ) = 1.5
Angle of prism (A) = ?

We know that,

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

$$\text{or, } 1.5 = \frac{\sin\left(\frac{A+37.20}{2}\right)}{\sin\frac{A}{2}}$$

$$\text{or, } 1.5\sin\frac{A}{2} = \sin\left(\frac{A+37.20}{2}\right)$$

$$\text{or, } 1.5\sin\frac{A}{2} = \sin\frac{A}{2}\cdot\cos\frac{37.20}{2} + \cos\frac{A}{2}\cdot\sin\frac{37.20}{2}$$

$$\text{or, } 1.5\sin\left(\frac{A}{2}\right) = \sin\left(\frac{A}{2}\right)\times 0.9477 + \cos\left(\frac{A}{2}\right)\times 0.3189$$

dividing by $\sin\frac{A}{2}$ on both side.

$$1.5 - 0.9477 = \cot\frac{A}{2}\times 0.3189$$

$$\frac{0.5523}{0.3189} = \cot\frac{A}{2}$$

$$\frac{A}{2} = \cot^{-1}(1.73)$$

$$\frac{A}{2} = 30$$

$$\therefore A = 60^\circ$$

∴ Angle of ~~minimum deviation~~ prism (A) = ~~30~~ 60°

(1) find the tempreture at which r.m.s velocity of a gas is half its value at 0°C

⇒ Soln:- Given that,

Root mean square velocity of gas at 0°C (C_{rms} at $T = v$ (say)

then, Root mean square velocity of gas at T_1°C (C_{rms} at $T_1 = \frac{v}{2}$

$$\frac{C_{rms} \text{ at } T}{C_{rms} \text{ at } T_1} = \sqrt{\frac{273+T}{273+T_1}}$$

$$\frac{v}{\frac{v}{2}} = \sqrt{\frac{273}{273+T_1}}$$

$$2 = \sqrt{\frac{273}{273+T_1}}$$

$$4 = \frac{273}{273+T_1}$$

$$4T_1 + 1092 = 273$$

$$4T_1 = -819$$

$$T_1 = \frac{-819}{4}$$

$$T_1 = -204.75°C = (273-204.75)K$$

$$\therefore T_1 = 68.25K$$

Hence, the required tempreture at which r.m.s velocity of a gas is half value at 0°C is -204.75°C or 68.25K

(2) Taking the density of nitrogen at S.T.P as 1.251 kg/m³. Find the r.m.s speed of nitrogen molecules at 30°C

→ Soln:- Given that,

Density of nitrogen at S.T.P (ρ) = 1.251 kg/m³

Temperature (T) = 30°C = 303 K

We know that,

r.m.s speed of gas molecules at S.T.P $(C_{rms}) = \sqrt{\frac{3P}{\rho}}$

where, $P = 1.01 \times 10^5$ N/m² at S.T.P $(C_{rms}) = \sqrt{\frac{3 \times 1.01 \times 10^5}{1.25}} = 492.14$

∴ $C_{r.m.s}$ of Nitrogen gas molecules at S.T.P $(C_{r.m.s})_1 = \sqrt{\frac{3RT_0}{M}}$ — (i)

and C_{rms} at temperature T $(C_{r.m.s})_2 = \sqrt{\frac{3RT}{M}}$ — (ii)

dividing eqn (ii) by (i); we get

$$\frac{(C_{r.m.s})_2}{(C_{r.m.s})_1} = \frac{\sqrt{\frac{3RT}{M}}}{\sqrt{\frac{3RT_0}{M}}}$$

or, $(C_{r.m.s})_2 = \sqrt{\frac{T}{T_0}} \times (C_{r.m.s})_1$

$(C_{r.m.s})_2 = \sqrt{\frac{303}{273}} \times 492.14 = 518.48$ m/s

Hence, the r.m.s speed of Nitrogen molecules at 30°C is 518.48 m/s

(3) Assuming the density of Nitrogen at S.T.P to be 1.2 kg/m3 find the r.m.s velocity of the nitrogen molecules at 127°C

⇒ Soln:

Density of Nitrogen (ρ) = 1.251 kg/m^3

$P_0 = 760 mmHg = 760 \times 10^{-3} \times 13.6 \times 10^3 \times 9.8$

$= 101292.8 N/m^2$

$T_0 = 0°C = 273 K$

$T = 127°C = 400K$

Rms velocity of Nitrogen (c) = ?

From gas equation; we have,

$P_0 V_0 = R T_0$

$R = \frac{P_0 V_0}{T_0}$ —— (1)

But we know that,

molecular wt. of Nitrogen (M) = 28×10^{-3} kg

volume of 1mole of Nitrogen at s.t.p (V_0) = $\frac{M}{\rho} = \frac{28 \times 10^{-3}}{1.25}$

$= 22.38 \times 10^{-3} m^3$

putting the value in eqn. (1) we get

$R = \frac{P_0 V_0}{T_0} = \frac{101292.8 \times 22.38 \times 10^{-3}}{273}$

$= 8.304 J/moK$

∴ Rms velocity (c) = $\sqrt{\frac{3RT}{M}} = \sqrt{\frac{3 \times 8.304}{28 \times 10^{-3}}}$

$= 596.56 m/s$

∴ Required r.m.s velocity of Nitrogen at 127°c is 596.56 m/s

(1) A steel rod of length 1m at 0°c is heated to 100°c. Calculate the increase in length of rod. Cubical expansivity of steel $= 36 \times 10^{-6}$ °c

⇒ soln:- Given that

Original length $(l_0) = 1m$
Initial temperature $(\theta_1) = 0°c$
final temperature $(\theta_2) = 100°c$
cubical expansivity of steel $(\gamma) = 36 \times 10^{-6}$/°c
∴ Linear expansivity of steel $(\alpha) = \gamma/3 = 12 \times 10^{-6}$/°c

we know that,

Increase in length, $\Delta l = l_0 \alpha \theta$

or, $\Delta l = 1 \times 12 \times 10^{-6} (100 - 0)$

∴ Increase in length $\Delta l = 0.0012m$

(2) A glass rod of length 1.03 m at 0°c is heated to 50°c find the coefficent of linear expansion of the rod, if its increase in length is 0.4 mm.

⇒ soln:- Given that

Length of rod $(l) = 1.03m$
initial temperature $(\theta_0) = 0°c$
final temperature $(\theta) = 50°c$
∴ change in temperature $(\Delta\theta) = \theta - \theta_0 = 50 - 0 = 50°c$
change in length $(\Delta l) = 0.24mm = 0.24 \times 10^{-3}m$

we know that, $\Delta l = l \alpha \Delta\theta$

or, $0.24 \times 10^{-3} = 1.03 \times \alpha \times 50°c$

or, $\dfrac{0.24 \times 10^{-3}}{1.03 \times 50} = \alpha$

∴ $\alpha = 4.66 \times 10^{-3}$

(1) A cyclist rides constant speed of 36 km/hr along a circle of the radius 20 m. At what angle to the vertical should be inclined his bicycles.

→ soln:- Given that,

speed $(v) = 36\ km/hr = \frac{36000}{3600}\ m/s = 10\ m/s$

Radius $(R) = 20\ m$

vertical angle$(\theta) = ?$

we know that, $\tan\theta = \frac{v^2}{rg}$

$\tan\theta = \frac{(10)^2}{20 \times 10}$

$\tan\theta = \frac{\cancel{100}}{\cancel{200}}$

$\theta = \tan^{-1}(1/2)$

$\therefore \theta = 26.56^\circ$

i.e if $\theta = 26.56^\circ$ to the vertical should be incline the his cycle

(2) A motorcycle rides going with a velocity of 60 km/hr around a curve with radius of 50 m must lean at an angle to the vertical find the angle at which he leans.

→ soln:- Given that

velocity $(v) = 60\ km/hr = \frac{600\cancel{00}}{36\cancel{00}} = 16.67\ m/s$

Radius $(R) = 50\ m$

Angle$(\theta) = ?$

we have, $\tan\theta = \frac{v^2}{rg}$

$\tan\theta = \frac{(16.67)^2}{50 \times 10}$

$\theta = \tan^{-1}(0.555)$

$\therefore \theta = 29.06^\circ$

He leans at $\theta = 29.06^\circ$ with vertical.

(9) A cyclist move on a circular path radius 5m with a constant speed of 18 km/hr. Calculate the angle of inclination of the cyclist with vertical.

⇒ Soln:- Given that,

Radius of (R) = 5 m

velocity (v) = 18 km/hr = $\frac{18000}{3600}$ = 5 m/s

angle (θ) = ?

we know that,

$$\tan\theta = \frac{v^2}{rg}$$

$$\tan\theta = \frac{(5)^2}{5 \times 10}$$

$$\tan\theta = \frac{1}{2}$$

$$\theta = \tan^{-1}(1/2)$$

$$\therefore \theta = 26.56^\circ$$

Hence, the cyclist incline at $\theta = 26.56^\circ$

1) A bar magnet of 10 cm length has pole strength of 10 Am. Determine the magnetic field at a point on its axis at distance 15 cm from the centre of magnet. $\mu_0 = 4\pi \times 10^{-7}$ TMA^{-1}

→ Soln:- Given that,

Length of magnet $(L) = 10 cm = 0.1 m$
pole strength $(m) = 10$ Am
Distance at point $(d) = 15 cm = 0.15 m$
Effective length $(2l) = 85\%$ of $L = 0.085 m$

$$l = \frac{0.085}{2}$$

$$\therefore l = 0.0425 m$$

Now

$$\text{magnetic field } (B) = \frac{\mu_0}{4\pi} \frac{2Md}{(d^2 - l^2)^2}$$

$$= \frac{\mu_0}{4\pi} \frac{2 \times m \times 2l \times d}{[d^2 - l^2]^2}$$

$$= \frac{\mu_0}{4\pi} \frac{2 \times 10 \times 2 \times 0.0425 \times 0.15}{[(0.15)^2 - (0.0425)^2]^2}$$

$$= \cancel{\frac{\mu_0}{4\pi}}\ 5.95 \times 10^{-5} T$$

Hence, the magnetic field is $5.95 \times 10^{-5} T$

AC

(1) A bar magnet 10 cm long is placed in the magnetic meridian with N-pole pointing north. A Natural point is obtained at a point 25 cm from each pole. Calculate its magnetic moment. Horizontal components of earth's magnetic field = 0.34 oersted

→ soln:- Given that

Length of bar magnet $(2l) = 10\ cm\ cm = 0.1 m$

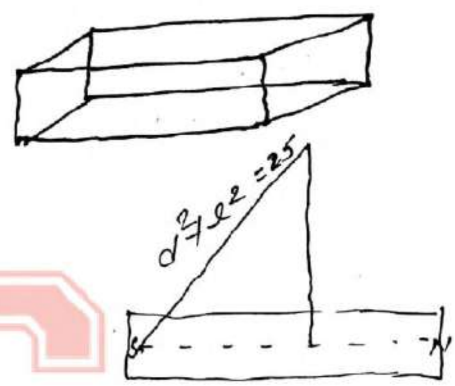
Horizontal components of earth magnetic field $(H) = 0.34$ oersted

$\mu_0 = 4\pi \times 10^{-7}\ TMA^{-1}$

$= 0.34 \times 10^{-4}$ Tesla

from the figure, we have,

$d^2 + l^2 = (25)^2 cm = (0.25)^2 m$



At neutral point, we have,

$f = H$

$$\frac{\mu_0}{4\pi} \times \frac{M}{(d^2+l^2)^{3/2}} = H$$

$$\text{or } M = \frac{4\pi H (d^2+l^2)^{3/2}}{\mu_0}$$

$$M = \frac{4\pi \times 0.34 \times 10^{-4} \times (0.25)^3}{4\pi \times 10^{-7}}$$

$= 5.3125\ Am^2$

Hence, its magnetic moment is $5.3125\ Am^2$

(4) A bar magnet 5 cm long is kept with its north pole pointing geographical north. A neutral point is found at a distance of 25 cm from each pole. Calculate pole strength of magnet $\mu_0 = 4\pi \times 10^{-7}$ TMA^{-1}, $H = 3.4 \times 10^{-5}$ T

→ soln:- Given that

$2l = 6$ cm $= 0.06$ m

or, $l = 0.03$ m

$NP = SP = \sqrt{d^2+l^2} = 25$ cm $= 0.25$ m

Horizontal component of earth field (H) $= 0.35 \times 10^{-4}$ T

$\mu_0 = 4\pi \times 10^{-7}$ TMA^{-1}

pole strength (m) = ?

We know,

This is the broadside on position of the magnet at neutral point.

$H = B$

i.e $H = \frac{\mu_0}{4\pi} \times \frac{2ml}{(d^2+l^2)^{3/2}}$

$= \frac{4\pi \times 10^{-7} \times 2 \times 0.03 \times m}{4\pi \times (0.25)^3}$

$m = \frac{0.35 \times 10^{-4} \times (0.25)^3 \times 4\pi}{2 \times 0.003 \times 4\pi \times 10^{-7}}$

$m = 93.12$ Am

Therefore, the pole strength of the magnet is 93.2 Am.

(3) A bar magnet 20 cm long is placed in the magnetic meridian with its north pole pointing south. The neutral point is observed a distance of 30 cm from one its pole. Calculate the pole strength of the magnet $\mu_0 = 4\pi \times 10^{-7}$ TMA^{-1}, $H = 3.4 \times 10^{-5}$ T

→ soln:- Given that

$$2l = 20\,cm = 0.2\,m$$
$$or,\ l = 0.1\,m$$
$$d = 0.3\,m + 0.1\,m = 0.4\,m$$
$$H = 0.32 \times 10^{-4}\,T$$
$$\mu_0 = 4\pi \times 10^{-7}\,TMA^{-1}$$

when the north pole points south, the neutral point are found on the axial line then,

$$B = H = \frac{\mu_0}{4\pi} \times \frac{2Md}{(d^2 - l^2)^2}$$

$$M = \frac{4\pi H (d^2 - l^2)^2}{2\mu_0 d}$$

$$M = \frac{4\pi \times 0.32 \times 10^{-4} \left[(0.4)^2 - (0.1)^2\right]^2}{2 \times 4\pi \times 10^{-7} \times 0.4}$$

$$= 9\,Am^2$$

Now

$$\text{pole strength} = \frac{M}{2l}$$
$$= \frac{9}{2 \times 0.1}$$
$$= 45\,Am \quad \text{Ans}$$

(5) A bar magnet 10 cm long is placed along the magnetic meridian with its North pole pointing North. The neutral point is obtained at a point 20 cm from each pole. calculate the pole strength moment of the magnet. $\mu_0 = 4\pi \times 10^{-7} TmA^{-1}$ $H = 3.4\times10^{-5} T$

Solution:

Given that,

$2l = 10cm = 0.1m$

$\therefore l = 0.05m$

Horizontal component of earth magnetic field $(H) = 3.4\times10^{-5} T$

$\mu_0 = 4\pi \times 10^{-7} TmA^{-1}$

from the figure: we have

~~At neutral point~~ $d^2+l^2 = (20)^2 = (0.20)^2$

At neutral point; we have,

$f = H$

$\frac{\mu_0}{4\pi} \times \frac{M}{(d^2+l^2)^{3/2}} = H$

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

$= \frac{4\pi \times 3.4\times10^{-5} \times (0.20)^3}{4\pi \times 10^{-7}}$

$= 2.72 Am^2$

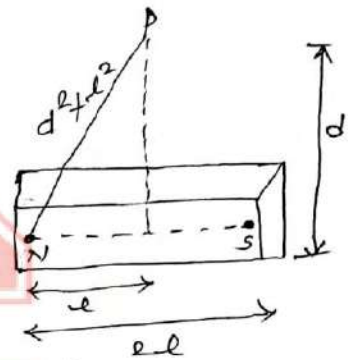


fig. Bar magnet.

$\therefore$ magnetic moment is $2.72 Am^2$

Again, At neutral point:

$H = B$

$H = \frac{\mu_0}{4\pi} \times \frac{2ml}{(d^2+l^2)^{3/2}}$

$3.4\times10^{-5} = \frac{\mu_0}{4\pi} \times \frac{2\times m \times 0.05}{(0.20)^3}$

$\therefore$ pole strength $(m) = 27.2$

(1) An object is placed 15 cm from a diverging lens of focal length 10 cm calculate the image distance and magnification

→ soln:- Given that

object distance (u) = 15 cm
focal length (f) = 10 cm
image distance (v) = ?

from the lens formula; we have

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

or, $\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = -\frac{1}{10} - \frac{1}{15}$

$= -0.167$

or, $v = -\frac{1}{0.167}$

$\therefore v = -6$ cm

therefore, the position of image is 6 cm in same side.

Magnification $= \frac{v}{u} = -\frac{6}{15} = -0.4$

(2) An object is placed 24 cm from a concave mirror of focal length 16 cm find the position of image and magnification

→ soln:- Given that

object distance (u) = 24 cm
focal length (f) = 16 cm
image distance (v) = ?

from the lens formula; we have

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

or, $\frac{1}{v} = \frac{1}{16} - \frac{1}{24} = \frac{1}{48}$

image distance (v) = 48 cm

magnification (m) $= \frac{v}{u} = \frac{48}{24} = 2$

It means that the image is two times larger than an object.

(3) The image obtained with converging lens is erect and three times the length of the object. The focal length of the lens is 20 cm. Calculate the object and image distance.

⇒ Given that

Magnification $(m) = \frac{I}{O} = 3$

focal length $(f) = 20$ cm

object distance $(u) = ?$

Image distance $(v) = ?$

we know that,

$$m = \frac{I}{O} = \frac{v}{u} = 3$$

or, $v = -3u$ ... (1) (negative sign for virtual and erect image.

from general mirror formula, we have

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

or, $\frac{1}{20} = \frac{1}{u} - \frac{1}{3u} = \frac{3-1}{3u} = \frac{2}{3u}$

or, $3u = 40$

$\therefore u = 13.33$ cm

putting the value of 'u' in eqn ... (1)

$v = -3u$

$v = -3 \times 13.33$

$v = -40$ cm

Hence, object distance is 13.33 and image distance is 40cm.

(4) An object is placed 10 cm from a convex lens of focal length 12 cm. Find out the image distance and magnification.

⇒ Soln:- Given that

object distance $(u) = 10cm$

focal length $(f) = 12cm$

for convex lens,

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

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

or, $\frac{1}{v} = \frac{1}{12} - \frac{1}{10}$

or, $\frac{1}{v} = \frac{10-12}{120}$

$\therefore v = -60cm$

$\therefore$ Image distance $(v) = -60cm$

Now, Magnification $(m) = \frac{v}{u} = -\frac{60}{10} = -6$

(5) An object is placed 6 cm from the convex mirror of focal length 10 cm. Calculate the image distance and magnification.

⇒ Soln:- Given that

object distance $(u) = 6cm$

focal length of convex mirror $(f) = -10cm$

Image distance $(v) = ?$

Magnification $(m) = ?$

We have,

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

$$\frac{1}{-10} = \frac{1}{6} + \frac{1}{v}$$

$$v = \frac{6 \times (-10)}{6+10} = -3.75$$

Now

magnification $(m) = \frac{v}{u} = \frac{-3.75}{6} = -0.625$

6) An object 20 mm high is placed 10 cm from spherical mirror and forms a virtual image which is 40 mm high. What is the radius of curvature of the mirror.

⇒ Soln:

Given that

Height of object (o) = 20 mm

object distance (u) = 10 cm

Height of image (I) = 40 mm

Radius of curvature (R) = ?

we know that;

$$\text{Magnification}(m) = \frac{I}{O} = \frac{v}{u}$$

$$\text{or, } \frac{\cancel{40}2}{\cancel{20}} = \frac{v}{u}$$

$$v = 2u$$

$$v = 2 \times 10 = 20\text{cm}$$

$$\therefore v = -20\text{cm} \text{ (virtual image)}$$

Now using mirror formula; we have:

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

$$\text{or, } \frac{1}{f} = \frac{1}{10} - \frac{1}{20}$$

$$\therefore f = 20\text{ cm}$$

Now, Radius of curvatur (R) = 2f = 2 × 20

= 40 cm

① What is the result of mixing 10 gm of ice at $-5°C$ and 50 gm of water at 100°C given that latent heat of fusion of ice $= 3.36\times10^5 J/kg$ specific heat capacity of water $= 4200 J/kg$ and specific heat capacity of ice $= 2100 J/kg$

→ soln.: Given that,

mass of ice $(m_i) = 10gm = 0.01 kg$

mass of water $(M_w) = 50gm = 0.05 kg$

Temprature of ice $(\theta_1) = -5°C$

Temprature of water $(\theta_2) = 100°C$

latent heat fusion of ice $(l_f) = 3.36\times10^5 J/kg$

specific heat capacity of ice $(s_i) = 2100 J/kg$

specific heat capacity of water $(s_w) = 4200 J/kg$.

Let, θ be the temprature of mixture. then, from the principle of calorimetry.

we have,

Heat gained = Heat lost

or, $m_i s_i (0+\theta_1) + m_i l_f + m_i s_w (\theta - 0) = M_w s_w (\theta_2 - \theta)$

or, $0.01\times2100\times5 + 0.01\times3.36\times10^5 + 0.01\times4200\times\theta = 0.05\times4200 (100-\theta)$

or, $105 + 3360 + 42\theta = 210(100-\theta)$

or, $3465 + 42\theta = 21000 - 210\theta$

$\therefore \theta = 69.58°C$

Hence, the temprature of the mixture is 69.58°C

(2) A metal of mass 100gm at 100°c is dropped into 80gm of water at 20°C contained in a calorimeter of mass 120gm. The final temprature of the calorimeter and its contents rise to 80°c compute the specific heat capacity of the metal. Specific heat capacity of copper = 0.0094 cal gm^{-1} °c^{-1}

⇒ soln:- Mass of calorimeter (m_c) = 120 gm
Mass of water (m_w) = 80gm
Mass of metal ball (m_m) = 100gm
Initial temprature of calorimeter + water (t_1) = 20°c
Initial temprature of mixture (t_2) = 100°c
final temprature of mixture (t) = 80°
Specific heat of water (S_w) = 1cal/gm°c
specific heat of calorimeter (S_c) = 0.0094 cal/gmc
specific heat of metal (S_m) = ?

The specific heat of the solid metal

$$S = \frac{m_c s_c (t-t_1) + m_w s_w (t-t_1)}{m_m (t_2-t)}$$

$$= \frac{120 \times 0.0094 \times (80-20) + 80 \times 1 \times (80-20)}{100 \times (100-80)}$$

$\therefore S = 0.1158$ cal/gmc

(3) what is the results of mixing 10 gm ice at $-8°C$ to 10 gm water at $20°C$. Given that, specific heat capacity of ice = 0.5 cal/gm°C
latent heat of fusion of ice = 80 cal/gm°C
specific heat capacity of water = 1 cal/gm°C

Solution:

Mass of ice (m_i) = 10gm
Temperature of ice (θ_i) = $-8°C$
Mass of water (m_w) = 10gm
Temperature of water (θ_w) = $20°C$
specific heat capacity of ice (S_i) 0.5 cal/gm°C
latent heat of fusion of ice (L_f) 80 cal/gm°C
specific heat capacity of water (S_w) = 1 cal/gm°C

We have,
total heat required to convert ice at $-8°C$ to $0°C$ water $= m_i s_i (0-\theta_i) + m_i L_f$
$= 10 \times 0.5 (0+8) + 10 \times 80$
$= 840$ cal

But total required to convert water at $20°C$ to water at $0°C$
$= m_w s_w (20-0)$
$= 10 \times 1 \times 20$
$= 200$ cal.

Here, heat lost by water at $20°C$ is less than heat gained by ice at $-8°C$ to $0°C$ ice,

$m_i s_i (0+8) + m L_f = 200$

or, $m = \dfrac{200 - 10 \times 0.5 \times 8}{80}$

$\therefore m = 2$ gm of ice is melted.

4) A ball of copper weighing 400gm is transformed from a furnace to 1kg of water at 20°c. The temperature of water increase to 50°c. What is the original temperature of the ball? Specific heat capacity of water is $4.2 \times 10^3 J kg^{-1} K^{-1}$, specific heat capacity of copper is $400 J kg^{-1} K^{-1}$

⇒ soln:- Given that

mass of the water used $(M_w) = 1 kg$
Initial temperature of water $(t_1) = 20°c$
Mass of copper ball $(M_c) = 400gm = 0.4 kg$
Temperature of the mixture $(t_2) = 50°c$
Initial temperature of copper ball $(t) = ?$
Specific heat capacity of water $(S_w) = 4.2 \times 10^3 J kg^{-1} K^{-1}$
Specific heat capacity of copper $(S_c) = 4200 J kg^{-1} K^{-1}$

Heat lost by copper ball to decrease temperature from t°c to 50°c is;

$$= M_c S_c (t - t_2) = 0.4 \times 400 (t - 50) = 160 (t - 50)$$

Similarly, Heat gained by 1 kg of water to increase its temperature from 20°c of 50°c is;

$$= M_w S_w (t_2 - t_1) = 1 \times 4200 (50 - 20) = 126000 J$$

Now from principal of calorimeter, we have

Heat lost = Heat gained.

or, $160(t - 50) = 126000$

$160t - 800 = 126000$

$\therefore t = 837.5°c$

∴ Temperature of the copper ball is 837.5°c

(5) A glass window 4mm thick has length 2.5m and height 1.5m. How much heat will be conducted through the glass for 1min. when the temperature of room is 30°C and that of outside is 27°C. Thermal conductivity for glass is 0.85 W/mK

⇒ Soln:- Given that,

thickness of window (d) = 4mm = 4×10^{-3} m

Area of window (A) = $2.5 \times 1.5 = 3.75 \, m^2$

time (T) = 1 min = 60 sec.

Temperature difference $(\theta_1 - \theta_2) = 30 - 27 = 3°C$

Thermal conductivity for glass (K) = 0.85 W/MK

We know that,

$$\text{Heat conduction}(Q) = \frac{KA(\theta_1 - \theta_2)t}{d}$$

$$= \frac{0.85 \times 3.75 \times 3 \times 60}{4 \times 10^{-3}}$$

$$= 143437.5 \, J$$

Hence, the amount of heat conducted is 143437.5 J.

(1) A 2 kg object moving with velocity of 8 m/s collides with a 3 kg object moving with a velocity of 5 m/s along the same line. Calculate their common velocity if both object moves off together.

→ Soln.: Given that,

mass of 1st object $(m_1) = 2kg$
velocity of 1st object $(v_1) = 8 m/s$
mass of 2nd object $(m_2) = 3kg$
velocity of 2nd object $(v_2) = 5 m/s$

Let 'v' be the common velocity :-

According to the principle of conservation of linear momentum: we have,

$$m_1 v_1 + m_2 v_2 = (m_1 + m_2) v$$

$$v = \frac{m_1 v_1 + m_2 v_2}{m_1 + m_2}$$

$$v = \frac{2 \times 8 + 3 \times 5}{2+3}$$

$$v = 6.2 \text{ m/s}$$

Hence, their common velocity after collision is 6.2 m/s

(1) A car of mass 1000 kg moves up an inclination of 30° at constant speed of 20 m/s. calculate the power developed by an engine of a car if the coefficient of friction is 0.2. value of acceleration due to gravity = 9.8 m/s²

⇒ Soln:- Given that

Mass of car (m) = 1000 kg
Inclination of plane (θ) = 30°
velocity of car (v) = 20 m/s
Acceleration due to gravity (g) = 9.8 m/s²
Here, if the car moves up an inclined plane of inclination angle (θ) then power developed by car is given by,

$$\text{power}(P) = \text{Total force} \times \text{velocity} = f_r \times v = (mg\sin\theta + f_f) \times v$$
$$= (mg\sin\theta + \mu R) \times v$$
$$\cancel{= mg(\sin\theta +}$$

where, f_f is the friction force μR,

$$= (mg\sin\theta + \mu mg\cos\theta) \times v$$
$$= mg(\sin\theta + \mu\cos\theta) \times v$$
$$= 1000 \times 9.8(\sin 30° + 0.2 \times \cos 30°) \times 20$$
$$= 131948 \text{ watts.}$$

(2) What is the acceleration of block sliding down a 45° slope if the coefficient of sliding friction between two surface is 0.17

⇒ Soln:- Given that

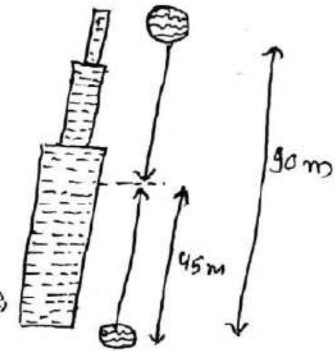
Slope (θ) = 45°
coefficient of sliding friction (μ_s) = 0.17
we have, acceleration of block sliding down is given by

$$a = g(\sin\theta - \mu_s\cos\theta)$$
$$= 10(\sin 45° - 0.17 \times \cos 45°)$$
$$= 5.86 \text{ m/s}^2$$

∴ Acceleration of block sliding down (a) = 5.86 m/s²

(1) A body is dropped from a top of a tower 90m hight. At the same time another body is projected vertically upwards from the bottom. If ~~another body~~ they meet at halfway, find the initial velocity of the projected body.

→ Sol:- Given that



for a dropping body.

initial velocity (u) = 0

Distanced travelled (s) = 45m

let, 't' be the time travelled, then we have,

$$s = ut + \frac{1}{2} g t^2$$

or, $45 = 0 \times t + \frac{1}{2} \times 10 \times t^2$

or, $\frac{45 \times 2}{10} = t^2$

$t^2 = 9$

$\therefore t = 3$ sec

for the body projected upward;

let 'u' be the initial velocity then,

distance travelled (s) = 45m

time taken (t) = 3sec.

Now

we have,

$$s = ut - \frac{1}{2} g t^2$$

or, $45 = u \times 3 - \frac{1}{2} \times 10 \times (3)^2$

or, $45 = 3u - \frac{90}{2}$

or, $45 + \frac{90}{2} = 3u$

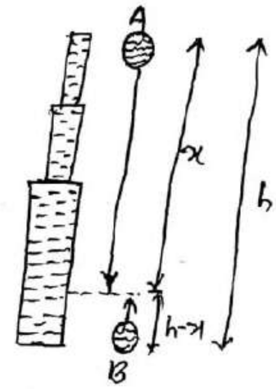
$\frac{180}{2} = 3u$

$3u = 90$

$\therefore u = 30$ m/s

(2) from the top of the tower, 100m height, a ball is dropped. At the same time, another ball is projected vertically upward from the ground with the velocity of 25 m/s. find when and where two balls meet. the value of acceleration due to gravity = 9.8 m/s²

→ soln:. Given that



Height of tower (h) = 100m

Initial velocity of ball A $(u_1) = 0$

Initial velocity of ball B $(u_2) = 25$ m/s

Time at which they meets (t) = ?

Let, 'x' is the height from top where two ball meets.

Hence, Height of the ball A falls = x m

Height from bottom the ball 'B' attain to meet = h-x

for, falling ball 'A';

$$h = ut + \frac{1}{2}gt^2$$

or, $x = 0 \times t + \frac{1}{2} \times 9.8 \times t^2$

Or, $x = \frac{9.8t^2}{2}$

$$x = 4.9t^2 \quad \text{--- (I)}$$

Again, from the ball (B) thrown upward; we get

$$h = ut - \frac{1}{2}gt^2$$

or, $h - x = 25 \times t - \frac{1}{2} \times 9.8 \times t^2$

or, $h - x = 25t - 4.9t^2$

$100 - x = 25t - 4.9t^2$ --- (II)

from eqn:. (I) and (II)

$100 - (4.9t^2) = 25 - 4.9t^2$

∴ t = 4 sec.

put the value in eqn:. (I)

$x = 4.9 \times (4)^2 = 80$ m

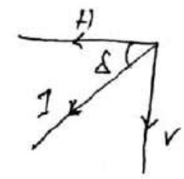
∴ the ball meet at height 80m below the top after 4 sec.

(1) Calculate the horizontal and vertical component of the flux density of earth's magnetic field at a place where resultant flux density is 10^{-5} Tesla and angle of dip is 51°

→ soln:- Given that

Total intensity $(I) = 10^{-5}$ Telsa

Angle of dip $(\delta) = 51°$



we have,

Horizontal component $(H) = I\cos\delta = 10^{-5} \times \cos 51° = 6.29 \times 10^{-6}\,T$

Vertical component $(V) = I\sin\delta = 10^{-5} \times \sin 51° = 7.77 \times 10^{-6}\,T$

(2) The horizontal components of the flux density of earth's magnetic field at a place is 0.25×10^{-5} T and its vertical component is 0.35×10^{-5} T. Calculate (a) The angle of dip and (b) earth's total magnetic field at the place.

→ soln:- Given that

Vertical component $(V) = 0.2 \times 10^{-5}\,T$

Horizontal component $(H) = 0.34 \times 10^{-5}\,T$

Angle of dip $(\delta) = ?$

Total flux density $(I) = ?$

The angle of dip 'δ' is given by

$$\tan\delta = \frac{V}{H} = \frac{0.2 \times 10^{-5}}{0.34 \times 10^{-5}} = 0.59$$

$$\therefore \delta = \tan^{-1}(0.59) = 30.54°$$

Again from $H = I\cos\delta$; we have

$$I = \frac{H}{\cos\delta} = \frac{0.34 \times 10^{-5}}{\cos 30.54°} = 3.95 \times 10^{-6}\,T$$

(3) If the earth's magnetic field at a place is 0.34 gauss and the angle of dip is 30°, calculate the horizontal and vertical component of the field in Tesla.

→ soln:

Earth's magnetic field $(I) = 0.34\ G = 0.34 \times 10^{-4}\ T$

Angle of dip $(\delta) = 30°$

Now,

Horizontal component $(H) = I \cos\delta$

$= 0.34 \times 10^{-4} \times \cos 30°$

$= 2.94 \times 10^{-5}\ T$

Similarly

vertical component $(V) = I \sin\delta$

$= 0.34 \times 10^{-4} \times \sin 30°$

$= 1.7 \times 10^{-5}$ Tesla.

(4) The earth's total magnetic field intensity at a place is $4.5 \times 10^{-5}\ T$ and angle of dip is 30°. Calculate the horizontal and vertical components.

→ soln: Given that

magnetic intensity $(I) = 4.5 \times 10^{-5}\ T$

Angle of dip $(\delta) = 30°$

Horizontal component $(H) = ?$

vertical component $(V) = ?$

We know that,

$H = I \cos\delta = 4.5 \times 10^{-5} \times \cos 30° = 3.9 \times 10^{-5}\ T$

Similarly

Vertically component $(V) = I \sin\delta$

$= 4.5 \times 10^{-5} \times \sin 30°$

$= 2.25 \times 10^{-5}\ T$

(i) The refractive index of glass and water are 3/2 and 4/3 resp. Calculate the ~~critical~~ critical angle for glass-water interface.

Soln.: Given that

Refractive index of glass $({}_a\mu_g) = 3/2 = 1.5$

Refractive index of water $({}_a\mu_w) = 4/3 = 1.33$

we have,

$$ {}_g\mu_w = \frac{{}_a\mu_g}{{}_a\mu_w} = \frac{1.5}{1.33} = 1.128 $$

The critical angle in glass-water interface is given by,

$$ \sin c = \frac{1}{{}_g\mu_w} $$

$$ = \frac{1}{1.128} $$

or, $\sin c = 0.886$

$$ c = \sin^{-1}(0.886) $$

$$ \therefore c = 62.44^\circ $$

Therefore, the required critical angle in glass-water interface is 62.44°. A

(i) Calculate the total translational kinetic energy of 3 mole of an ideal gas at 27°C. Take $R = 8.317\ J/mol K$

⇒ Soln:-

Number of moles (n) = 3

Tempretur (T) = 27°c = 300K

universal gas constant (R) = 8.317 J/mole

Number of molecules in 3 moles of gas = $3N_A$

[where N_A = Avogadro's number]

So, Translational K.E of 3 moles of gas $= 3N_A \times \frac{3}{2} KT$

$= \frac{9}{2} N_A \times \frac{R}{N_A} \times T$

$= \frac{9}{2} RT = \frac{9}{2} \times 8.317 \times 300$

$= 1.12 \times 10^4 J$

Q. A simple pendulum is oscillating at the rate of 30 times per minutes. find time period and length of pendulum ($g = 9.8 m/s^2$)

⇒ Soln.: Given that

$g = 9.8 m/s^2$

pendulum oscillates @ 30 minutes per minutes.

$\therefore$ Time period $(T) = \frac{1 min}{30} = \frac{60}{30} = 2 sec.$

we know that,

$$T = 2\pi\sqrt{\frac{l}{g}}$$

$$2 = 2\pi\sqrt{\frac{l}{9.8}}$$

$$\therefore l = \frac{9.8}{\pi^2}$$

$\therefore$ length of pendulum $(l) = 1 m$

(1) An object of mass 10 kg is moving with a velocity of 6 m/s calculate its kinetic energy. If a constant opposing force of 20N suddenly acts on it find the time it takes to come to the rest

→ Soln:- Given that

Mass(m) = 10kg

velocity(v) = 6 m/s

opposing force(f) = 20N

we know that,

$$K.E = \frac{1}{2}mv^2 =$$

$$= \frac{1}{2} \times 10 \times 6^2$$

$$= 5 \times 36$$

$$= 180 J$$

$$\text{Retardation } (a) = \frac{f}{m} = \frac{20}{10}$$

$$= 2 m/s$$

Let, 't' be the time to come to rest. Then, final velocity (v) = 0 rest, we have,

$$v = u + at$$

$$v = 6 - 2 \times t$$

$$\therefore t = 6/2 = 3$$

$\therefore$ Time (t) = 3 sec to come at rest.

(2) A bucket of water having total mass 3 kg is whirled by using rope in a vertical circle of radius 1.5 m with a speed of 6 m/s find the maximum and minimum tension on the rope.

⇒ Soln:- Given that

Mass (M) = 3 kg

Radius (r) = 1.5 m

velocity (v) = 6 m/s

we know that,

$$T - mg = \frac{mv^2}{r}$$

$$T = \frac{mv^2}{r} + mg$$

$$= \frac{3 \times (6)^2}{1.5} + 3 \times 9.81$$

$$= 101.43 \text{ N}$$

Similarly, tension will be minimum at higest point of circle then, we have,

$$T = \frac{mv^2}{r} - mg$$

$$= \frac{3 \times (6)^2}{1.5} - 3 \times 9.81$$

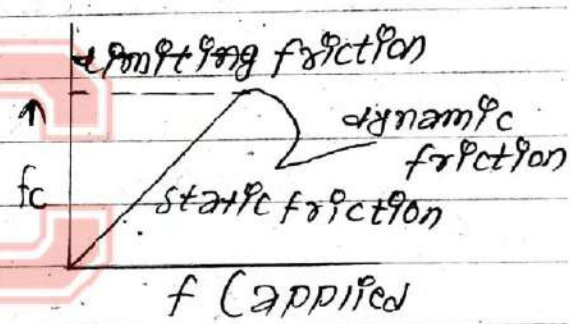
$$\therefore T_{min} = 42.57 \text{ N}$$

(x) limiting friction :- The value of force of friction just before ~~moving~~ it body starts moving is called limiting friction.

or,

The maximum value of time slation friction is called limiting fraction.

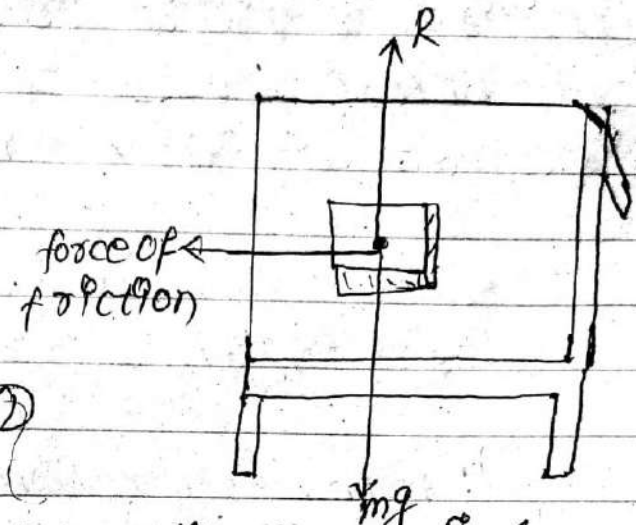
The graph between applied force f and ~~force~~ force of friction



coefficient of friction :-

The fore of friction (F_c) when body of mass m' slides over ~~another~~ another body is directly proportional to the normal reaction (R) is the force on the sliding body due to the body on which the bodys is sliding one plane surface as shown in fig. 1

The normal reaction is equal to the weight of the body · that is $R = mg$.



$\therefore f_c = \mu R \quad -(I)$

fig. 1

where is the proportionly constant called coefficant of friction

Thus from equation $-(I)$
coefficant of friction $(\mu) = \frac{fc}{R}$

It han not unit because fc and R have the same units.

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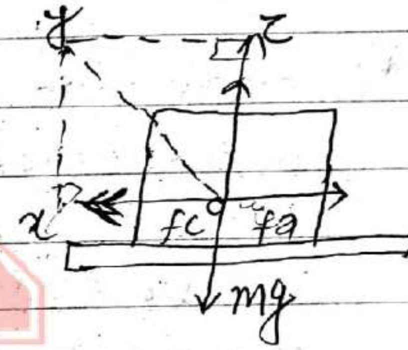
angle of friction Q.N prove that the coefficant of friction is equal to tangent of angle of friction.

The angle of friction is defined as the angle made by the resultant of normal reaction and force of friction with th normal reaction,

consider a block is placed on the table as shown in fig. 1 applied force is fa and The force of friction is fc work in opposite direction. If fa > fc the block starts to move other wise doesn't move. Let f be the resultant of normal reaction R and force of friction $\vec{fc}$. The angle made by f with the normal reaction $\vec{R}$ called the angle of friction (α)



from ~~at, od~~
right angled triangle
ΔOYZ

$$\tan\theta = \frac{YZ}{OZ}$$

$$\therefore \tan\theta = \frac{f_c}{R} \quad \text{--- (1)}$$

Again, $\mu = \frac{f_c}{R}$ - (ii) $\left(\because \mu = \frac{f_c}{R}\right)$

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

$$\therefore \mu = \tan\theta \quad \text{---- (3)}$$

down.

*) prove that coefficant of friction is equal to the tangent of angle of repose.

or, $\mu = \tan\theta$

The angle of repose is defined as the angle of inclination of an inclined plane on it just start to fall down

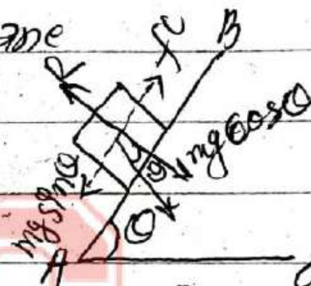


fig. 1

let, θ be angle of repose that weight of object can be resolved in to two components

i) mg sinθ which balances the normal reaction R ie $mg\cos\theta = R$ — (I)

(ii) mg sinθ which blanced the force of friction (fc) ie. $mg\sin\theta = fc$ — (II)

dividing (II) by (I) $\frac{mg\sin\theta}{mg\cos\theta} = \frac{fc}{R}$

$\tan\theta = \mu$

proved

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(*)
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Work Energy and power

Work :- when a force produced a displacement on a body is said to be work.
suppose a force $\vec{f}$ acts on a body to have a displacement $\vec{s}$ then, work done by the force

$$w = \vec{f} \cdot \vec{s}$$
$$= fs \cos\theta \quad —(1)$$

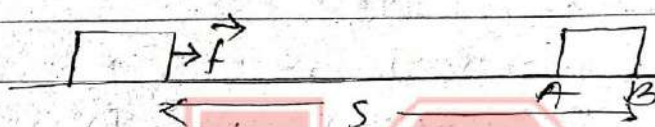

fig 1

fig.2

where θ is the angle between $\vec{f}$ and $\vec{s}$ as shown in fig.2

when the displacement is produced in the directly application of force as shown in fig.1 i.e $\theta = 0$

then $w = fs$

thus the work done by a countant force is the produe of force and displacement when the two vector $\vec{f}$ and $\vec{s}$ are in same direction.

(v) special cases:-

(i) when θ is acute angle [i.e $\theta < 90°$]
The work done is possitive

(ii) when $\theta = 90°$, then $\cos 90° = 0$
$W = 0$

(iii) when $90 < \theta < 180°$ $\cos\theta$ is negative
and Hence work done is negative

unit of work done → Joule(J) [in SI unit]
→ erg [in CGS unit]

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work-Energy thearom
suppose a car mass 'm' moving in intial velocity a is acted on by a resultant force f for a distance S is as ~~showing~~ shown in fig.1. It be the acceleration produced and v be the final velocity after travelling the distance S, then we have

$$v^2 = u^2 + 2as$$
$$a = \frac{v^2 - u^2}{2S}$$

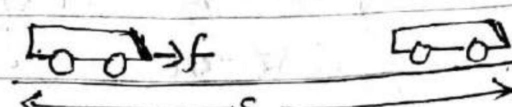

fig.1

thus, by Netwon's seond equs of motion we have.

$$f = ma$$

$$f = m\left(\frac{v^2 - u^2}{2s}\right)$$

$$fs = \frac{1}{2}m(v^2 - u^2)$$

$$fs = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

$$w = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

st V.V.I Hence the work of resultant force is equal to the change in kinetic energy this realation is called work - energy theorm

(v^{1000}) principle converxation of mechanical energy Total energy]

→ It state that the total mechanical energy i.e ~~energy~~ the sum of kinetic energy and potental energy of a body falling freely under the gravity remains constant

$$\text{Total energy} = K.E + P.E = \text{constant}$$

proof

suppose a body of mass 'm' is kept slationary at a point A heigh 'h' above the ground as show in fig. (i) then at point 'A' $K.E. = \frac{1}{2}mu^2 = 0$, $P.E = mgh$

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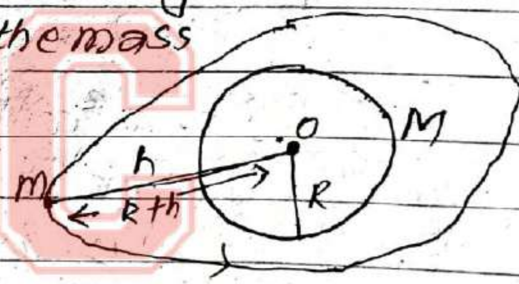
Satellite

A body which revolved continuously around a bigger body is called satellite.

Orbital velocity (V_0):- The velocity required to keep the satellite into it's orbit is called orbital velocity.

Consider a satellite of mass m revolving around the earth at height 'h' from the surface as shown in fig.1

Let 'V_0' be the orbital velocity of satellite. Let M be the mass of earth.



To revolve the satellite around the earth.

centripetal force = gravitational force

$$\frac{m v_0^2}{(R+h)} = \frac{GMm}{(R+h)^2}$$

$$v_0^2 = \frac{GM}{(R+h)}$$

$$v_0 = \sqrt{\frac{GM}{R+h}} = \sqrt{\frac{gR^2}{R+h}}$$

which is the required expression of the orbital velocity of satellite.

(#) moment of inertia (I)

The moment of inertia is defined as the sum of the product of masses and square of the perpendicular distance from the axis of rotation. It is represented by I

$$I = m_1 r_1^2 + m_2 r_2^2 + m_3 r_3^2 + \cdots + m_n r_n^2$$

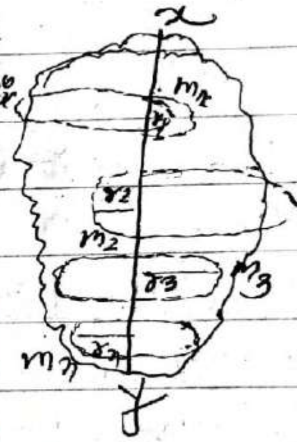
$$= \sum_{i=1}^{n} m_i r_i^2$$

unit → $kg\,m^2$

1) **Rotational Kinetic energy ($K.E_{rot}$) :-**

consider a rigid body rotating about an axis xy having constituent particles having masses $m_1, m_2 --- m_n$ at perp. distance $r_1, r_2 --- r_n$ from the axis of rotation moving with same angular velocity ω as shown in fig.1

then the kinetic energy of rotating body is equal to the sum of kinetic energy of constituents particles



$$K.E_{rot} = \frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2 + ---- + \frac{1}{2} m_n v_n^2$$

$$= \frac{1}{2} \left[m_1 (r_1 \omega^2) + m_2 (r_2 \omega^2) + ---+ m_n (r_n \omega^2) \right.$$

$$= \frac{1}{2} \left[m_1 r_1^2 + m_2 r_2^2 + ---+ m_n r_n^2 \right] \omega^2$$

$K.E_{rot} = \frac{1}{2} I \omega^2$ which is required expression

where $I = \sum_{i=1}^{n} m_i r_i^2$

(#) **Angular momentum (L) :-**

Angular momentum of a rigid body is defined as the moment of momentum

suppose a particle A of mass m revolves in a circles of radius r with uniform linear velocity and angular velocity ω as shown

(29)

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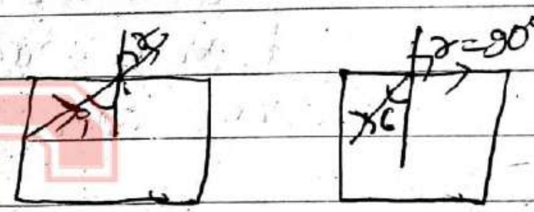
(1) prove that $\mu = \frac{1}{\sin C}$, then symbols have their usual meanings.

→ consider a ray passes from denser (water) to air (rarer medium) with the angle of incidence i and angle of refraction r as shown in fig 1
let μ be absolute refractive index of glass when the angle of refraction is $90°$ then the angle of incidence become critical angle C as shown in fig. 2

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



$$a\mu_g \times g\mu_a = 1$$

$$a\mu_g = \frac{1}{g\mu_a}$$

$$= \frac{1}{\frac{\sin i}{\sin r}}$$

$$a\mu_g = \frac{\sin r}{\sin i}$$

$i = C$ when $r = 90°$

$$a\mu_g = \mu = \frac{\sin 90°}{\sin C} = \frac{1}{\sin C}$$

$$\boxed{\therefore \mu = \frac{1}{\sin C}}$$

proved

Black body

A perfectly black body is the one which obsulbs raditions of all weave-length incident on it. for a black body the reflection coefficent (r) and the transmission uetticia are both zero. However the obsurption coefficent (a) = 1. This impelies that a perfect black body neither reflectsnor transmit the radiation falling not and hence it appears completely black.

Black body radition

The emission of radition form black body is called black body radition. It is not only obsurbs the radition but also earth radition. at the thermal equilibrum the rate of obsurption of heat energy is equal to the rate of emission of heat energy. The radition emitted by black body depend upon surface temprature and not on nature of materail.

Stefan Boltzamann law :- It states that the total amount of heat energy radiated per second per unit area of a prefectly black body is directly propeortionol to fourth power of it's absolute temprature T then