Guru Aanklan

Grand Test	HSC Examination Physics Code - Set - A	SOLUTIONS

SECTION- A

Marks 8

1. (A) quantum of light energy (1)
2. (B) common emitter configuration (1)
3. (C) $10\pi^2 \text{cm}/\text{s}^2$ (1)
4. (C) amount of gas (1)
5. Stopping potential (Cut off potential) :
   i. The minimum negative potential given to collector plate for which photoelectric current stops or becomes zero is called stopping or cut off potential. It is denoted by V_O.
   ii. When the stopping potential is sufficient to repel most energetic photoelectrons with the maximum kinetic energy, photoelectric current becomes zero. (1/2)
   iii. At this stage $\frac{1}{2}mv_{\max}^2 = eV_0$

   When m = mass of electron
   e = magnitude of charge on electron

   $$\therefore \quad V_0 = \frac{1}{2e}mv_{\max}^2$$

   $$\therefore \quad V_0 = \frac{1}{e} \times K.E_{\max}$$ (1/2)

6. Given : Radius of big drop, R = 6 mm
   Radius of smaller drop, r = 1 mm

   To find : Number of droplets, n = ?

   Formula : $$\text{Number of droplets} = \frac{\text{Volume of big drop}}{\text{Volume of small drop}}$$

   Calculation : Volume of big drop

   $$V_1 = \frac{4}{3}\pi R^3$$

   Volume of each small drop $V_2 = \frac{4}{3}\pi r^3$

   From formula

$$n = \frac{V_1}{V_2} = \frac{\frac{4}{3}\pi R^3}{\frac{4}{3}\pi r^3}$$ (1/2)

$$\therefore \quad n = \left(\frac{R}{r}\right)^3 = \left(\frac{6}{1}\right)^3$$

$$\therefore \quad n = 216$$ (1/2)

7. **Curie's law :**

Magnetization of a paramagnetic sample is directly proportional to the external magnetic field and inversely proportional to the absolute temperature. (1/2)

Mathematically,

$M_z \propto B_{ext}$ and $M_Z \propto \frac{1}{T}$ (1/2)

$\therefore \quad M_Z \propto \frac{B_{ext}}{T}$

$\therefore \quad M_Z = C \times \frac{B_{ext}}{T}$ C = Curie's constant

8. i. To produce linear motion in a body, the unbalanced force is applied to overcome its inertia. In this case inertia of a body is called the mass, which depends upon the amount of matter concentrated in the body.
ii. The relation between mass, force and linear acceleration is given by
F = ma ......(1)
iii. To produce rotational motion in a body an unbalanced torque is applied to overcome its inertia. In this case inertia of a body is called the rotational inertia or moment of inertia (l)
iv. The relation between moment of inertia, torque and angular acceleration is given by
$\tau = 1\alpha$ ....(2)
v. Using equation (1) and (2), it is concluded that, the moment of inertia plays same role in rotational motion as the mass of the body does in linear motion. (1/2)

SECTION - B **Marks 14**

9. (½ mark each point)

Fresnel diffraction	Fraunhoffer diffraction
Source of light and screen are kept at finite distance.	Source of light and screen are at infinite distance.
Spherical or cylindrical wave fronts considered.	Only plane wave fronts are considered.
It is observed in straight edge, narrow slit etc.	It is observed in single slit, double slit etc.
Lenses are not used.	Convex lenses are used.

10. i. The phenomenon of emission of electrons by certain substance (metals) when they are exposed to radiation of suitable frequency is called as photoelectric effect. (1)
ii. The emitted electrons are called photoelectrons and resulting current in the circuit due to them is called photoelectric current.
iii. When ultraviolet light on the emitter plate, electrons are ejected from it which are attracted towards positive collector plate by the electric field. Thus light falling on the surface of emitter causes current in the external circuit.

iv. Certain metals like zinc, cadmium, magnesium, etc responded only to ultraviolet light, having short wavelength, which leads to causing electron emission from the metals surface.

v. However some alkali metals such as lithium, sodium, potasium, caesium and rubidium are sensitive to visible light. All photo sensitive substances emit electrons when they are illuminated by light. (1)

11. Given: $\phi_1 = 0,\ \phi_2 = 6\times10^{-2}Wb,\ t = 2\text{ sec}$

to find: Average e.m.f, e = ?

Formula: $e = \frac{d\phi}{dt} = \frac{\phi_2 - \phi_1}{dt}$ (1/2)

Calculation: From formula

$$e = \frac{6\times10^{-2} - 0}{2} \quad (1)$$

$\therefore$ $e = 3\times10^{-2}$ volt (1/2)

12. (1 mark each for any 2 point)

Sr.	AM	FM
1.	Alternation in amplitude of the desired signal amounts to marked distortion.	Noise can be easily minimized in FM system. (1/2)
2.	In AM, use of an excessively large modulating signal may result in distortion because of over modulation.	No restriction is placed on the modulation index. The instantaneous frequency deviation is proportional to instantaneous magnitude of the signal. (1/2)
3.	The average power in modulated wave is greater than that contained in unmodulated carrie wave.	The average power in frequency modulated wave is the same as that contained in the unmodulated wave. (1/2)

13. Given: $\frac{W_1}{W_2} = \frac{81}{1}$

To find: $\frac{a_1}{a_2} = 2$

Formula: $\frac{W_1}{W_2} = \frac{I_1}{I_2} = \frac{a_1^2}{a_2^2}$ (1/2)

Calculation: From formula:

$$\frac{81}{1} = \frac{a_1^2}{a_2^2} \quad (1/2)$$

$\therefore$ $\frac{a_1}{a_2} = \frac{9}{1};$

$\therefore$ $a_1 : a_2 = 9:1$ (1)

14. i. **Donor impurity :** Every pentavalent dopant atom has tendency to donate one electron for conduction, such atom is called donor impurity. (1)

ii. **Acceptor impurity :** Trivalent impurity has tendency to accept any electron in its close vicinity, such atom is called acceptor impurity. (1)

15. i. The temperature at which the domain structure is destroyed and the ferromagnetic substance looses its magnetism is called Curie temperature. (1)

ii. Above the Curie temperature, a ferromagnetic substance is converted into paramagnetic substance. The Curie temperature is different for different substances. (1/2)

Sr.	Substances	Curie temp.in K
1.	Cobalt (CO)	1394
2.	Iron (Fe)	1043
3.	Nickel (Ni)	631
4.	Gadolinium (Gd)	317

(1/2)

OR

15. **Properties of diamagnetic substances : (Any 4 Proper (1/2 M) Each)**

i. If a thin rod of a diamagnetic material is suspended freely in an external uniform magnetic field, it comes to rest with its length perpendicular to the direction of the field.

ii. These materials when placed in an external non-uniform magnetic field, it tend to move from the stronger part of the field to the weaker part of the field.

iii. In the absence of external magnetic field, the net magnetic moment of diamagnetic substances is zero.

iv. Diamagnetic substances loose their magnetism on removal of external magnetic field.

v. If a watch-glass containing a small quantity of a diamagnetic liquid is placed on two dissimilar magnetic poles, the liquid shows a depression in the middle.

vi. If a magnetic field is applied to diamagnetic liquified in one arm of U-tube, the liquid level in that arm is lowered.

vii. If a diamagnetic gas is introduced between the pole-pieces of a magnet, it spreads at right angles to the magnetic field.

SECTION - C **Marks 33**

16. Given : $n = 50$ Hz, $v = 350$ m/s,
$x = 7$m, $t = 0.005$ second

To find : i. $\delta_1 = ?$
ii. $\delta_2 = ?$

Formula : $$\delta = \frac{2\pi x}{\lambda} = 2\pi nt$$ (1/2)

Calculation : Since, $\lambda = \frac{v}{n}$

$$\lambda = \frac{350}{50} = 7\text{m}$$ (1/2)

From formula

$$\delta_1 = \frac{2\pi \times 7}{7} = 2\pi \text{ rad}$$

$\therefore$ $$\delta_1 = 2\pi \text{ rad}$$ (1/2)

From formula

$$\delta_2 = 2\pi \times 50 \times 0.005$$ (1/2)

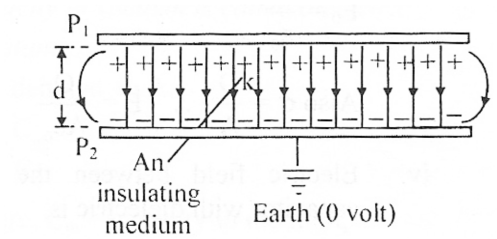
$$= \frac{2\pi \times 50 \times 5}{1000}$$

$\therefore \quad \delta_2 = \frac{\pi}{2}$ rad (1)

17. **Expression for capacity of a parallel plate capacitor :**

i. A parallel plate capacitor consists of two parallel metal plates P_1 and P_2 seperated by a small distance d.

ii. The space between the plate is filled with a medium of dielectric constant k as shown in the figure.



(1/2)

iii. Plate P_1 is given a charge +Q while plate P_2 is earthed.

iv. Positive charge +Q which is given to plate P_1, induces a negative charge -Q on the inner surface of plate P_2. Positive charge on the outer side of plate P_2 will get earthed because of production of electrostatic repulsive force between two positive charge.

v. As distance d between the two plates is very small as compared to the linear dimensions of the plates,the electric field is produced in the dielectric medium. This field is directed from P_1 in P_2. (1/2)

vi. According to Gauss theorem, magnitude of the electric intensity at a point in the dielectric medium is given by

$E = \frac{\sigma}{K\varepsilon_0}$ ....(1)

Where σ is the magnitude of the surface charge density on either plate.

But $\sigma = \frac{Q}{A}$ ....(2) (1/2)

vii. Since E is uniform between the plates

$\therefore \quad E = \frac{V}{d}$ ....(3) (1/2)

where V = P.D between the plates.

viii. Comparing equation (2) and (3), we have

$$\frac{Q}{k\varepsilon_0 A} = \frac{V}{d}$$

$\therefore \quad \frac{Q}{V} = \frac{k\varepsilon_0 A}{d}$ ....(4) (1/2)

By definition $\frac{Q}{V} = C$ ....(5)

ix. From equation (4) and (5), we have

$C = \frac{k\varepsilon_0 A}{d}$ ....(6) (1/2)

This is required expression for the capacity of a parallel plate capacitor.

x. From equation (6) it is concluded that capacity of a parallel plate capacitor depends on

a. area of plates $\left(C \propto k\right)$

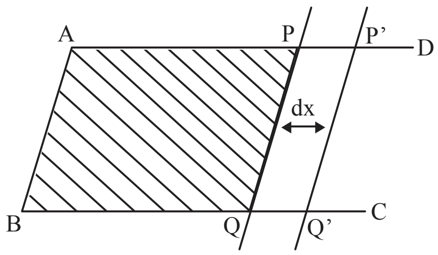
b. Dielectric constant of medium $\left(C \propto k\right)$ and

c. distance of separatation between the two plates $\left(C \propto \frac{1}{d}\right)$

18. **Relation between surface tension and surface energy :**

Surface energy :

i. Let, ABCD in an open rectangular frame of wire on which a wire PQ can slide without friction.



(1/2)

ii. The frame held in horizontal position is dipped into soap solution and taken out, so that a soap film APQB is formed. Due to surface tension of soap solution, a force F will act on the wire PQ which tending to pull it towards AB.

iii. Magnitude of force due to surface tension is, F = 2Tl. [$\because$ T = F/l] 2 is used because soap film has two surfaces which are in contact with wire.

iv. Let the wire PQ is pulled outwards through a small distance dx to the position P'Q', by applying an external force F' equal and opposite to F. Work done by this force, $\Delta W = F'dx = 2T\ell dx$ · (1/2)

v. But $2\ell dx == \Delta A =$ increase in area of two surfaces of film.

$\therefore \Delta W = T\Delta A$ (1/2)

vi. This work done is stored in the form of potential energy (surface energy).

$\therefore$ surface energy , $E = T\Delta A$ (1/2)

$\therefore \quad \frac{E}{\Delta A} = T$ (1)

Hence surface tension = surface energy per unit area.

vii. Thus surface tension is equal to the mechanical work done per unit surface area of the liquid, which is also called as surface energy.

19. For voltmeter V = 150 V and V_g = 0.75 V

$I_g = 15mA = 15\times10^{-3}$ A

$\therefore \quad n = \frac{V}{V_g} = \frac{150}{0.75} = 200$ (1/2)

Also, $G = \frac{V}{V_I} = \frac{0.75}{15\times10^{-3}} = 50\Omega$ (1/2)

$\therefore \quad R = G\left(n-1\right) = 50\left(200-1\right)$

$\therefore \quad R = 9950\ \Omega$ in series (1/2)

For ammeter, I = 25 amp

$I_g = 15\text{mA} = 15 \times 10^{-3}\text{ A}$

$\therefore \quad n = \frac{I}{I_g} = \frac{25}{15 \times 10^{-3}} = 1667$ (1/2)

$G = \frac{G}{n-1} = \frac{50}{1667-1} = \frac{50}{1666} = 0.03\ \Omega$ (1)

$\therefore \quad S = 0.003\ \Omega$ in parallel.

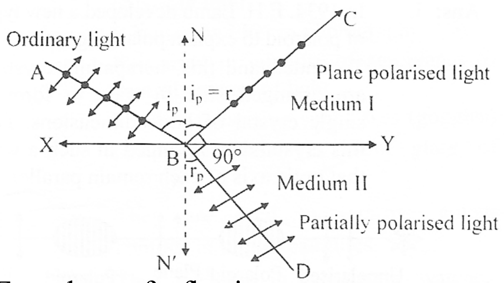
20. i. The motion of a body along the circumference of the circle with constant speed is called uniform circular motion.
ii. In U.C.M direction of velocity is along the tangent drawn to the position of particle on circumference of circle.
iii. Hence direction of velocity goes on changing continuously, however the magnitude of velocity is constant. Therefore magnitude of angular velocity is constant.
iv. Example of U.C.M :
a. Motion of the earth around the sun.
b. Motion of the moon around the earth.
c. Revolution of electron around the nucleus of atom.

Characteristics of U.C.M:
i. It is a periodic motion with definite period and frequency.
ii. Speed of particle remains constant but velocity changes continuously.
iii. It is an accelerated motion.
iv. Work done during the period of U.C.M is zero.

21. **Statement :** The tangent of the polarising angle is equal to the refractive index of the refracting medium at which partial reflection takes place. According to Brewster's law,

$\tan i_p = \mu$.

i. Let XY is the interface of refracting media
AB = incident ordinary light
BD = partially polarised or unpolarised light.
BC = reflected plane polarised light
$\angle NBC$ = reflected polarised angle
$\angle ABN$ = incident polarising angle (1/2)



(1/2)

ii. From laws of reflection

$\angle ABN = \angle NBC$

$\therefore \quad i_p = r \quad$ ......(1)

Also, $\angle CBD = 90^0$

$\therefore \quad r_p + r = 90^o$

$\therefore \quad i_p + r = 90^0 \quad$ (From (1))

$\therefore \quad r_p = 90^0 - i_p$

iii. From Snell's law, (1/2)

$$\frac{\sin i_p}{\sin r_p} = \mu$$

$$\therefore \frac{\sin i_p}{\sin\left(90^0 - i_p\right)} = \mu \quad \text{(From equation (2))}$$

$$\therefore \frac{\sin i_p}{\cos i_p} = \mu$$

$$\therefore \tan i_p = \mu$$

Hence proved. (1)

22.

No.	Elastic	Plastic
1.	Body regains its original shape or size after removal of external force.	Body does not regain its shape or size after removal of external force.
2.	External force changes the dimensions of the body temporarily.	External force changes the dimensions permanently.
3.	Internal restoring force is set up inside the body	Internal restoring force is not set up inside the body.
4.	Ratio of stress and strain remains constant.	Ratio of stress and strain do not remains constant.

(1)

i. Stress is defined as applied force per unit cross sectional area a body.

ii. $$\text{Stress} = \frac{\text{Applied force}}{\text{Area of cross section}}$$ (1)

$$= \frac{\text{Elastic restoring force}}{\text{Area of cross section}} = \frac{F}{A}$$

iii. Unit : N/m^2 or Pa is SI system and $dyne/cm^2$ in CGS system.

iv. Dimension : $[M^1L^{-1}T^{-2}]$ (1)

23. **Weight of a body :**

i. Weight of a body is the gravitational force exerted on it by the earth.

ii. When a man stands on the floor then the floor exerts normal reaction on him equal to his weight, W = N = mg (1)

Weightlessness of a body :

i. A body is said to be in the state of weightlessness if its apperant weight is zero.

ii. The sensation of weightlessness experienced by an astronaut is not the result of zero gravitational acceleration, but there being zero difference between the acceleration of the spacecraft and the acceleration of the astronaut. (1)

Feeling of weightlessness of an astronaut in orbiting satellite :

i. Consider an astronaut of mass m standing on the floor, of a satellite and satellite is moving with constant speed along the orbit.

ii. At the time of orbiting, the satellite as well as the astronaut are attracted towards the centre ofth earth with same centripetal acceleration.

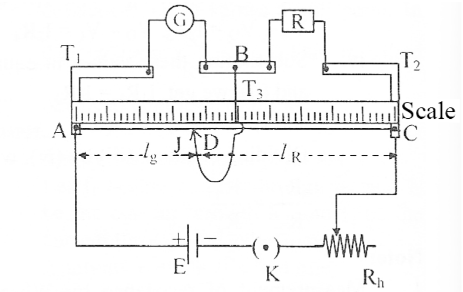
iii. So astronaut is unable to exert weight on the floor of the satellite, in turn satellite does not provide normal reaction on the astronaut. Therefore astronaut feels weightlessness.

iv. If a is centripetal acceleration of the satellite then the force exerted by the wall on the astronaut = N = mg – ma. But a = g. N = mg – mg = 0. hence astroanut feels weightlessness. (1)

24. **Kelvin's method to determine the resistance of a galvenometer :**

i. 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.

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



(1/2)

G : Galvenometer
R : Resistance from resistance box
AC : Metal wire one meter long
R_b : Rheostat
E : Cell
K : Plug key
J : Jockey (1/2)

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

iv. The rheostat is used to adjust the deflection in the galvenometer to half of its maximum value. hence, this method is also called half current method or half scale method.

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

vi. The value of R is adjusted, 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.

vii. 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. (1/2)

viii. Let
l_g = length of the wire corresponding to left gap.
l_R = length of wire corresponding to right gap.
G = resistance of galvanometer

ix. In the balanced condition.

$$\frac{G}{R} = \frac{\text{Resistance of wire of length } l_g}{\text{Resistance of wire of length } l_R}$$ (1/2)

$$\therefore \quad \frac{G}{R} = \frac{\sigma l_g}{\sigma l_R} = \frac{l_g}{l_R}$$ (1/2)

where, σ = resistance per unit length of wire

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

x. Since $l_g + l_R = 100$ cm

$\therefore \quad I_R = (100 - l_g)$

$\therefore \quad G = R\left(\dfrac{l_g}{100 - l_g}\right)$ (1/2)

Measuring l_g and R we can easily determine value of G.

25. Given : $\ell = 1\text{m}, A = 6l^2 = 6(1)^2 = 6\text{m}^2, e = 0.4,$

$\sigma = 5.67 \times 10^{-8}\ \text{J/m}^2\text{sK}^4$

$= 5.67 \times 10^{-8}\ \text{W/m}^2\text{K}^4$

$\dfrac{dQ}{dt} = 3000$ watt (1/2)

To find : $T = ?$

Formula : $\dfrac{dQ}{dt} = \sigma A e T^4$ (1/2)

Calculation : From Formula

$\therefore \quad T^4 = \dfrac{dQ/dt}{\sigma A e}$

$\therefore \quad T^4 = \dfrac{3000}{5.67 \times 10^{-8} \times 6 \times 0.4}$ (1/2)

$= \dfrac{500}{5.67 \times 10^{-8} \times 0.4}$

$T^4 = \dfrac{1000}{5.67 \times 0.8 \times 10^{-8}}$

$\therefore \quad T = \left[\dfrac{1000}{5.67 \times 0.8 \times 10^{-8}}\right]^{1/4}$

$= \left[\dfrac{10000 \times 10^8}{5.67 \times 8}\right]^{1/4} = \left[\dfrac{10^{12}}{45.36}\right]^{1/4}$ (1)

$\therefore \quad T = 385.3$ K (1/2)

26. Given : $V_2 = \dfrac{1}{64} V_1, T_1 = 24$ hours

To find : $T_2 = ?$

Formula : $I_1\omega_1 = I_2\omega_2$ (1/2)

Calculation : From formula

$\dfrac{2}{5} MR_1^2 \times \dfrac{2\pi}{T_1} = \dfrac{2}{5} MR_2^2 \times \dfrac{2\pi}{T_2}$

$\therefore \quad \dfrac{T_2}{T_1} = \left(\dfrac{R_2}{R_1}\right)^2$ .....(1) (1/2)

Now, $V_2 = \frac{1}{64}V_1$

$\therefore$ $\frac{4}{3}\pi R_2^3 = \frac{1}{64}\left(\frac{4}{3}\pi R_1^3\right)$

$\therefore$ $\left(\frac{R_2}{R_1}\right)^3 = \frac{1}{64}$

$\therefore$ $\frac{R_2}{R_1} = \left(\frac{1}{64}\right)^{1/3}$

$\therefore$ $\frac{R_2}{R_1} = \frac{1}{4}$ (1/2)

From equation (1),

$T_2 = \left(\frac{R_2}{R_1}\right)^2 \times T_1 = \left(\frac{1}{4}\right)^2 \times 24$ (1/2)

$= \frac{1}{16} \times 24 = \frac{3}{2}$ hours ;

$\therefore$ $T_2 = 1.5$ hours (1/2)

OR

26. Given : $M = 3kg, l = 2m, n_1 = 0, t = 10s$

$n_2 = 900 r.p.m = \frac{900}{60} = 15$ r.p.m

To find : $\tau = ?$ (1/2)

Formula : $\tau = 2\pi l\left(\frac{n_2 - n_1}{t}\right)$

Calculation : Since M.I of rod , $I = \frac{Ml^2}{12}$ (1/2)

From formula

$\therefore$ $\tau = 2\pi \frac{Ml^2}{12} \times \left(\frac{n_2 - n_1}{t}\right)$ (1/2)

$= 2\pi \frac{3 \times 2^2}{12} \times \left(\frac{15 - 0}{10}\right) = 3\pi$ (1)

$\therefore$ $\tau = 3 \times 3.14 = 9.42$ Nm (1/2)

SECTION - D **Marks 15**

27. **Application of eddy currents :** (1/2)

i. Dead beat galvanometer :

When a galvenometer is used for measuring current, the coil is wound on a light aluminium frame to make it dead beat i.e. to bring the coil quickly to rest. This is because the motion of the metal frame in the magnetic field gives rise to eddy current in the frame. The eddy current opposed the motion and brings the coil to rest quickly.

ii. Induction motor (speedometer): (1/2)

Eddy currents are used to know the speed of any vehicle. A pointer shows the speed on a calibrated scale. Speedometer consists of a strong magnet, kept rotating according to the speed of the vehicle. A magnet is rotated in an aluminium drum, pivoted by means of spring. Eddy currents are produced in the drum. The drum turns in the direction of the rotating magnet. A pointer attached to the drum indicates the speed of the vehicle on a caliberated scale.

iii. Electric Brake (Induction brake) : (1/2)

When the light is to be stopped, the power supplied to rotate the axle is switched off. At the same time, a stationary magnetic field is applied to the rotating drum giving rise to strong eddy currents in the drum. These eddy currents produces a torque which opposes the rotation of the drum and hence the axle. Thus train is brought to rest quickly and smoothly.

iv. Induction furnace : (1/2)

The metal, which is to be melted, is placed in a huge crucible. High frequency alternating current is allowed to flow through the coil. As a result, a rapidly variable magnetic field is produced which provide very strong eddy currents. Heat which is produced in this process is enough to melt the entire block of metal in short time. This method is generally used to make alloys of different metals is vacuum.

Given : $V = 50$ volt, $m_p = 1.673 \times 10^{-27}$ kg

to find : $\lambda = ?$

Formula : $\lambda = \dfrac{h}{\sqrt{2m_p eV}}$ (1/2)

Calculation : From formula

$$\lambda = \frac{6.63 \times 10^{-34}}{\sqrt{2 \times 1.673 \times 10^{-27} \times 1.6 \times 10^{-19} \times 50}} \quad (1/2)$$

$$= \frac{6.63 \times 10^{-34}}{\sqrt{1.673 \times 1.6 \times 10^{-44}}} \quad (1/2)$$

$$= \frac{6.63 \times 10^{-34} \times 10^{22}}{\sqrt{1.673 \times 1.6}} \quad (1)$$

$\therefore$ $\lambda = 0.04052 \times 10^{-10}$ m

$\therefore$ $\lambda = 0.04052$ A.U (1/2)

OR

27.

Sr.	Step-up transformer	Step-down transformer
1.	The number of turns in its secondary is more than that in its primary ($N_S > N_P$)	The number of turns in primary is greater than secondary ($N_P > N_S$).
2.	Alternating voltage across the ends of its secondary is more than that across its primary i.e. $e_S > e_P$	Alternating voltage across the ends of the primary is more than that across its secondary i.e. $e_p > e_S$
3.	Transformer ratio K > I	Transfomer ratio K < 1
4.	Primary coil made of thick wire.	Secondary coil made of thin wire.
5.	Secondary coil is made of thin wire.	Primary coil is made of thin wire
6.	Current through secondary is less than primary.	Current through primary is less than secondary.

(Any 4 points (1/2 M) each points)

Given : $p = n_1 = 3, \quad n = n_2 = 4$

To find : $\lambda_L = ?$

Formula : $$\frac{1}{\lambda_L} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$ (1/2)

Calculation : From formula

$$\frac{1}{\lambda_L} = R\left[\frac{1}{3^2} - \frac{1}{4^2}\right]$$ (1/2)

$$\therefore \quad \frac{1}{\lambda_L} = R\left[\frac{1}{9} - \frac{1}{16}\right]$$

$$= R\left[\frac{16-9}{9\times16}\right]$$

$$= \frac{1.907\times10^7\times7}{9\times16}$$ (1/2)

$$\therefore \quad \lambda_L = \frac{9\times16}{1.097\times7}\times10^{-7}$$ (1)

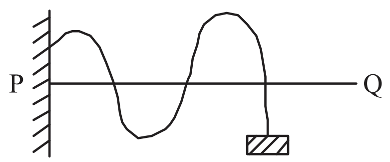
$$= 18.752\times10^{-7}\,\text{m}$$

$$\therefore \quad \lambda_L = 18750 \text{ A.U}$$ (1/2)

28. **Velocity of transverse wave along a stretched string :**

i. Consider a string of length 'l' fixed at point P from a rigid boundary. String is stretched by applying load at the other end Q.

ii. Let,
   l = length of string
   m = linear density of the string
   T = tension applied between P and Q
   v = velocity of the transverse wave along the stretched string



(1/2)

iii. If the string is plucked at right angles to its length then transverse progressive waves travel along the string.

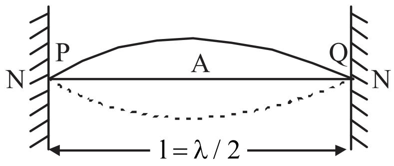
iv. Velocity of this wave is given by $v = \sqrt{\frac{T}{m}}$ (1/2)

Expression for frequency in fundamental mode of vibration :

i. Consider a string stretched between two riding supports as shown in the figure. When string is plucked, it starts vibrating.

ii. Due to interference between incident and reflected transverse wave, stationary waves are formed on the string. Nodes (N) are formed at the end and antinodes (A) are formed at the centre as shown in the figure.

iii. Let,
l = length
n = frequency of vibration
λ = wavelength
v = velocity of wave



(1/2)

iv. Velocity of transverse wave is given by

$$v = \sqrt{\frac{T}{m}} \quad .....(1)$$

$$\therefore \quad n\lambda = \sqrt{\frac{T}{m}} \quad (\because v = n\lambda)$$

$$\therefore \quad n = \frac{1}{\lambda}\sqrt{\frac{T}{m}} \quad ......(2)$$ (1/2)

$$\because \quad l = \frac{\lambda}{2}$$

$$\therefore \quad \lambda = 2l \quad ......(3)$$ (1/2)

From equation (2) and (3)

$$n = \frac{1}{2l}\sqrt{\frac{T}{m}} \quad ....(4)$$ (1/2)

This is the expression for the fundamental frequency of vibrating stretched string. This frequency is also called first harmonic.

Given: $x = 10$ m $\quad R = ?$

Equation of standing wave

$$y = 0.02\cos\left(\frac{2\pi x}{60}\right)\sin(150\ \pi t)\text{ metre.}$$

To find: $R = ?$

Formula: $y = R.\sin 2\pi nt$ (1/2)

Calculation: Comparing given equation with formula we have,

Amplitude, $R = 0.02\cos\left(\frac{2\pi x}{60}\right)$ (1/2)

$$= 0.02 \times \cos\left(\frac{360 \times 10}{60}\right)$$ (1/2)

$$\therefore \quad R = 0.01\text{m}$$ (1/2)

OR

28. **Causes** :
End corrections arises because air particles in the plane of the open end of tube are not free to move in all direction, hence reflection take place at the plane small distance outside the tube. (1)

Limitation :

i. Inner diameter of tube must be uniform throughout its length,

ii. Effect of flow of air outside tube is to be neglected.

iii. Effect of temperature of air outside is to be neglected.

iv. Tip of the prong of vibrating tuning fork must be held horizontally (perpendicular to resonance tube) at the centre and at a small distance above open end of the tube. (1)

Given : $T = 1000\text{g wt.} = 1000 \times 10^{-3}\,\text{kg wt.}$

$= 1 \times 9.8\ \text{N} = 9.8\ \text{N},\ v = 68\ \text{m/s},$

$\rho = 7900\ \text{kg/m}^3$

To find : $A = ?$ (1/2)

Formula : $v = \sqrt{\frac{T}{m}}$

Calculation : Since mass of the wire, $M = \rho V = A\ell\rho$

Also, $m = \frac{M}{l} = \frac{A\ell\rho}{l}$

$\therefore$ $m = A\rho$

From formula

$$v = \sqrt{\frac{T}{A\rho}} \quad (1/2)$$

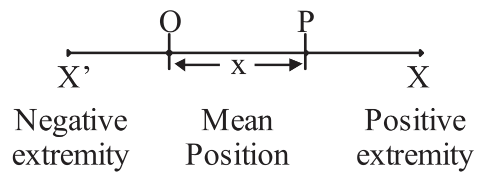
$$\therefore \quad v^2 = \frac{T}{A\rho} \quad (1/2)$$

$$\therefore \quad A = \frac{T}{v^2\rho} = \frac{9.8}{(68)^2 \times 7900} \quad (1)$$

$$\therefore \quad A = 2.683 \times 10^{-7}\,\text{m}^2 \quad (1/2)$$

29. **Conservation of energy in linear S.H.M:**

i. Suppose a particle of mass m performing linear S.H.M is at point P which is at a distance x from the mean position O as shown in figure.



ii. Kinetic energy of particle at point P is given by

$$K.E = \frac{1}{2} m\omega^2 \left(A^2 - x^2\right)$$

iii. Potential energy at point P is given by

$$P.E = \frac{1}{2} m\omega^2 x^2$$

iv. Total energy at point P is given by $T.E = K.E + P.E$

$$= \frac{1}{2}m\omega^2\left(A^2 - x^2\right) + \frac{1}{2}m\omega^2 x^2$$

$$= \frac{1}{2}m\omega^2\left(A^2 - x^2 + x^2\right)$$

$$\therefore \quad T.E = \frac{1}{2}m\omega^2 A^2 \quad ....(1)$$

v. If particle is at mean position :
x = 0

$$\therefore \quad K.E = \frac{1}{2}m\omega^2 A^2$$

$$P.E = \frac{1}{2}n\omega^2\left(0\right)^2 = 0$$

$$\therefore \quad T.E = K.E + P.E = \frac{1}{2}m\omega^2 A^2 \quad ....(2)$$

vi. If particle is at extreme position :
x = A

$$K.E = \frac{1}{2}m\omega^2\left(A^2 - A^2\right) = 0$$

$$P.E = \frac{1}{2}m\omega^2 A^2$$

$$\therefore \quad T.E = P.E + K.E = \frac{1}{2}m\omega^2 A^2 [\ ] \quad ......(3)$$

vii. From equation (1), (2) and (3) it is observed that total enegy of a particle performing linear S.H.M at any point in its path is constant. Hence total energy of linear S.H.M remain conserved.

Let the original length of pendulum be l

$\therefore$ New length $l' = \frac{106}{100}l,$

Change in length

$$\Delta l = l' - l = \frac{6}{100}l$$

$$\because \; T \propto \sqrt{l}$$

$$\because \; T = k\sqrt{l}$$

Differentiating both side we get, $\frac{\Delta T}{T} = \frac{\Delta l}{2l}$

% change in period $= \frac{\Delta T}{T} \times 100\%$

$$= \frac{1}{2}.\frac{\Delta l}{l} \times 100\%$$

$$= \frac{1}{2} \times \frac{6l}{100l} \times 100\%$$

$$= \frac{1}{2} \times 6 = 3\%$$

$\therefore$ Percentage change in period = **3%**

OR

29. i. Consider a particle 'P' is moving along the circumference of a circle of radius 'A' with constant angular speed ω in anticlockwise direction.

ii. At any instant t = 0 particle P has its projection at point M as shown in the figure. Particle P is called as reference particle and the circle on which it moves is called as reference circle.

iii. As reference particle P revolves, its projection moves back and fourth about centre O along the horizontal diameter, BC.

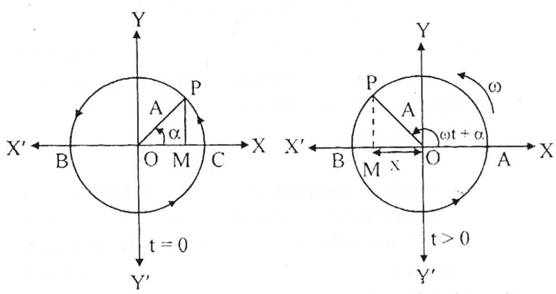


Fig. (a) Fig. (b)

(1/2)

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

v. Suppose that particle P starts initial position with initial phase α. In time t the angle between OP and X axis is $(\omega t+\alpha)$ as shown in the figure b.

vi. In figure b

$\cos(\omega t+\alpha)=\dfrac{x}{A}$, where x = displacement from mean position. (1/2)

$\therefore \quad x = A\cos(\omega t+\alpha)$ ....(1) (1/2)

Equation (1) represents displacement of projection of P at time t.

vii. The velocity of particle is the time rate of change of displacement.

i.g. $v=\dfrac{dx}{dt}=\dfrac{d}{dt}\left[A\cos(\omega t+\alpha)\right]$

$\therefore \quad v=-A\omega\sin(\omega t+\alpha)$ ....(2) (1/2)

Equation (2) represents velocity of projection of P at time t.

viii. The acceleration of particle is the time rate of change of velocity.

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

$\therefore \quad a=-A\omega^2\cos(\omega t+\alpha)$ (1/2)

$\therefore \quad a=-\omega^2 x \quad \left[\because\ x=A\cos(\omega t+\alpha)\right]$

$\therefore \quad a=-\omega^2 x$ ....(3)

Equation (3) represents acceleration of projection of P at time t.

From equation (3) (1/2)

$a\propto -x \qquad [\because\ \omega^2$ = constant quantity]

iv. As acceleration of projection of P is directly proportional to its displacement and its direction is opposite to that of displacement, thus projection of particle P performs simple harmonic motion. But M is projection of partricle P performing U.C.M. Hence S.H.M is the projection of U.C.M along a diameter of circle.

Given: $A_1 = 20\text{cm}, A_2 = 10\text{cm}, \alpha_1 = 0,$

$\alpha_2 = \pi/2$

To find: $R = ?, \ \delta = ?$

Formula: i. $R = \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos(\alpha_1 - \alpha_2)}$

ii. $\tan\delta = \dfrac{A_1 \sin\alpha_1 + A_2 \sin\alpha_2}{A_1 \cos\alpha_1 + A_2 \cos\alpha_2}$

Calculation: From formula (i)

$$R = \sqrt{20^2 + 10^2 + 2\times 20\times 10\cos\left(0 - \frac{\pi}{2}\right)} \quad (1/2)$$

$$= \sqrt{400 + 100 + 400\times 0}$$

$\therefore$ $R = 22.36$ cm (1/2)

Phase of resultant S.H.M. is given by

From formula (ii)

$$\tan\delta = \frac{20\sin 0 + 10\sin\frac{\pi}{2}}{20\cos 0 + 10\cos\frac{\pi}{2}} \quad (1/2)$$

$$= \frac{20\times 0 + 10\times 1}{20\times 1 + 10\times 0} = 0.5$$

$\therefore$ $\delta = \tan^{-1}(0.5)$

$\therefore$ $\delta = 26^\circ\ 33'$ (1/2)

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