HSC - BOARD - 2016

Date: 24.02.2016

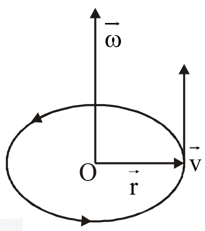
PHYSICS (54) - SOLUTIONS

SECTION - I

Q. 1

(i) Analytical method :

i. Consider a particle performing circular motion in anticlockwise sense with centre O and radius r as shown in figure



ii. Let $\vec{\omega}$ = angular velocity

$\vec{v}$ = linear velocity

$\vec{r}$ = radius vector

iii. Linear displacement in vector form is given by

$\overrightarrow{\delta s} = \overrightarrow{\delta\theta} \times \vec{r}$

Dividing both side by δt, we have

$\frac{\overrightarrow{\delta s}}{\delta t} = \frac{\overrightarrow{\delta\theta}}{\delta t} \times \vec{r}$ ......(i) _______**(1) marks**

iv. Taking limiting value in equation (i) we have $\lim_{\delta t \to 0} \frac{\overrightarrow{\delta s}}{\delta t} = \lim_{\delta t \to 0} \frac{\overrightarrow{\delta\theta}}{\delta t} \times \vec{r}$

$\therefore \frac{\overrightarrow{ds}}{dt} = \frac{\overrightarrow{d\theta}}{dt} \times \vec{r}$

But $\frac{\overrightarrow{ds}}{dt} = \vec{v}$ = linear velocity

$\frac{\overrightarrow{d\theta}}{dt} = \vec{\omega}$ = angular velocity

$\therefore \vec{v} = \vec{\omega} \times \vec{r}$ _______**(1) marks**

or

Calculus method

i. Let a particle is moving in XY plane with position vector,

$\vec{r} = r\,\hat{i}\cos\omega t + r\,\hat{j}\sin\omega t$ .....(i)

ii. Angular velocity is directed as perpendicular to plane i.e., along Z-axis

It is given by $\vec{\omega} = \omega\hat{k}$

Where $\hat{k}$ = unit vector along Z - axis

iii. $\vec{\omega}\times\vec{r} = \omega\hat{k}\times\left(r\hat{i}\cos\omega t + r\hat{j}\sin\omega t\right)$ [From equation (i)] _______**(1) marks**

$= \omega r\cos\omega t.\left(\hat{k}\times\hat{i}\right) + \omega r\sin\omega t.\left(\hat{k}\times\hat{j}\right)$

$= \omega r\ \hat{j}\cos\omega t + \omega r\left(-\hat{i}\right)\sin\omega t$

$\therefore\ \vec{\omega}\times\vec{r} = -r\omega\ \hat{i}\sin\omega t + \omega r\ \hat{j}\cos\omega t$

$\therefore\ \vec{\omega}\times\vec{r} = r\omega\left(-\hat{i}\ \sin\omega t + \hat{j}\cos\omega t\right)$ ......(ii)

Also $\vec{v} = \dfrac{d\vec{r}}{dt} = r\left(-\omega\hat{i}\sin\omega t + \omega\hat{j}\cos\omega t\right)$

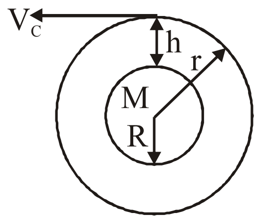
$= r\omega\left(-\hat{i}\sin\omega t + \hat{j}\cos\omega t\right)$ ......(iii)

From (ii) and (iii)

$\therefore\ \vec{v} = \vec{\omega}\times\vec{r}$ _______**(1) marks**

Topic:Circular motion; Sub-Topic:UCM_ L-1 _Target-2016_ XII-HSC Board Test___Physics

(ii)



(i) Let,
M = mass of the earth
R = radius of the earth
h = height of the satellite from the earth's surface
m = mass of the satellite
Vc = critical velocity of the satellite in the given orbit
r = (R + h) = radius of the circular orbit

(ii) For the circular motion of the satellite, the necessary centripetal force is given as

$$F_{cp} = \frac{mv_c^2}{r} \quad .....(i)$$

(iii) The Gravitational force of attraction between the earth and the satellite is given by

$$F_G = \frac{GMm}{r^2} \quad ....(ii)$$

(iv) Gravitational force provides the centripetal force necessary for the circular motion of the satellite

$\therefore\ F_{CP} = F_G$

$\therefore\ \dfrac{mv_c^2}{r} = \dfrac{GMm}{r^2}$ [From (i) and (ii)] _______**(1) marks**

$\therefore\ v_c^2 = \dfrac{GM}{r}$

$$v_c^2 = \sqrt{\frac{Gm}{r}} \quad ....(iii)$$

(v) But r = R + h

$$\therefore v_c = \sqrt{\frac{GM}{(R+h)}} \quad ...(iv)$$

$$\text{Also GM} = gh = (R+h)^2$$

$$\therefore v_c = \sqrt{g_h(R+h)} \quad .....(v)$$ _______**(1) marks**

Equation (iv) and (v) represent critical
velocity of satellite orbiting at a certain height above the earth surface

Topic:Gravitation; Sub-Topic:Critical velocity_ L-1 _Target-2016_ XII-HSC Board Test___Physics

(iii) Expression for kinetic energy of rolling body :

i. Let,
Mass = mass of the body
v = linear velocity of the body
ω = angular of inertia
I = moment of inertia
K = radius of gyration

ii. K.E. of rolling body = translational K.E. + rotational K.E.

$$K.E_{rolling} = \frac{1}{2}Mv^2 + \frac{1}{2}I\omega^2$$

$$= \frac{1}{2}Mv^2 + \frac{1}{2}MK^2\left[\frac{v^2}{r^2}\right]$$ _______**(1) marks**

$$\left[\because I = MK^2 \text{ and } v = r\omega\right]$$

$$\therefore K.E_{rolling} = \frac{1}{2}Mv^2\left[1 + \frac{K^2}{r^2}\right]$$ _______**(1) marks**

Since the value of 'K' is different for different. Bodies K_1, E_1 also varies from body to body

Topic:Rotional motion; Sub-Topic:Rolling motion _ L-1 _Target-2016_ XII-HSC Board Test _Physics

(iv) **Emissive power**

The emissive power of a body at a given temperature is defined as the quantity of radiant energy emitted by the body per unit surface area of the body at that temperature **(1) marks**

Coefficient of emission

The ratio of the emissive power of a body at a given temperature to the emissive power of a perfectely black body at the same temperature is called coefficient of emission (emissivity) of the body. _______**(1) marks**

Topic:Kinetic theory of gases; Sub-Topic:Emissive power and Emissivity_ L-1 _Target-2016_ XII-HSC Board Test _Physics

(v) $r = 5cm = 5\times10^{-2}\ m$

$n = 90\,r.p.m = \left(\frac{90}{60}\right) r.ps | \omega = 2\pi = \frac{3}{2}\times 2\pi = 3\pi\, rad/s$

$\therefore\ m r \omega^2 = \mu mg$ _____**(1/2) marks**

$\therefore r\omega^2 = \mu g$

$\mu = r\omega^2/g = \frac{5\times10^{-2}\times(3\pi)^2}{9.8} = \frac{5\times9\pi^2\times10^{-2}}{9.8}$ ________**(1) marks**

$= \frac{5\times9\times(3.14)^2\times10^{-2}}{9.8}$

$\mu = 0.4527$ ________**(1/2)marks**

Topic:Circular motion; Sub-Topic:Centripetal force_ L-2 _Target-2016_ XII-HSC Board Test _Physics

(vi) Fundamental frequency of an air coloumn in pipe closed at one end

$n = \frac{V}{4L_1}$

third overtone of an open pipe $n = 4\left(\frac{V}{2L_2}\right)$ _______**(1) marks**

$\therefore \frac{V}{4L_1} = 4\left(\frac{V}{2L_2}\right)$

$\therefore \frac{L_1}{L_2} = \frac{2}{16} = \frac{1}{8}$ ________**(1) marks**

Topic:Stationary wave; Sub-Topic:Air columns_ L-2 _Target-2016_ XII-HSC Board Test _Physics

(vii) $T = 6.28$ sec.

Pathlength $= 20$ cm $\therefore\ a = 10\,cm = 10\times10^{-2} m$

$v = ?$ and $x = 6\times10^{-2} m$

$\omega = \frac{2\pi}{T} = \frac{2\times3.14}{6.28} = 1\,rad/s$ ________**(1/2) marks**

$v = \pm\omega\sqrt{(100-36)\times10^{-4}}$

$= 1\times8\times10^{-2}$ ________**(1) marks**

$v = 8\times10^{-2} m/s$ ________**(1/2) marks**

Topic:Oscillation; Sub-Topic:SHM_ L-2 _Target-2016_ XII-HSC Board Test _Physics

(viii) $E = 5\pi T$

Formula $E = T.\Delta A$ ________**(1/2) marks**

$5\pi T = T.\Delta A$

$\therefore \Delta A = 5\pi$

$4\pi r^2 = 5\pi$

$r^2 = \frac{5}{4} \quad \therefore r = \sqrt{\frac{5}{4}}$ ________(1) marks

$d = 2 \times r = 2 \times \sqrt{\frac{5}{4}} = \sqrt{5}$

$d = 2.23\,\text{cm}$ ________(1/2) marks

Topic:Surface tension; Sub-Topic:Surface energy _ L-2 _Target-2016_ XII-HSC Board Test _Physics

Q.2

(i) (D)

Velocity $= v$; Diameter = D. $\therefore$ radius $= \frac{D}{2}$

Angular displacement (θ) $\quad \omega = \frac{\theta}{t}$

$v = r \times \omega$

$v = \frac{D}{2} \times \frac{\theta}{t}$

$\therefore \boxed{\theta = \frac{2vt}{D}}$

Angular displacement $(\theta) = \frac{2vt}{D}$

Topic:Circular motion; Sub-Topic:Angular displacement _ L-1 _Target-2016_ XII-HSC Board Test _Physics

(ii) (B)

$W_1 < W_2$

Force is same

$\therefore k_1 x_1 = k_2 x_2 \quad ...(1)$

$k_1 > k_2 \quad \therefore x_1 < x_2 \quad ...(2)$

Work done $W = \frac{1}{2} k x^2$

$W_1 = \frac{1}{2} k_1 x_1^2 = \frac{1}{2} k_1 x_1 \times x_1 \qquad W_2 = \frac{1}{2} k_2 x_2 \times x_2$

From equation (1) & (2)

$\therefore W_1 < W_2$

Topic:Oscillation; Sub-Topic:Work done by spring _ L-1 _Target-2016_ XII-HSC Board Test _Physics

(iii) (A)

Four times that of A

$r_A = 2 r_B$

$stress = \frac{F}{A}$

$\therefore stress \propto \frac{1}{r^2}$

$\therefore \frac{stress_A}{stress_B} = \frac{r_B^2}{r_A^2}$

$\therefore stress\ of\ B = \frac{r_A^2}{r_B^2} \times stress\ of\ A$

$= \frac{4r_B^2}{r_B^2} \times stress_A$

$\therefore$ stress on $B = 4$ stress on A

Topic:Elasticity; Sub-Topic:Stress _ L-1 _Target-2016_ XII-HSC Board Test _Physics

(iv) (D)

π radian

Sound waves reflected by denser medium. There is a phase change of π radian.

Topic:Wave motions; Sub-Topic:Reflection of sound waves _ L-1 _Target-2016_ XII-HSC Board Test _Physics

(v) (B)

$n_1\sqrt{\frac{\sigma-1}{\sigma}}$

Frequency of vibration of wire n_2

$\frac{n_2}{n_1} = \sqrt{\frac{\sigma-1}{\sigma}}\ as\ \frac{T_1}{T_2} = \frac{\sigma}{\sigma-1}\ and\ \frac{n_2}{n_1} = \sqrt{\frac{T_2}{T_1}}$

Topic:Stationary waves; Sub-Topic:Resonance _ L-1 _Target-2016_ XII-HSC Board Test _Physics

(vi) (C)

$C_v = (3+f)R$

$C_p = (4+f)R$

$\therefore \gamma = \frac{4+f}{3+f}$ for polyatomic gas.

Topic:Kinetic theory of gases; Sub-Topic:Specific heat _ L-1 _Target-2016_ XII-HSC Board Test _Physics

(vii) (C)

3 m/s

Moment of Inertia $I = 5\,kg\,m^2$

$\omega = 6\ rad/s$ $m = 20\,kg$

$\frac{1}{2}I\omega^2 = \frac{1}{2}mv^2$

$5 \times 36 = 20 \times v^2$

$v^2 = \frac{5 \times 36}{20} = 9$

$v = 3\,m/s$

Topic:Rotational motion; Sub-Topic:Kinetic energy _ L-1 _Target-2016_ XII-HSC Board Test _Physics

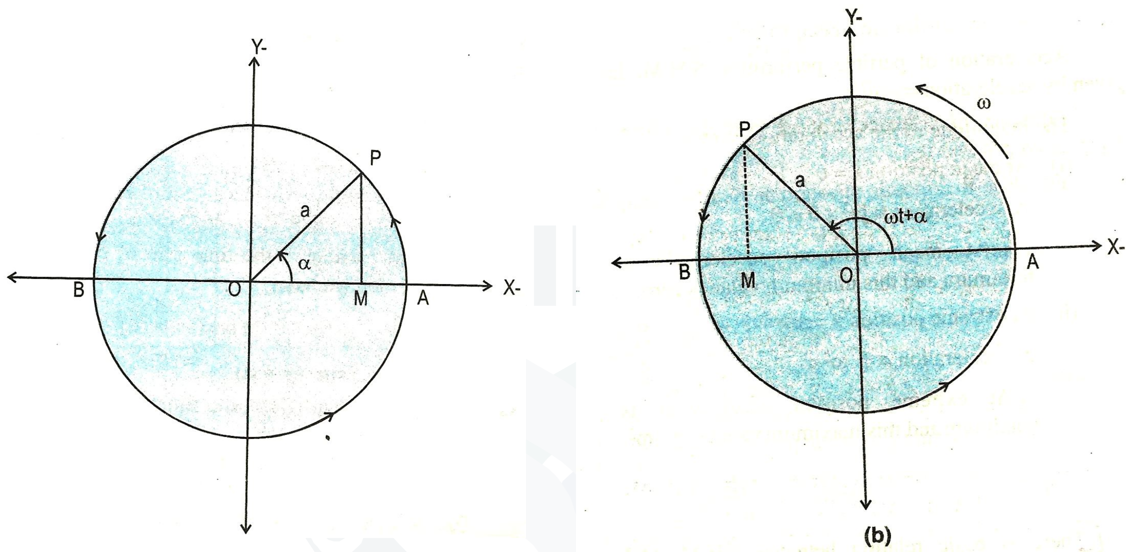
Q.3.

Linear S.H.M. is defined as the linear periodic motion of a body, in which the resorting force (or acceleration) is always directed towards the mean position and its magnitude is directly proportional to the displacement from the mean position. **[1 MARK]**

There is basic relation between S.H.M. and U.C.M. that is very useful in understanding S.H.M. For an object performing U.C.M. the projection of its motion along any diameter of its path executes S.H.M.

Consider particle 'P' is moving along the circumference of circle of radius 'a' with constant angular speed of ω in anticlockwise direction as shown in figure.

Particle P along circumference of circle has its projection particle on diameter AB at point M. Particle P is called reference particle and the circle on which it moves, its projection moves back and forth along the horizontal diameter, AB.



[1 mark]

The x–component of the displacement of P is always same as displacement of M, the x–component of the velocity of P is always same as velocity of M and the x–component of the acceleration of M.

Suppose that particle P starts from initial position with initial phase α (angle between radius OP and the x–axis at the time t = 0) In time t the angle between OP and $x-$axis is $(\omega t+\alpha)$ as particle P moving with constant angular velocity (ω) as shown in figure.

$$\cos(\omega t+\alpha)=\frac{x}{a}$$

$$\therefore x=a\cos(\omega t+\alpha)........(i)$$ **[1 MARK]**

This is an expression for displacement of particle M at time t.

As velocity of particle is the time rate of change of displacement then we have

$$v=\frac{dx}{dt}=\frac{d}{dt}\left[a\cos(\omega t+\alpha)\right]$$

$$\therefore V=-a\omega\sin(\omega t+\alpha)$$

As acceleration of particle is the time rate of change of velocity, then we have

$$\text{acceleration} = \frac{dv}{dt} = \frac{d}{dt}\left[-a\omega\sin\left(\omega t+\alpha\right)\right]$$

$$\therefore \text{ acceleration} = -a\omega^2\cos\left(\omega t+\alpha\right)$$

$$\therefore \text{ acceleration} = \omega^2 x$$ **[1 MARK]**

It shows that acceleration of particle M is directly proportional to its displacement and its direction is opposite to that of displament. Thus particle M performs simple harmonic motion but M is projection of particle performing U.C.M. hence S.H.M. is projection of U.C.M. along a diameter, of circle.

Topic:Oscillation; Sub-Topic:SHM_ L-2 _Target-2016_ XII-HSC Board Test _Physics

$\frac{d\theta_1}{dt} = 4^0 C/\min$ at $\theta_1 = 50^0 C$ $\theta_0 = 25^0 C$

$\frac{d\theta_2}{dt} = ?$ at $\theta_2 = 45^0 C$

According to Newtons law of colling

$$\frac{d\theta}{dt} = K\left(\theta-\theta_0\right)$$ **[1 MARK]**

$$\frac{d\theta_1}{dt} = k\left(\theta_1-\theta_0\right) \text{ and } \frac{d\theta_2}{dt} = k\left(\theta_2-\theta_0\right)$$

$$\frac{\frac{d\theta_1}{dt}}{\frac{d\theta_2}{dt}} = \frac{\theta_1-\theta_0}{\theta_2-\theta_0} = \frac{50^0-25^0}{45^0-25^0} = \frac{25^0}{20^0}$$ **[1 MARK]**

$$\frac{d\theta_2}{dt} = \frac{20^0}{25^0}\times\frac{d\theta_1}{dt}$$

$$\frac{d\theta_2}{dt} = \frac{20^0}{25^0}\times 4 = \frac{16}{5} = 3.2$$

$$\frac{d\theta_2}{dt} = 3.2^0 C/\min$$ **[1 MARK]**

Topic:Kinetic theory of gases; Sub-Topic:Newton's law of cooling_ L-2 _Target-2016_ XII-HSC Board Test _Physics

OR

Q.3

Formation of stationary waves by analytical method :

(i) Consider two identical progressive waves travelling along X axis in opposite direction. They are given by

$y_1 = A\sin\frac{2\pi}{\lambda}(vt - x)$ along positive X-axis ....(i)

$y_2 = A\sin\frac{2\pi}{\lambda}(vt + x)$ along negative X-axis ...(ii)

(ii) The resultant displacement 'y' is given by the principle of superposition of waves.

$y = y_1 + y_2 \qquad ...(iii)$

$y = A\sin\frac{2\pi}{\lambda}(vt - x) + A\sin\frac{2\pi}{\lambda}(vt + x)$ **[1 MARK]**

(iii) By using sin C + sin D

$= 2\sin\left[\frac{C+D}{2}\right]\cos\left[\frac{C-D}{2}\right],$

we get

$y = 2A\sin\left[\frac{2\pi}{\lambda}\left(\frac{vt - x + vt + x}{2}\right)\right]\cos\left[\frac{2\pi}{\lambda}\left(\frac{vt - x - vt - x}{2}\right)\right]$

$= 2A\sin\left(\frac{2\pi vt}{\lambda}\right)\cos\left(\frac{2\pi}{\lambda}(-x)\right)$

$\therefore\ y = 2A\sin 2\pi nt\cos\left(\frac{2\pi x}{\lambda}\right)\left(\because\ n = \frac{v}{\lambda}\right)$

$\left[\because\ \cos(-\theta) = \cos\theta\right]$

$\therefore\ y = 2A\cos\left(\frac{2\pi x}{\lambda}\right)\sin 2\pi nt$ **[1 MARK]**

(iv) $Let\ R = 2A\cos\left(\frac{2\pi x}{\lambda}\right)$

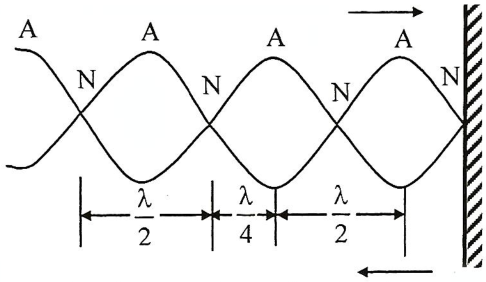
$\therefore\ y = R\sin(2\pi nt) \qquad ...(iv)$

$But\ \omega = 2\pi n$

$\therefore\ y = R\sin\omega t \qquad ...(v)$

Equation (v) represents the equation of S.H.M. Hence, the resultant wave is a S.H.M. of amplitude R which varies with x.

(v) The absence of x in equation (v) shows that the resultant wave is neither travelling forward nor backward. Therefore it is called stationary waves.



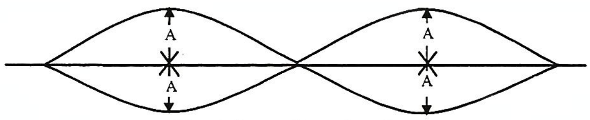
Position of nodes and antinodes on stationary wave

Position of antinodes :

The points of a medium, which vibrate with maximum amplitude are called antinodes.

Since $R = 2A\cos\left(\frac{2\pi x}{\lambda}\right)$

At antinode: $R = \pm 2A$



Position of antinodes

$\therefore \cos\left(\frac{2\pi x}{\lambda}\right) = \pm 1$

$\therefore \left(\frac{2\pi x}{\lambda}\right) = 0, \pi, 2\pi, 3\pi, ...n\pi$

$\therefore x = 0, \frac{\lambda}{2}, \lambda, \frac{3\lambda}{2} ....$

$\therefore$ Distance between two consecutive antinodes $= x_1 - x_0 = \frac{\lambda}{2}, x_2 - x_1$

$= \lambda - \frac{\lambda}{2} = \frac{\lambda}{2}$ and so on. **[1 MARK]**

Thus distance between two successive antinodes is $\lambda/2$.

Nodes :

The pairs of medium, which vibrate with minimum amplitude are called nodes.

Amplitude at node is minimum i.e. 0.

$\therefore R_{\min} = 0$

Since, $R = 2A\cos\left(\frac{2\pi x}{\lambda}\right)$

$\therefore \cos\left(\frac{2\pi x}{\lambda}\right) = 0$

$\therefore \frac{2\pi x}{\lambda} = \frac{\pi}{2}, \frac{3\pi}{2}, \frac{5\pi}{2}, ...$

$\therefore x = \frac{\lambda}{4}, \frac{3\lambda}{4}, \frac{5\lambda}{4}, ...$

Distance between two consecutive nodes,

$x_1 - x_0 = \frac{3\lambda}{4} - \frac{\lambda}{4} = \frac{\lambda}{2},$

$x_2 - x_1 = \frac{5\lambda}{4} - \frac{3\lambda}{4} = \frac{\lambda}{2}$ and so on.

Thus distance between two successive nodes is $\frac{\lambda}{2}$. **[1 MARK]**

Hence nodes and antinodes are equispaced. The distance between nodes and adjacent antinode is $\frac{\lambda}{4}$.

Topic:Stationary wave; Sub-Topic:Formation of stationary wave_ L-2 _Target-2016_ XII-HSC Board Test _Physics

$n_1 = 1.5\, n_{48}$. beat frequency = 4 Hz, the set of tunning forks is arranged in series of decending frequencies.

$n_2 = n_1 - 4$

$n_3 = n_2 - 4 = n_1 - 2 \times 4$

$n_4 = n_3 - 4 = n_1 - 3 \times 4$

$n_{48} = n_{47} - 4 = n_1 - 47 \times 4 = n_1 - 188$ **[1 Mark]**

But $n_1 = 1.5\, n_{48}$

$\therefore n_{48} = 1.5 n_{48} - 188$

$\therefore (1.5 - 1) n_{48} = 188$ **[1 Mark]**

$\therefore 0.5\, n_{48} = 188$

$n_{48} = \frac{188}{0.5} = \frac{188}{1/2} = 376\,\text{Hz}$

$\therefore n_1 = 1.5 \times 376$ **[1 Mark]**

$n_1 = 564\,\text{Hz}$

$n_{42} = n_1 - 4 \times 41$

$= 564 - 164$

$n_{42} = 400\ Hz$

Topic:Stationary wave; Sub-Topic:Formation of beats_ L-2 _Target-2016_ XII-HSC Board Test _Physics

Q.4

(i) $m = 600$ kg

$d = 5000$ m $= 5$ km

$g_d = g\left(1 - \frac{d}{R}\right)$ **[1 Mark]**

$= g\left(1 - \frac{5}{6400}\right)$

$g_d = 9.8 \times 0.999$

$g_d = 9.7902\ m/s^2$ **[1 Mark]**

weight on surface $= mg$

$= 600 \times 9.8$

$= 5880\ N$

weight at depth 5000m $= mg_d$

$= 600 \times 9.7902$

$= 5874\ N$

$\therefore$ decrease in weight $= mg - mg_d$

$= 5880 - 5874$

decrease in weight $= 6\ N$ **[1 Mark]**

Topic:Gravitation; Sub-Topic:Change in g due to depth_ L-2 _Target-2016_ XII-HSC Board Test _Physics

(ii) **Principle of parallel axes :**

The moment of inertial of a body about any axis is equal to the sum of its moment of inertia about a parallel axis passing through its centre of mass and the product of its mass and the square of the perpendicular distance between the two parallel axes.

Mathematically, $I_O = I_C + Mh^2$

where I_O = M. I of the body about any axis passing through centre O.

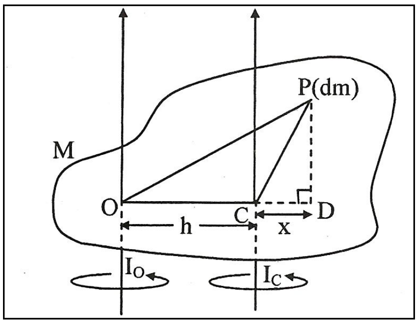
I_C = M. I of the body about parallel axis passing through centre of mass.

h = distance between two parallel axes. **[1 mark]**

Proof :

i. Consider a rigid body of mass M rotating about an axis passing through a point O as shown in the figure.

Let C be the centre of mass of the body, situated at distance h from the axis of rotation.



ii. Consider a small element of mass dm of the body, situated at a point P.

iii. Join PO and PC and draw PD perpendicular to OC when produced.

iv. M. I of the element dm about the axis through O is $(OP)^2$ dm

$\therefore$ M.I of the body about the axis thorugh O is given by

$I_O = \int (OP)^2\, dm$ ...(1)

v. M.I of the element dm about the axis through c is CP^2 dm

$\therefore$ M.I of the body about the axis through C

$$I_C = \int CP^2 dm \qquad ...(2)$$

vi. From the figure,

$$OP^2 = OD^2 + PD^2$$

$$= (OC + CD)^2 + PD^2$$

$$= OC^2 + 2OC.CD + CD^2 + PD^2$$

$\because \quad CP^2 = CD^2 + PD^2$

$\therefore \quad OP^2 = OC^2 + 2OC.CD + CP^2 \qquad ...(3)$ **[1 Mark]**

vii. From equation (1)

$$I_O = \int OP^2 dm$$

From equation (3)

$$I_O = \int \left(OC^2 + 2OC.CD + CP^2\right) dm$$

$$\therefore \quad I_O = \int \left(h^2 + 2hx + CP^2\right) dm$$

$$= \int h^2 dm + \int 2h.xdm + \int CP^2 dm$$

$$= h^2 \int dm + 2h \int xdm + \int CP^2 dm$$

$$I_O = h^2 \int dm + 2h \int xdm + I_C$$

[From equation (2)]

$$\therefore \quad I_O = I_C + h^2 \int dm + 2h \int x \, dm \qquad ...(4)$$

viii. Since $\int dm = M$ and $\int x \, dm = 0$ and

algebraic sum of the moments of the masses of its individual particles about the centre of mass is zero for body in equilibrium.

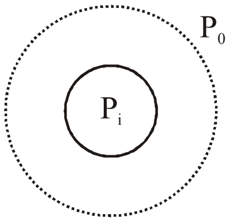
$\therefore$ Equation (4) becomes

$$I_O = I_C + Mh^2$$

Hence proved. **[1 Mark]**

Topic:Rotational motion; Sub-Topic:Theorem of parallel axes_ L-2 _Target-2016_ XII-HSC Board Test _Physics

(iii) Expression for excess pressure inside a drop :



i. Free surface of drops or bubbles are spherical in shape.
Let,
P_i = Inside pressure of a drop or air bubble
P_0 = outside pressure of bubble
r = radius of drop or bubble.

ii. Let the radius of drop increases from r to $r + \Delta r$ so that inside pressure remains constant.

iii. Initial area of drop $A_1 = 4\pi r^2$,

Final surface area of drop $A_2 = 4\pi(r + \Delta r)^2$

Increase in surface area

$$\Delta A = A_2 - A_1 = 4\pi\left[(r + \Delta r)^2 - r^2\right]$$

$$= 4\pi\left[r^2 + 2r\Delta r + \Delta r^2 - r^2\right]$$

$$= 8\pi r\Delta r + 4\pi\Delta r^2$$ **[1 Mark]**

iv. As Δr is very small

$\therefore$ term containing Δr^2 is neglected

$\therefore \quad \Delta A = 8\pi r\Delta r$

v. Work done by force of surface tension

$$dW = T\Delta A = (8\pi r\Delta r)T \quad \text{...(1)}$$

But $dW = F\Delta r = (P_i - P_0)A\Delta r$ **[1 Mark]**

From equation (1)

$$(P_i - P_0)A\Delta r = (8\pi r\Delta r)T$$

$$\therefore \quad P_i - P_0 = \frac{8\pi r\Delta rT}{4\pi r^2\Delta r} \qquad \left[\therefore A = 4\pi r^2\right]$$

$$\therefore \quad P_i - P_0 = \frac{2T}{r} \quad \text{...(2)}$$

Equation (2) represents excess pressure inside a drop or air bubble. It is also called Laplace's law of spherical membrane. **[1 Mark]**

Topic:Surface tension; Sub-Topic:Pressure in bubble_ L-2 _Target-2016_ XII-HSC Board Test _Physics

(iv) $A = 1.5\ mm^2 = 1.5 \times 10^{-3} \times 10^{-3}$

$A = 1.5 \times 10^{-6}\ m^2$

$Y = 2 \times 10^{11}\ N/m^2$ F = load

$\sigma = 0.291$ Lateral strain $= 1.5 \times 10^{-5}$

$g = 9.8\ m/s^2$

$$\sigma = \frac{\text{Lateral strain}}{\text{longitudinal strain}}$$

$$\text{longitudinal strain} = \frac{1.5\times10^{-5}}{0.291}$$ **[1 Mark]**

$$Y = \frac{\text{longitudinal stress}}{\text{longitudinal strain}} = \frac{Mg/\pi r^2}{\ell/L}$$

$$M = \frac{Y \times \text{longitudinal strain} \times \pi r^2}{g}$$ **[1 Mark]**

$$M = \frac{2\times10^{11}\times1.5\times10^{-5}\times\text{Area}}{0.291\times9.8}$$

$$M = \frac{2\times10^{11}\times1.5\times10^{-5}\times1.5\times10^{-6}}{0.291\times9.8}$$

$$= \frac{4.5\times10^{11}\times10^{-11}}{9.8\times291} = \frac{4.5}{2.852} = \frac{4.5}{2.852}$$

$M = 1.578$ kg **[1 Mark]**

Topic:Elasticity; Sub-Topic:Young's modulus_ L-2 _Target-2016_ XII-HSC Board Test _Physics

SECTION - II

Q.5

(i) The bending of light near the edge of an obstacle or slit and spreading into the region of geometrical shadow is called diffraction of light.

There are two types of diffraction:

(a) **Fresnel diffraction:** Diffraction pattern in which source of light and the screen are kept at finite distance from the diffracting system is called fresnel diffraction e.g. diffraction of straight edge, small opaque disc, narrow rectangular slit, etc. **[1 mark]**

(b) **Fraunhofer diffraction:** Diffraction pattern in which the source of light and the screen are effectively at infinite distances from the diffracting system, is called Fraunhofer diffraction.

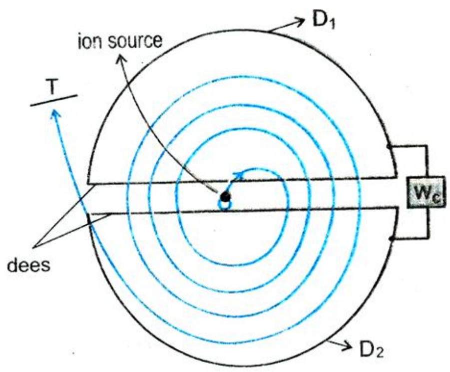
In this diffraction pattern, convex lens is used. **[1 mark]**

Example: Diffraction due to a single slit, double slit using a plane wavefront.

In Fresnel diffraction, spherical or cylindrical wavefronts are used whereas in Fraunhofer diffraction, plane wavefronts are used.

Topic:Interference and Diffraction; Sub-Topic:Diffraction_ L-1 _Target-2016_ XII-HSC Board Test_Physics

(ii)



[2 marks]

Cyclotron

Topic:Magnetic effect of electric current; Sub-Topic:Cyclotron_ L-1 _Target-2016_ XII-HSC Board Test_Physics

(iii) **1/2 mark each**

No.	Paramagnetic substance	Ferromagnetic substance
(i)	It is weakly attracted by a magnet	It is strongly attracted by a magnet
(ii)	When kept in a non-uniform magnetic field, it shows moderate tendency to move from weaker to the stronger part of the field	When kept in a non-uniform magnetic field, it shows strong tendency to move from weaker to the stronger part of the field.
(iii)	When kept in an external magnetic field it becomes weakly magnetised, and the direction of magnetic moment acquired will be same as that of the field.	When kept in an external magnetic field it becomes strongly magnetised, and the direction of magnetic moment acquired will be same as that of the field.
(iv)	When the external magnetic field is removed, the paramagnetic substance loses its magnetism.	When the external magnetic field is removed, the ferromagnetic substance retains magnetism permanently

Topic:Magnetism_; Sub-Topic:Magnetic substances_ L-1 _Target-2016_ XII-HSC Board Test___Physics

(iv) **Definition :**

When the electromagnetic waves (radiowaves) from the transmitting antenna propagate along the surface of the earth so as to reach the receiving antenna, the wave propagation is called ground wave propagation (surface wave propagation). **[1 mark]**

Explanation :

(i) Ground waves are the radiowaves which propagate along the surface of the earth.

(ii) There is loss of power in a signal during its propagation on the surface of the earth due to partial absorption of energy by ground. Hence ground wave propagation is suitable for low frequency and medium frequency. It is used for local broadcasting.

(iii) Ground wave propagation is possible only when the transmitting and receiving antenna are close to the earth's surface. **[1 mark]**

Topic:Communication system_; Sub-Topic:Wave propagation; L-1 _Target-2016_ XII-HSC Board Test___Physics

(v) **Given,** $G = 500\Omega$, $R_P = 21\Omega$ **[1/2 marks]**

$\therefore$ using $R_P = \dfrac{G.S}{G+S}$ **[1/2 marks]**

$\{\therefore$ G and S are in parallel combination in an ammeter$\}$

$\therefore$ $21 = \dfrac{500S}{500+S} \Rightarrow 21(500+S) = 500S$

$\Rightarrow$ $10500 + 21S = 500S$

$\Rightarrow$ $500S - 21S = 10500$ **[1/2 marks]**

$\Rightarrow$ $479S = 10500$

$\Rightarrow$ $S = \dfrac{10500}{479}\Omega = 21.92\Omega$

$\therefore$ shunt resistance is 21.92Ω **[1/2 marks]**

Topic:Magnetic effect of electric current; Sub-Topic:Ammeter_ L-2 _Target-2016_ XII-HSC Board Test___Physics

(vi) **Given,** $T_1 = 200K$, $\chi_1 = 1.8\times10^{-5}$

$\chi_1 - \chi_2 = 6\times10^{-6} = 0.6\times10^{-5}$ **[1/2 mark]**

$\Rightarrow \chi_2 = \chi_1 - 0.6\times10^{-5}$

$= 1.8\times10^{-5} - 0.6\times10^{-5} = 1.2\times10^{-5}$

$\Rightarrow \chi_2 = 1.2\times10^{-5}$

$\because \chi.T = \text{constant}$ **[1/2 mark]**

$\therefore \chi_1 T_1 = \chi_2 T_2 \Rightarrow T_2 = \left(\dfrac{\chi_1}{\chi_2}\right)T_1 = \left(\dfrac{1.8\times10^{-5}}{1.2\times10^{-5}}\right)\times 200K$ **[1/2 mark]**

$\Rightarrow T_2 = 300K$ **[1/2 mark]**

Topic:Magnetism_; Sub-Topic:Paramagnetic substances_ L-1 _Target-2016_ XII-HSC Board Test___Physics

(vii) **Given** $M = 2H,\ dI = -4A,\ dt = 2.5\times10^{-4}s$ **[1/2 mark]**

Using $\phi = MI$

$\therefore$ emf induced $= -\frac{d\phi}{dt} = -M\frac{dI}{dt}$ **[1/2 mark]**

$= 2\times\frac{4}{2.5\times10^{-4}}V$ **[1/2 mark]**

$\therefore \varepsilon = 32,000V = 32kV$ **[1/2 mark]**

Topic:Electro magnetic induction; Sub-Topic:Mutual induction_ L-1_Target-2016_ XII-HSC Board Test___Physics

(viii) **Given:** $\lambda = 4.33\times10^{-4}$ per year **[1/2 mark]**

$\therefore$ half life $= T_{1/2} = \frac{0.693}{\lambda}$ **[1/2 mark]**

$= \frac{0.693}{4.33\times10^{-4}}$ year

$= 0.16\times10^{4}$ year

= 1600 year

$= 0.16\times10^{4}\times365$ days

= 584000 days **[1 mark]**

Topic:Atom molecule Nuceli; Sub-Topic:Radio activity_ L-2 _Target-2016_ XII-HSC Board Test___Physics

Q.6

(i) (d)

$\because i_p = \tan^{-1}\mu \quad \therefore \mu = \tan(i_p) = \tan 60° = \sqrt{3}$

Topic:Wave theory of light_; Sub-Topic:Brewster's law_ L-1 _Target-2016_ XII-HSC Board Test___Physics

(ii) (c)

$R.P = \frac{a}{1.22\lambda}$ where a is aperture (diameter) of objective

Topic:_Interference and Diffraction_; Sub-Topic:Telescope _ L-1 _Target-2016_ XII-HSC Board Test___Physics

(iii) (b)

$E = \frac{1}{4\pi\epsilon_0 k}\cdot\frac{Q}{r^2}$

$\therefore E \propto \frac{1}{k}$

Topic:Electrostatics; Sub-Topic:Application of Gauss law_ L-1 _Target-2016_ XII-HSC Board Test___Physics

(iv) (a)

The internal resistance (r) of a cell is measured by potentiometer using the formula

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

Topic:_Current electricity; Sub-Topic:Application of potentiometer_ L-1 _Target-2016_ XII-HSC Board Test___Physics

(v) (d)

Energy of photon, $E = hv = hc/\lambda$

Topic:Electron and photons; Sub-Topic:Photoelectric effect_ L-1 _Target-2016_ XII-HSC Board Test___Physics

(vi) (b)

The ouput of NOR gate is one only if both inputs are zero, otherwise the output is zero.

Topic:Semi-conductor; Sub-Topic:Logic gates_ L-1_Target-2016_ XII-HSC Board Test___Physics

(vii) (c)

The process of superimposing a low frequency signal on a high frequency wave is called modulation.

Topic:Communication system_; Sub-Topic:Modulation_ L- 1 _Target-2016_ XII-HSC Board Test___Physics

Q.7

Transformer :

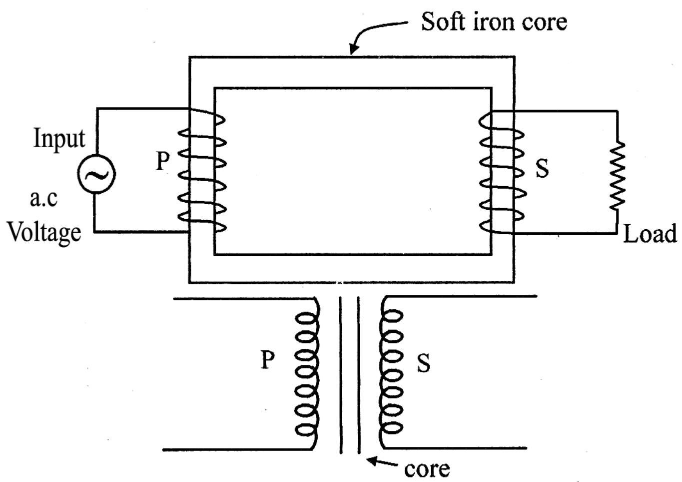
Transformer is an electrical device which converts low alternating voltage at high current to high alternating voltage at low current and vice-versa.

Principle : **[1/2 mark]**

It is based on the principle of mutual induction i.e. whenever the magnetic flux linked with a coil changes, an e.m.f. is induced in the neighbouring coil.

Construction : **[1 mark]**

i. A transformer consists of two sets of coils P and S insulated from each other. The coil P is called the primary coil and coil S is called the secondary coil.
ii. The two coils are wound separately on a laminated soft iron core.
iii. The a.c. input voltage is applied across the primary and the induced output a.c voltage is obtained across the secondary, which is used to drive current in the desired circuit.
iv. The two coils are electrically insulated from each other but they are magnetically linked.
v. To minimise eddy currents the soft iron core is laminated.



[1 mark]

Working **[1 mark]**

i. When an alternating voltage is applied to the primary coil the current through the coil goes on changing.

Hence the magnetic flux through the core also changes.

ii. As this changing magnetic flux is linked with both the coils, an e.m.f. is induced in each coil.

iii. The amount of the magnetic flux linked with the coil depends upon the number of turns of the coil.

iv. Let 'ϕ' be the magnetic flux linked per turn with both the coils at certain instant 't'.

v. Let 'N_p' and 'N_s' be the number of turns of primary and secondary coil,

$N_P\phi$ = magnetic flux linked with the primary coil at certain instant 't'

$N_S\phi$ = magnetic flux linked with the secondary coil at certain instant 't'

vi. Induced e.m.f. produced in the primary and secondary coil is given by

$$e_P = -\frac{d\phi_p}{dt} = -N_P\frac{d\phi}{dt} \quad ...(I)$$

$$e_S = -\frac{d\phi_s}{dt} = -N_S\frac{d\phi}{dt} \quad ...(II)$$

vii. Divide equation (II) and (I)

$$\therefore \frac{e_S}{e_P} = \frac{N_S}{N_P} \quad ...(III)$$

Equation (III) represents equation on transformer.

The ratio $\frac{N_S}{N_P}$ is called turns ratio (transformer ratio) of the transformer.

viii. For an ideal transformer,

Input power = Output power

$$\therefore e_P I_P = e_S I_S$$

$$\therefore \frac{e_S}{e_P} = \frac{I_P}{I_S} \quad ...(IV)$$

ix. From equation (III) and (IV)

$$\frac{e_S}{e_P} = \frac{N_S}{N_P} = \frac{I_P}{I_S}$$ **[1/2 mark]**

Topic:EMI_; Sub-Topic:Transformer_ L- 2 _Target-2016_ XII-HSC Board Test___Physics

Given: $A = 40\ cm^2 = 40 \times 10^{-4} m^2$

$Q = 0.2\ \mu C = 2 \times 10^{-7}\ C$

$\epsilon_0 = 8.85 \times 10^{-12}\ Wb/A-m$

$\therefore$ Surface charge density, $\sigma = \frac{Q}{A} = \frac{2 \times 10^{-7}\ C}{40 \times 10^{-4} m^2}$

$\therefore \sigma = 5 \times 10^{-5}\ C/m^2$ **[1 mark]**

$\therefore$ Electric field intensity, $E = \frac{\sigma}{\epsilon_0}$

$= \frac{5 \times 10^{-5}\ C/m^2}{8.85 \times 10^{-12}\ Wb/A-m}$

$= 5.65 \times 10^6 \, N/C$ **[1 mark]**

and Mechanical force acting per unit area

$$\frac{dF}{dA} = f = \frac{1}{2} \epsilon_0 E^2 = \frac{1}{2} \times 8.85 \times 10^{-12} \times \left(5.65 \times 10^6\right)^2$$

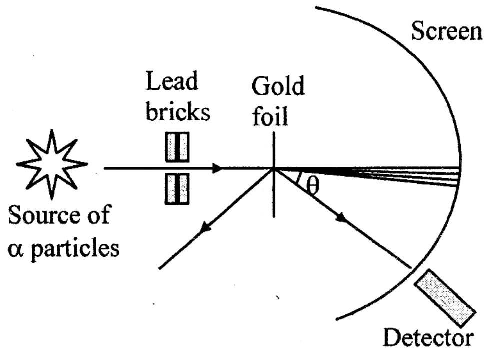
$= 141.26 \, N/m^2$ **[1 mark]**

Topic:Electrostatics_; Sub-Topic:Mechanical force_ L- 2 _Target-2016_ XII-HSC Board Test___Physics

OR

Geiger-Marsden experiment :

i. The experimental arrangement is as shown in figure.



[1 mark]

ii. In this experiment a narrow beam of α- particles from radioactive source was incident on a gold foil.

iii. The scattered α- particles were detected by the detector fixed on rotating stand. Detector used had zinc sulphide screen and microscope.

iv. α- particles produced scintillations on screen which could be observed through microscope.

v. The whole setup is enclosed in an evacuated chamber. **[1 mark]**

Observations :

i. Most of the α- particles passed undeviated.

ii. Only few (about 0.14%) scattered by more than 1°.

iii. Some α- particles were deflected slightly and very few (1 in 8000) deflected by more than 90°.

iv. Some α- particles were bounced back with $\theta = 180°$. **[1 mark]**

Mass defect : The difference between the actual mass of the nucleus and the sum of masses of consistuent nucleons is called mass defect.

Let,

M = Measured mass of nucleus

A = mass number

Z = atomic number

m_p = mass of hydrogen atom

m_a = mass of free neutron

(A – Z) = number of neutrons

$\therefore$ Mass defect

$\Delta m = [Zm_p + (A-Z)m_n] - M$ **[1 mark]**

Topic:Atoms, molecules and Nuclei_; Sub-Topic:Geiger Marsden experiment, Mass defects_ L- 2 _Target-2016_ XII-HSC Board Test___Physics

Given : $\phi_0 = 2.3eV = 2.3 \times 10^{-19} J$

$\lambda = 6800 \, \mathring{A} = 6.8 \times 10^{-7} \, m$ **[1/2 mark]**

$$\therefore \nu_0 = \frac{\phi_0}{h} = \frac{2.3 \times 1.6 \times 10^{-19}}{6.63 \times 10^{-34}}$$

$\therefore \nu_0 = 5.55 \times 10^{14}\ Hz$ **[1 mark]**

Incident frequency, $\nu = \frac{c}{\lambda} = \frac{3 \times 10^8}{6.8 \times 10^{-7}}$

$\therefore\ \nu = \frac{3}{6.8} \times 10^{15} = 4.412 \times 10^{14}\ Hz$ **[1 mark]**

$\because\ \nu < \nu_0$

$\therefore$ There will be no emission of photoelectrons. **[1/2 mark]**

Topic:Electrons and photons_; Sub-Topic:Photoelectric effects_ L- 2 _Target-2016_ XII-HSC Board Test___Physics

Q.8

(i) **Given:** ${}^a\mu_g = 1.5$, $\nu = 3.5 \times 10^{14}\ Hz,$ **[1/2 Mark]**

$c = 3 \times 10^8\ m/s$

$\therefore \lambda_a = \frac{c}{\nu} = \frac{3 \times 10^8\ m/s}{3.5 \times 10^{14}\ Hz} = 8.571 \times 10^{-7}\ m$ **[1/2 Mark]**

$\therefore$ using ${}^a\mu_g = \frac{\lambda_a}{\lambda_g}$

$\Rightarrow \lambda_g = \frac{\lambda_a}{{}^a\mu_g} = \frac{8.571 \times 10^{-7}}{1.5} = 5.714 \times 10^{-7}\ m$ **[1/2 Mark]**

$\therefore$ Change in wavelength $= \lambda_g - \lambda_a$

$= \left(5.714 \times 10^{-7} - 8.571 \times 10^{-7}\right)m$

$= -2.857 \times 10^{-7}\ m = -2857\ \mathring{A}$ **[1 Mark]**

Negative sign shows that wavelength decreases as the light passes from air to glass

wave number in glass $= \frac{1}{\lambda_g} = \frac{1}{5.714 \times 10^{-7} m}$

$= 0.175 \times 10^7\ m^{-1} = 1.75 \times 10^6\ m^{-1}$ **[1/2 Mark]**

Topic:Wave theory of light_; Sub-Topic:Refraction of light_ L-2 _Target-2016_ XII-HSC Board Test___Physics

(ii) **Given:** $m = 10,\ x_R = 2.09\, mm = 2.09 \times 10^{-3}\ m$

$\lambda_R = 6400\ \mathring{A} = 6.4 \times 10^{-7}\ m,\ \lambda_B = 4800\ \mathring{A} = 4.8 \times 10^{-7}\ m$ **[1/2 Mark]**

Using: $x = (2m-1)\dfrac{\lambda D}{2d}$ **[1/2 Mark]**

$$x_R = (2m-1)\frac{\lambda_R D}{2d}$$

$$\Rightarrow \frac{D}{d} = \frac{2x_R}{(2m-1)\lambda_R} = \frac{2 \times 2.09 \times 10^{-3} m}{(20-1) \times 6.4 \times 10^{-7} m}$$

$$\Rightarrow \frac{D}{d} = \frac{2 \times 2.09}{19 \times 6.4} \times 10^4$$

$$\Rightarrow \frac{D}{d} = 343.75 \quad ....(i)$$ **[1/2 Mark]**

$\therefore$ fringe width of red light,

$$X_R = \frac{\lambda_R D}{d} = 6.4 \times 10^{-7} m \times 343.75 \quad \{\text{using equation (i)}\}$$

$$\Rightarrow X_R = 2.2 \times 10^{-4} m = 0.22 mm$$

$\therefore$ fringe width of blue light,

$$X_B = \frac{\lambda_B D}{d} = 4.8 \times 10^{-7} m \times 343.75$$

$$\therefore X_B = 1.65 \times 10^{-4} m = 0.165 \ mm$$ **[1/2 Mark]**

$\therefore$ change in fringe width $= X_B - X_R = 0.165 \ mm - 0.22 \ mm$

$= -0.055 \ mm = -55 \ \mu m$

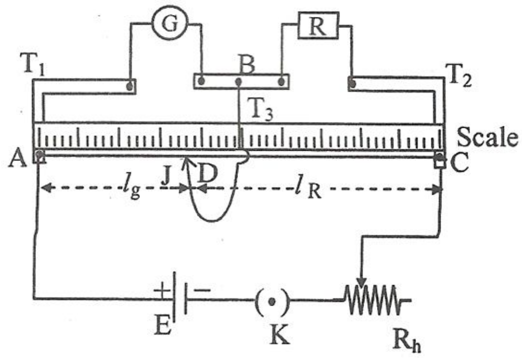
Negative signe indicates that fringewidth decreases by 55 μm. **[1 Mark]**

Topic:Interference and Diffraction_; Sub-Topic:Biprism_ L-2 _Target-2016_ XII-HSC Board Test___Physics

(iii) Kelvin's method to determine the resistance of a galvanometer:

(a) In Kelvin's method, the galvanometer whose resistance is to be determined is connected in the left gap of a meter-bridge and a known resistance R is connected in the right gap.

(b) A jockey is connected directly to the point D and it can slide along the wire.



[1 Mark]

G : Galvanometer

R : Resistance from resistance box

AC: Metal wire one meter long

R_h: Rheostat

E: Cell

K: Plug key

J: Jockey

(c) A cell of e.m.f 'E' is connected between points A and C of the wire in series with a high resistance box.

(d) The rheostat is used to adjust the deflection in the galvanometer to half of its maximum value. Hence, this method is also called half current method or half scale method.

(e) First the deflection in the galvanometer is adjusted at half of its original value and the reading is noted. It acts as null position.

(f) The value of R is adjected, so that the galvanometer gives a fairly large deflection i.e. full scale deflection.

If the jockey is touched to different points on the wire then galvanometer shows increase or decrease in the deflection.

(g) A point D is located on the wire so that when the Jockey is touched at that point, galvanometer shows the same deflection as before. It means that point D and B are at the same potential i.e. bridge is balanced.

(h) Let,

l_g = length of the wire corresponding to left gap.

l_R = length of wire corresponding to right gap

G = resistance of galvanometer

(i) In the balanced condition,

$$\frac{\text{G}}{\text{R}} = \frac{\text{Resistance of wire of length } l_g}{\text{Resistance of wire of length } l_R}$$

$$\therefore \frac{G'}{R} = \frac{\sigma l_g}{\sigma l_R} = \frac{l_g}{l_R}$$

where,

σ = resistance per unit length of wire

$$\therefore\ G = R\frac{l_g}{l_R}$$

(j) since $l_g + l_R = 100\,cm$

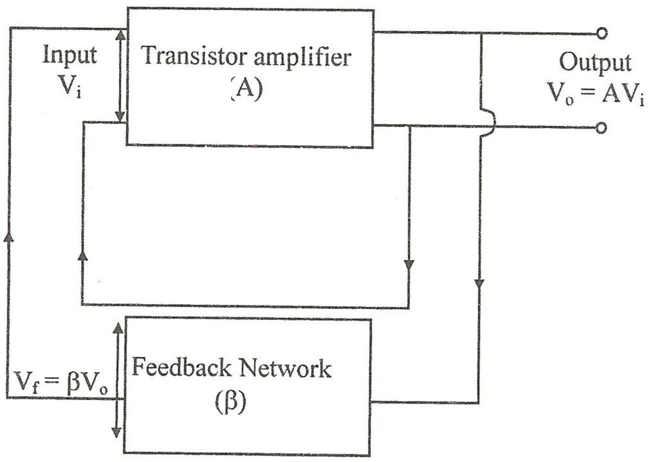
$$\therefore l_R = \left(100 - l_g\right)$$

$$\therefore G = R\left(\frac{l_g}{100 - l_g}\right)$$

Measuring l_g and R we can easily determine value of G. **[2 Marks]**

Topic:Current electricity_; Sub-Topic:Kelvin method_ L-2 _Target-2016_ XII-HSC Board Test___Physics

(iv) Principle of working of an oscillator:



[1 Mark]

(i) A simple oscillator consists of an amplifier and feedback network with frequency determining components.
(ii) A frequency-determining network, (resonant tank circuit) which also works as feedback network and transistor amplifier acts as element.
(iii) With enough feedback, the oscillations start as soon as the circuit is switched on.
(iv) With positive feedback, the output current of the amplifier will be in the right phase to increase the alternating current in the resonant circuit.
(v) The oscillations then built up in amplitude until the power losses in the circuit are equal to the power that the amplifier can develop.
(vi) The natural frequency of the oscillator is close to the resonant frequency of the resonant circuit.
(vii) Suppose the voltage gain without feedback of the amplifier is $A = \frac{V_o}{V_i}$.
(viii) The feedback factor β is the fraction the output voltage fed back to the input $V_i = V_f = \beta V_o$

$$\therefore \qquad A = \frac{V_o}{V_i} = \frac{1}{\beta}$$

$$\therefore \qquad A\beta = 1$$

(ix) The condition $A\beta = 1$, is called. Berkhausen's criterion. It states that the phase shift of the feedback voltage will be zero or integral multiple of 2π radian i.e. there will be positive feedback.

(x) The voltage gain of complete system is given by $A_f = \frac{A}{1 - A\beta}$

Thus, for the frequency for which $A\beta = 1, A_f$ will be infinite, i.e. the circuit will operate without any external signal voltage, which means the circuit will oscillate at that frequency. **[2 Mark]**

Topic:Semi-conductor_; Sub-Topic:Oscillators_ L-2 _Target-2016_ XII-HSC Board Test___Physics