CAREERS360

GSEB HSC PHYSICS

Question Papers (All Sets)

Q.1. (A) Answer the following questions in short as asked (5)

1. At which position of the simple hormonic oscillator, will the mechanical energy be four times the potential energy ?
2. Give Unit and dimensional formula of intensity of wave.
3. In order to create very sweet-music, the reverberation time should be ....
4. Linear momentum of one object becomes half the intial linear momentum. Then there will be ....% decrease in its kinetic energy.
5. Give the uitlity of the physical quantity phase.

(B) Answer any three in eight to ten sentences. (6)

1. Write he equation of displacement of S.H.O. with the helpp of differentiation, obtain the equation of velocity in terms of displacement. Write the values and positions of maxmum and minimum velocities.
2. Derive differential equation of forced oscillation with damping.
3. A wave originate at x=0 at t = 0 with initial Phase 'O'. If the wave is sinusiodal derive the equation y = Asin (wt-kx) at time t for a particle lying at distance x =x from the origin.
4. Define position vector of centre of mass, and explain centre of mass of a rigid body ?

(C) Attempt any THREE of the following Problems (9)

1. A spring of length ℓ having its force constant K is cut into two parts. These parts have their length in 4:1 proporotion and their force constants are K_1 and K_2 respectively show that $K_1 = \frac{5k}{4}$ and $K_2 = 5k$..
2. Prove that for a wave Propagating in a medium, the ratio of instantaneous velocity of a particle of the medium to the wave velocity is equal to the negative value of the slope of the waveform at that Point.
3. An atom is executing simple harmonic osceillations with an amplitude of 2.5 $x10^{-7}$ meter one is simultaneously emitting electromagnetic waves. These waves are recorded by a stationary recorder as shown in figure. If the velocity of waves emitted is 3×10^8 m/sec. Find out the maximum and the minimum frequencies as recorded by the recorder. The frequency of the oscillation of the atom is 2×10^{13} Hz. and it is emitting wave of the same frequency. Assume that the equations obtained for the Doppler effect for sound are also valid for electromagnetic waves.

4. A soldier is firing bullets, each having mass of 50 gm, with a speed of 1000 mmet/sec from a machine gun. He can withstand at most an average recoil force of 200 Newton what is the maximum number of bullets he can fire per second ?

Q.2. (A) Answer in Short. (5)

1. Write dimensional equation of torque.
2. What is Geodesic ?
3. Give Max plank's statement of the second law of thermodynamics ?
4. The ratio of temperature of two bodies of same material is 2:3 what is the ratio of their total emissive power ?
5. The ratio of radii of orbits of two artificial satellities is 4:1 what is the ratio of their periods ?

(B) Attempt any THREE of the following Questions. (6)

1. Taking $|\vec{L}| = I\,|\vec{w}|$ for a rotating rigid body drive $\vec{\tau} = I\vec{\alpha}$ and write the law of conservation of angular momentum for it.
2. Define gravitational potential and derive $\phi = \frac{-GM}{r}$
3. Accepting equation $d\varphi = nc_v dT + dW$ for an adiabatic process of an ideal gas derive equation PV^{γ} = constant.
4. Draw the diagram to obtain the parallel axis theorem. Taking I = $\sum miri^2$ & $Ic = \sum m_i r_{ci}^{\ 2}$, using the destance formula deduce the mathematical form of the parallel axis theorem.

(C) Attempt any THREE of the following Problems. (9)

1. A race track having 300m radius of curuature has an inclination of $15°$. If the co-efficient of friction between the surface of the road and that of the race car wheel is 0.2, with what maximum speed can a race car be driven safely on this road ? g = 9.8 m/s^2.
2. Prove that the projectiles thown in directions making equal angles with that of $45°$ to the horizontal direction have equal ranges.
3. A metal rod of 1m length is in a steady thermal state at atmosphereic pressure.

Its one end is placed in water at $100°$c and other end is placed in ice at 0^{o} c. At what distance from its hot end a flame of temperature 2000° c should be placed so that per unit time, same amount of water evaporates at the hot end as the amount of ice melts at cold end ? Latent heat of evaporation of water = 540 cal/gm. Latent heat of melting of ice is 80 cal/gm.

4. A carnot engine is operating between 1000k and 500k. In order to extract work of 210 Joules per cycle from this engine how much heat must be absorbed from the source in each cycle (J = 4.2 joules/cal)

Q.3. (A) Answer in short (5)

1. A circular resistive wire has resistance equal to 10Ω. Then what will be the resistance between any two end points of the diameter ?
2. State Faraday's First law of electrolysis.
3. How much shunt is required to increase the range of Ammeter n times?
4. If the planes of two concentric coils is parpendicular to each other, then what will be the value of the mutual inductance of the system ?
5. The unit of Thomson co.efficient σ is ....

(B) Attempt any three of the following questions. (6)

1. Define 'purallel connection' of resistor. Prove $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ for 3 resistors.
2. On what does the direction of emt in seback effect depend ? What are reference junction and 'test junction'. By keeping reference junction temperature fixed at 0^{o} c. Plot graph $e \rightarrow t$ write emperical formula between e & t.
3. Drive equation $F = q(\vec{V} \times \vec{B})$ for a charge q moving with velocity V in a magnetic field B. Also .write Lorentz force equation.
4. Using Faraday's law obtain $E = -B \ell v$ for a "U" shaped metallic frame placed in a maas field.

(C) Attempt any THREE of the following Problems. (9)

1. A conducting wire has a resistance of 10 ohms. Its length is now stretched to increase by 3% calculate the resulting value of the resistance.
2. For a thermocouple α=14μ $(^{o}c^{-1})$ and β=0.07μ (c^{-2}) find out netural and the inversion temperature.
3. A charge Q is uniformly spread over a disc of radius a made from a non-conducting material. This disc is now rotated about its geometrical axis with

frequency f find the magnetic field generated at the center of the disc.

4. Two solenoids, each of 1.5 meter length and having cross sections such that the larges one just fits outside the smaller one are placed co.axially with their ends matching each other. The smaller solenoid has 1500 turns and the larger one has 500 turns. If the cross sectional area of the smaller solenoid is $15x10^{-4}m^2$, find the mutual inductance of the system where $\mu_0 = 4\pi \times 10^{-7} \frac{T.M.}{A}$

Q.4. (A) Answer in short. (5)

1. When power is transmitted at voltage V and current I, the power loss is x. If voltage is stepped up 5 times then what will be the loss in power ? (in terms of x)
2. What is modulation.
3. "Optic axis of a tourmaline plate is a direction". Do you agree ?
4. The ratio of intensitres of two interfering waves is 1:4 what's the ratio of maximum resultant intensity to the minimum resultant intensity ?
5. V and I in an ac circuit are given by V = 50 sin (100t), I = 50sin (100 t+$\pi/3$) find the power factor.

(B) Answer the following questions (any three) (6)

1. Define the term Real Power for an A.C circuit. Derive the expression for power in case of on A.C. circuit with L-C.R in series.
2. Explain 'Ground wave' with respect to propogation of Electromagnetic Waves.
3. Acepting the expression for path difference $r_2 - r_1 = \frac{dx}{D}$.Obtain the expression for distance between two consecutive bright fringes. Also write the expression for the width of the fringe.
4. Assume a differential equation $\frac{d^2Q}{dt^2}+\frac{R}{L}\frac{dq}{dt}+\frac{Q}{LC}=\frac{V_m \text{coscot}}{L}$ for an A.C. circuit L-C-R in series. Write its complex form obtain the equation for complex charge (q).

(C) Attempt any THRE of the following problems (9)

1. Prove that if voltage obtained from an a.c. source is given by V=Vmsincot, its average value is $\frac{2V_m}{\lambda}$=0.637V_m for a half cycle of the wave.
2. In a series L-C-R circuit L=5 H, C = 80µ F and R = 40 ohm. A.C. of 230V and

variable frequency is applied to this series circuit calculate

1. resonant angular frequency ω_0.
2. impedence of circuit at resonance.
3. Potential drop across inductor V_L.

3. A parallel beam of a monochromatic light is incident normally on a slit having a width of 0.018 cm. The fraunhofer diffraction pattern formed at the focal planes of a lens of focal length 50 cm shows its first order maximum on the either side of the central peak with a separation of 0.45 cm between them. Find the wavelength and light used.
4. In young's dolue slit experiment seperation between the slits is 0.1 mm & a screen is placed at a distance of 1 meter from the slits. Find the seperation between consecutive bright fringes of the width of fringes for light of wavelenth $5000°$A.

Q.5. (A) Answer in short. (5)

1 What is the viscous force acting on stationary oil drop between two plates in Millikan's Experiment.
2. If stopping potential 5V, what is the value of maximum kinetic energy of the emitted electrons.
3. What is the function of moderator in a Nuclear reactor ?
4. .... gives measure of the stability of a nucleus.
5. What is depletion layer ?

(B) Attempt any three. (6)

1. In Thomson's Experiment of determining c/m, assuming $y = \frac{1}{2}\left(\frac{Ee}{m}\right)\frac{\ell^2}{v^2}$ explain with necessary equations, how the velocity of electron can be obtained. Obtain an expression for c/m of an electron.
2. Give the Einstein's Explanation for the photoelectric effect with necessary formula.
3. Asuming the radius of an electron in the n^{th} orbit in hydrogen atom $r = \frac{n^2h^2 \in_0}{\pi m Z_c^{\ 2}}$ obtain the experession for the energy of an electron in nth orbit.
4. Explain the reverse bias connection of PN junction diode with graph.

(C) Attempt any three Examples. (9)

1. Two electron beams have their velocity ratio 1:2. They enters in an uniform magnetic field perpendicular to it. Find the ratio of their deviations (Beams

are in the field for a very short duration)

2. Wavelength of Hα line in hydrogen atom is $6563 A^0$ calculate the wavelength of H_β lines.
3. 1 gm Ra^{226} has an activity of 3.7×10^{10} Becquerel calculate its half lite.
4. In a common emitter N-P-N amplifier if the collector current is changed by 8m A. When input voltage is given 4.0 milivoit, find its transconductance. If input resistance is 1000Ω, find voltage gain.

o-o-o-o-o

SOLUTION

A.1. (A) Answer the following Questions in short.

1. Mechanical energy = 4 (Potential Energy)

$$\therefore \frac{1}{2} KA^2 = 4\left(\frac{1}{2}ky^2\right)$$

$$\therefore A^2 = 4y^2$$

$$\therefore y = \pm A/2$$

At $y = \pm A/2$ Mechanical energy will be four times Potential Energy.

2. Unit of intensity of wave $\frac{Jolues}{(meter)^2.\sec ond} = \frac{Watt}{(meter)^2}$

Dimensional formula of intensity of wave = $M^1L^0T^{-3}$.

3. In order to create very sweet-music, the reverberation time should be less than 0.8 second.

4. Linear momentum of one object becomes half the initial linear momentum. Then there will be 75% decrease in its kinetic energy.

5. One basis of location of reference particle and no. of revolutions made by it before reaching that point the position of the SHO on its path and the no of oscillations can be known through the phase.

(B) Answer any three in eight to ten sentences.

1 Displacement of SHO is

$y = A \sin(\omega t + \phi)$ .... (1)

Differentiating (1) w.r.t. time

$$V = \frac{dy}{dt}$$

$$\therefore \quad V = \frac{dy}{dt}[A\sin(\omega t + \phi)]$$

$$V = A\omega\cos(\omega t + \phi)$$

Here $\cos(\omega t+\phi) = \pm\sqrt{1-\sin^2(\omega t + \phi)}$

$$\therefore \quad V = A\omega\sqrt{1-\sin^2(\omega t + \phi)}$$

$$= \pm A\omega\sqrt{1-y^2/A^2}$$

$$= \pm A\omega\sqrt{A^2 - y^2}$$

Cases :-

1. at y = 0 ie at mean position $\Rightarrow v = \pm A\varpi$ →→ →
2. At $y = \pm A$ (ie. at extreme end points) V = 0.

2. Oscillations under the influence of on external periodic force are called the

"forced oscillation". Let Fosinwt be the external periodic force.
W $\rightarrow$ angular frequency of external periodic force applied to the system.
These oscillations occurs under the following force.

1. Restoring force = -ky
2. Resistive force $=-b\frac{dy}{dt}$=-bv
3. External periodic force = Fosinwt.
   Now according to Newton's 2nd law

$$m\frac{d^2y}{d+z} = -ky - b\frac{dy}{dt} + fo\sin wt$$

$$\frac{d^2y}{d+z} = \frac{-k}{m}y\frac{-b}{m}\frac{dy}{dt} + \frac{Fo}{m}\sin wt$$

writing $\frac{b}{m} = r, \frac{k}{m} = w_o^{\ 2}$ and $\frac{Fo}{m} = a_o$ inabout equation & rearranging it, wege :

$$\frac{d^2y}{dt^2} + r,\frac{dy}{dt} + w_o^{\ 2}y = ao\sin \omega t.$$

3. o o o o o o o
0 1 2 3 4 5 6
|_______________x_______|

As shown in figure consider particles as 1-dimensional, electric medium.

Now at t = 0 suppose a disturbance is produced in such a way that particle at x = 0 starts performing SHM at its mean position with amplitude A & angular frequency ω. Here ϕ=0.

Hence desplacement of purticle at x = 0 is given by

y = Asin (ωt)......(1)

When the wave travels distance x, then 5[th] particle starts erpforming SHM. The phase of successive particles decreases as we go aw2ay from 0. Hence at any time the phase of 5[th] particle is less than the phase of 0, by δ then desplacement of 5th particle can be written as :

y = Asin (ωt-δ) ...(2)

from defination of wavelength.

$$\delta = \frac{2\pi x}{\lambda}$$

substituting value of δ in above eq.

y = Asin (ωt - $\frac{2\pi x}{\lambda}$) ....(3)

but K=$\frac{2\pi}{\lambda}$, K $\rightarrow$ wave vector.

y = A Sin (ωt-kx) ....(4)

4. Defination of Position vector of centre of mess.
For a system made up of n particles, let the position vecotrs of the particles

with an arbitarily selected origin, be given by $r_1, r_2....r_n$ Let $m_1, m_2......m_n$ be the mass of the respective particles we define the centre of mass of the system of particles as a point whose position vector is given by expression.
vector r_{cm} is given by expression.

$$r_{cm} = \frac{m_1\vec{r}_1 + m_2\vec{r}_2 + ...+ m_n\vec{r}_n}{m_1 + m_2 + ...+ m_n}$$

→ <u>centre of Mass of rigid body</u>

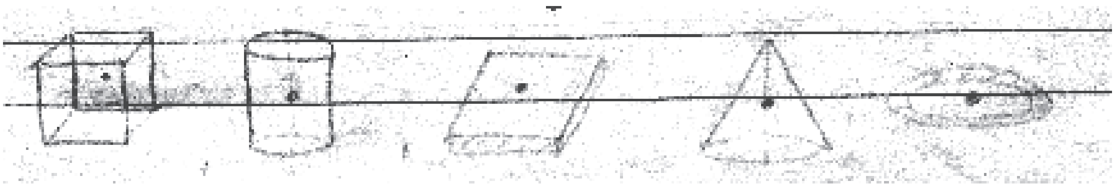
→ Location of center of mass of a body depends upon its hsape and distribution of mass within it.

→ The centre of mass may be inside the body even outside it.

→ cg. G circular disc of uniform density has its centre of mass located at the centre of the disc which is inside the body but for a ring it is at the centre of the ring but it is outside the matereal of the body.

→ centre of mass of rigid bodies having symmentry in shape and are of uniform density can reading be calculated mathematically But for a body which is not symmeture it can be difficult work.

→ For some symmeteric bodies, centre of mass are shown in fig.



(C) 1. Attempt any three problems.

1. for given spring $K \propto \frac{1}{\ell}$ $\therefore k \,.\, l$ = constant.

$\therefore$ $k_1\ell_1 = k_2\ell_2 = k\ell$ ....(1)

$\ell = \ell_1 + \ell_2$ ....(2)

$\frac{\ell_1}{\ell_2} = \frac{4}{1}$

$\therefore$ $\ell_1 = 4\ell_2$ ....(3)

$\ell_2 = \frac{\ell_1}{4}$ ....(4)

Substituting value of ℓ_2 in (2)

$\ell = \ell_1 + \frac{\ell_1}{4} = \frac{5\ell_1}{4}$

Now from (1) $k_1\ell_1 = k\ell = k\ \frac{5\ell_1}{4}$

$\therefore$ $K_1 = \frac{5\ell_1}{4}$

from (2) & (3) $\ell = 4\ell_2 + \ell_2 = 5\ell_2$

from (1) $k_2\ell_2 = k\ell$

$= k \times 5\ell_2$

$\therefore \quad k_2 = 5k$

2. For a progressive harmonic wave

$y = A\sin(\omega t - kx)$

$\therefore$ Instantaneous velocity of a particle of the medium is

$$Vp = \frac{dy}{dt} = \frac{d}{dt}[A\sin(\omega t - kx)]$$

$\therefore \quad Vp = Aw\cos(\omega t - kx)$ ......(1)

Wave velocity ν is given by

$$\nu = \frac{w}{k} \quad ......(2)$$

$$\therefore \quad \frac{Vp}{\nu} = \frac{A\omega\cos(\omega t-kx)}{\omega/k}$$

$$\therefore \quad \frac{Vp}{\nu} = Ak\cos(\omega t-kx) \quad ......(3)$$

Now, slope of waveform at instant t at distance x is

$$\frac{dy}{dx} = \frac{d}{dx}[A\sin(\omega t - kx)]$$

$$= A\cos(\omega t-kx)(-k)$$

$$\frac{dy}{dx} = -Ak\cos(\omega t-kx) \quad ....(4)$$

from equation (3) & (4) we get

$$\frac{Vp}{\nu} = \frac{-dy}{dx}$$

3. $A = 2.5 \times 10^{-7}$ m

$fs = 2 \times 10_{13}$ Hz.

Let meximum velocity of the atom executing S.H.M. be Vs

$Vs = A\omega$

$= A(2\pi fs)$

$= 2.5 \times 10^{-7} \times 2 \times 3.14 \times 2 \times 10^{13}$

$= 3.14 \times 10^{7}$ m/s.

Maximum frequency (f1)when atom is moving towards the recorder then freq record by recorder will be maximum.

atom recorder

<---S L

$v_s = -ve \quad V_L = 0$

Here $V_L = 0$

$Vs = -3.14 \times 10^{7}$ m/s.

$f_1 = 2 \times 10^{13}$ Hz.

$V = 3 \times 10^{8}$ m/s.

$\therefore \quad f_L = f_1$

$\therefore$ $f_L = \left(\frac{V+v_L}{V+v_S}\right)f_S$

$f_1 = \left(\frac{3x10^8}{3x10^8 - 3.14x10^7}\right)2x10^{13}$

f_1 = 2.234 x 10^{13} Hz.

Minimum frequency (f_2) when atom is moving away from recordes with maximum velocity then the frequency recorded by recordes will be minimum.

Here V_L = 0

Vs = -3.14 x 10^7 m/s.

f_1 = 2 x 10^{13} Hz.

V = 3 x 10^8 m/s.

$\therefore$ $f_L = f_1$

$\therefore$ $f_L = \left(\frac{V+v_L}{V+v_S}\right)f_S$

$f1 = \left(\frac{3\times10^8}{3\times10^8 + 3.14\times10^7}\right)2\times10^{13}$

f1 = 1.810 x 10^{13} Hz.

Calculation

log f_2 = (log 6 - log 3.314) x 10^{13}

log f_2 = (0.7781 - 0.5203) x 10^{13}

log f_2 = (0.2578) x 10^{13}

f_2 = 1.810 x 10^{13} Hz

4. Momentum of each bullet = $\vec{P} = m\vec{v}$

= 50x 10^{-3} kg x 1000 $\frac{mt}{sec.}$

= 50 $\frac{kg\ mt}{sec.}$

Suppose he can fire n bullets per second.

$\therefore$ New momentum imparted to the bullet per second = Momen tum experience by the machine give in the opposite direction

= reactive force experience by the solder.

$\therefore$ n(50) = 200 Newton

$\therefore$ n=4 bullets per second

Q.2. (A) Answer the following in short :-

1. $M^1 L^2 T^{-2}$
2. In the four dimensional (x,y,z,t) space; the curve on the surface giving the minimum distance between any two points of any surface is called the geodesic.
3. It is impossible to construct a heat engine based on the cyclic process, which by absorbing heat from one body only and without making any change in the

working substance can convered it (heat) completely into the mechanical energy.

4. W = $e\,\sigma T^4$

$$\frac{W_2}{W_1} = \left(\frac{T_2}{T_1}\right)^4$$

$$\frac{W_2}{W_1} = \left(\frac{2}{3}\right)^2$$

$$= \frac{16}{81}$$

Ratio of emissive power is 16 : 81

5. $T^2 \propto R^3$

$T \propto R^{3/2}$

$$\frac{T_1}{T_2} = \left(\frac{R_1}{R_2}\right)^{\frac{3}{2}}$$

$$= \left(\frac{4}{1}\right)^{3/2}$$

$$= \frac{8}{1}$$

$\therefore$ Ratio of periods is 8:1

(B) Attempt any three of the following question.

1. Two equations of angular momentum are

$\vec{L} = I\vec{W}$......(1)

$\vec{L} = \vec{r}x\vec{p}$ ..... (2)

Differentating equation (2) w r t time

$$\therefore \quad \frac{d\vec{l}}{dt} = (\vec{r}x\frac{d\vec{p}}{dt}) + \left(\frac{d\vec{r}}{dt}x\vec{p}\right)$$

Now $\frac{d\vec{r}}{dt} = \bar{v}, \frac{d\vec{p}}{dt} = \vec{F}$

$$\frac{d\vec{p}}{dt} = \left(\vec{r} \times \vec{F}\right) + (\vec{v} \times \vec{p})$$

since V & P are along some direction

$\therefore \quad \vec{v} \times \vec{p} = 0$

Now $\vec{\tau} = \vec{r} \times \vec{F}$ represents the torque acting on the particle we have

$$\frac{d\vec{l}}{dt} = \vec{\tau}$$

Now from equation (1) $\frac{d\vec{l}}{dt} = I\frac{d\vec{w}}{dt} = I\,\vec{\alpha}$ = angular occeleration.

Hence $\vec{\tau} = I\vec{\alpha}$

Law of conservation of angular momentum "If resultant torque acting on a rigid body is zero then the total angular momentum remains constant".

2. Gravitational Potential (ϕ)

The work done in bringing a particle of unit mass from an infinite distance to specific point in the gravitational field is known as the gravitational potential ϕ at that point

→ Suppose we want to find potential at any point of the gravitational field due to a particle of mass M.

→ consider a unit mass (m=1) at a destance x, from the particle of mass M. The gravitational force acting on particle of unit mass will be

$$F = \frac{GM}{x^2}$$

→ Suppose unit mass is displaced towards M by dx then work done

$$dw = \frac{GM}{x^2}.dx$$

→ If the unit mass is displaced from a point at distance x =r_1 from M to another point at destance x = r then the total work done will be

$$w = \int_{r1}^{r} \frac{GM}{x^2} dx = GM\left[\frac{-1}{x}\right]_{r1}^{r}$$

$$= -GM\left[\frac{1}{r} - \frac{1}{r1}\right]_{r1}$$

If we take $r_1 = \infty$ then w=$\frac{-GM}{r}$ and as we are taken a body of unit mass so work done becomes gravitational potential (ϕ)

for earth M=Mc

$$\phi = \frac{-GMe}{r}$$

3. Consider a system of n-mole ideal gas for a n adiultratic process for differential changes dQ = 0

Hence from 1st law of thermodynamics.

→ dT = nc_vdt + dw = 0

or dw = - nc_vdT

→ but dw = pdv = work done during very small change in volume/

Pdv = -nc_vdT ......(1)

→ for an ideal gas PV = nRT

Pdv + vdp = nRdT = R(ndT)

sustituting value of ndT from this eq. to eq (1)

$$\text{Pdv + vdp} = \frac{-Pdv}{c_v} R$$

but C_p-C_v = R

→ $$\text{Pdv + Vdp} = -\left(\frac{Cp - Cv}{Cv}\right)Pdv$$

$$= -\left(\frac{Cp - Cv}{Cv}\right) Pdv$$

$$= (1 - \gamma) Pdv$$

Where $\gamma = \frac{C_p}{C_v}$

Pdv + Vdp = Pdv - γ Pdv

Vdp + γpdv = 0

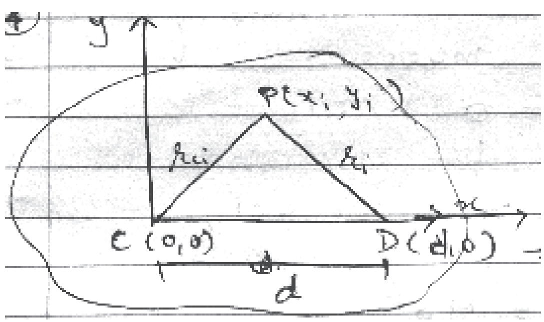
dividing above equation by Pv, we get $\frac{dp}{p} + \gamma \frac{dv}{v} = 0$

Integrating on both the sides ln P + γln V = constant

→ In (Pv^{γ}) = constant

Pv^{γ} = constant

4. Fig shows crossection of a rigid body with the plane of paper through its center of mass C.



→ Let Ic, be moment of inertia of body about axis passing through c & ⊥er to plane of paper.

→ I = moment of inertia of the body about an axis passing through point D & parallel to the axis passing through C.

Distance CD between two wxis is 'd'

Then I = $\sum_{i=1}^{n} m_i r_1^2$ ....(1)

Ic = $\sum m_i r_{ci}^2$ ....(2)

from distance formula r_1^2 = $(x_i - d)^2 + (y_i - 0)^2$

= $x_i^2 - 2dxi + d^2 + y_i^2$

By multiplying $\sum m_i$ on both the sides

→ $I = \sum_i m_i x_i^2 - 2d \, , \sum_i m_i x_i + d^2 \sum_i m_i y_1^2 + d^2 \sum m_i$

→ But again from distance formula

$x_i^2 + y_i^2 = r_{ci}^2$

$\sum mi = M$ = total mass of body.

Also $\sum \frac{m_i x_i}{M}$ = x co-ordinate of centre of mass = 0

Using these relation we get,

$$I = \sum m_i x_{ci}^2 + Md^2$$

$$I = I_c + Md^2$$

(C) Attempt any three

1. r = 300 m

$\theta = 15^o$

$\mu = 0.2$

$g = 9.8 \text{ m/s}^2$

$v = ?$

$$\frac{V^2}{rg} = \frac{\tan\theta + \mu}{1 - \mu\tan\theta}$$

where $\tan 15^o = 0.2679$

$$V^2 = rg\left(\frac{\mu + \tan\theta}{1 - \mu\tan\theta}\right)$$

$$= 300 \text{ x } 9.8 \left(\frac{0.2 + 0.2679}{1 - (0.2)(0.2679)}\right)$$

$$= 2940\left(\frac{0.4679}{1 - 0.05358}\right)$$

$$= 2940\left(\frac{0.4679}{0.9464}\right)$$

$v^2 = 1453.53$

$V = 38.12$ m,/sec.

2. Let the angle of projections be $\theta_1 = 45^o + \alpha$ and $\theta_2 = 45^o - \alpha$

$$R_1 = \frac{V_o^2 \sin 2\theta_1}{g} = \frac{v_o^2 \sin 2(45^\circ + \alpha)}{g}$$

$$= \frac{V_o^2 \sin 2(90 + 2\propto)}{g}$$

$$R_1 = \frac{V_o^2 \cos 2\alpha}{g} \ldots\ldots(1)$$

$$R_2 = \frac{V_o^2 \sin 2\propto}{g} = \frac{V_o^2 \sin 2(45^\circ - \propto)}{g}$$

$$= \frac{V_o^2 \sin(90 - 2\propto)}{g}$$

$$R_2 = \frac{V_o^2 \cos 2\propto}{g} \ldots.(2)$$

From equation (2\1) & (2) $R_1 = R_2$

3. Let flame be placed at x cm from hot end. Let in 1 sec m gm of water evaporates at hot end & same amount of ice melts at coldend.

For Water :-

L = 540 cal/gm

T_1 = 2000^o C

T_2 = 100^oC

t = 1 sec/

$mL = \frac{KA(T_1-T_2)}{x}$

$$m\,(540) = KA\left(\frac{2000-100}{x}\right)$$

$$= \frac{KA(1900)}{x} \;.......(1)$$

For Ice :-

Flame is kept at a distance x from hot end

$\therefore$ From cold end at distance of (100-x)

$mL = \frac{KA(T_1-T_2)}{100-x}$

$$m\,(80) = KA\left(\frac{2000-0}{100-x}\right)$$

$$= \frac{KA(2000)}{100-x} \;......\;(2)$$

dividing (1) by (2)

$$\frac{540}{80} = \left(\frac{1900}{2000}\right)\left(\frac{100-x}{x}\right)$$

$$\frac{27x}{4} = \frac{19}{20}(100-x)$$

540 x = 7600 - 76x

616x = 7600

$x = \frac{7600}{616}$

x = 12.33 cm.

4. T_1 = 100k

T_2 = 500k

W = 210 joules

Q = ?

$$\eta = 1-\frac{T_2}{T_1}$$

$$\eta = \frac{W}{Q1}$$

$$\frac{W}{Q1} = \perp - \frac{T_2}{T_1}$$

$$= 1 - \frac{500}{1000}$$

$$\frac{W}{Q1} = \frac{1}{2}$$

$$Q1 = 2W$$

$$= 2\ (210)$$

$$= 420 \text{ Joules}$$

$$= \frac{420}{4.2} cal$$

$$Q = 100 \text{ cal}$$

Q.3 (A) Anwer in short

1. 2.5 Ω will be resistance between any two end points of diameter.
2. Faraday's 1st law : "The mass m of an element deposited on the cathed on passing on electric current through it is directly. Propostional to the amount of charge passing through the electrolyte.
3. It resistence will decrease and will be equal to $\frac{G}{(n-1)}$

   (Resistance of ammetes = $\frac{GS}{G+S}$

$$= \frac{G\left(\frac{G}{n-1}\right)}{G+\left(\frac{G}{n-1}\right)}$$

$$= \frac{G^2}{G(n-1)+G}$$

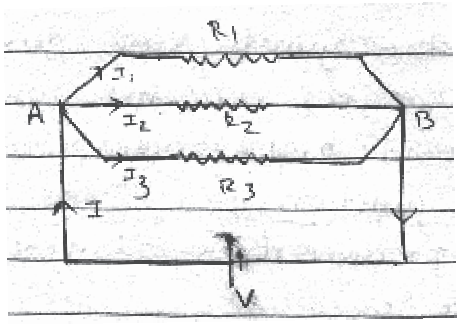
$$= \frac{G}{n-1}$$

4. :Zero.
5. volt/centigrade is unit of Thomson co-efficient.

(B) Attempt anythree

1. Parallel connnection:- The combination of more then one resistance in which potential difference across each of them is equal to the applied potential diference is called parallel connection suppose three resistences R_1,R_2,R_3

are connected in parallel and potential difference V is applied across them by connecting a battery.



→ Let I the electric cuirrent passing through the battery.

→ Let I_1, I_2, I_3 be the currents passing through resistance R_1, R_2, R_3 respectively.

Applying Kirchoff's second law at junctionm A $I = I_1 + I_2 + I_3$

Applying Kirchoff's second law in loop V-A-R_1-B-V; V.A-R_2-B-V and V.A-R_3-B-V respectively we get

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

Similarly

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

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

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

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

If R is eqvivalent resistance of circuit then according to ohm's law.

$$\frac{I}{V} = \frac{1}{R}$$

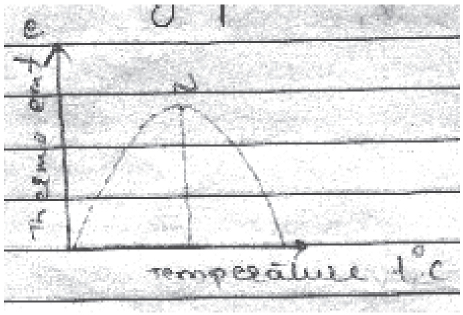
$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

2. In theromocouple the junction at lower temperature is known as reference juction and the junction at higher temperature is known as test junction.

→ The thermo emf produced is of the order of micro volts per $^\circ$c.

→ The direction of emf produced in thermo couple depends on the type of metal used and on juction temperature. In case of Bi & Antimony (sb). the thermo emf is produced from Antimany to Bismuth.

→ When reference junction is kept at °C and that of test junction is increased then the thermo emf changes according to the graph shown in figure.



→ When temperature of reference junction is °c then the relation between thermo emt and temperature is obtained emprically as, are constants depending on the type of metals.

$e = \propto t + \frac{1}{2}\beta t^2$ $\propto$ and β are constant depend on type of metal.

3. Suppose I electric current passes through a conductor of length dI

n→ number of positively charged partirterles per unit volume of the conductor.

q = charge on one particle,

v = drift volocity of positive charge in dirction of current.

We known that

I = q n A V

$\therefore$ I $\bar{dl}$ = q n A $\bar{v}$ d ℓ.

If this conductor is placed in a magnetic field of intensity $\bar{B}$ then the force acting on it is given by :

$\bar{df}$ = I$\bar{dl}$ x $\bar{B}$

ℓ = q n A dl $(\bar{v} \times \bar{B})$

But n A d l = total number of charged particles on the current element

Force action on one particle = $\frac{\bar{df}}{nAdl}$

= q (v x $\bar{B}$)

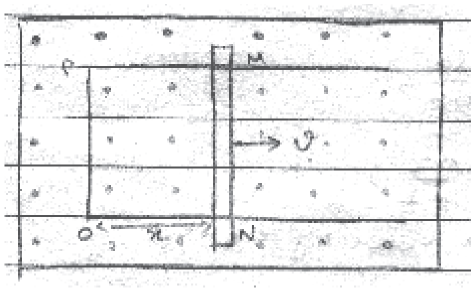
Thus $\bar{F}$ = q $(\bar{v} x \bar{B})$

In addition to magnetic field if the eletric field is also present then the resulatant force acting on charged particle will be

$\overline{F} = q\overline{E} + q\left(\overline{v} x \overline{B}\right)$

Above equation is called Lorentz force.

4. In figure, the magnetic field lines of force of a uniform magnetic field are representive by dots. The lines are coming out of plane of paper namally.



→ A U-shaped conducting wire is placed in magnetic field such that its plane remins perpendicular to the magnetic field. A conducting rod is placed on this wire which can slide over it without friction.

Suppose B = Magnetic field intensity.

l = ⊥er destance between two arms of wire.

At time t the position of the rod is represented by MN.

If ϕ is flux linked with closed loop PMNO, then ϕ = B x (area of PMNO)

= B l x

Where x = PM = ON

Now when rod moves over the wire with velocity if, the value of X & hence the fluxchanges. So induced emf is produced.Now according to Farady's law value of induced cmf is given by.

$$\varepsilon = \frac{-d\phi}{dt}$$

$$\varepsilon = d\left(\frac{Bix}{dt}\right)$$

$$= -.Bl..\frac{dx}{dt}$$

But $\frac{dx}{dt} = \vartheta \rightarrow$ velocity of rod.

$\therefore \quad \varepsilon = -Bl\vartheta$ Here -Ve sign indicate the presence of Lenz's law.

(C) Attempt any three problems

1. Resistance of conducting wire $R = \frac{\rho l}{A}$ .. (1)

Differentating about eq.

$$dR = \frac{\rho l}{A}dl = \frac{\rho l}{A^2}\times\frac{A}{\rho L} = \frac{\rho l dA}{A^2}\times\frac{A}{\rho l}$$

$$= \frac{dl}{l} - \frac{dA}{A} \text{ ..... (2)}$$

But volume of wire A.ℓ = constant

dA.ℓ + A.dℓ = o

$$\therefore \quad \frac{dA}{A} = \frac{-dl}{l} \text{ .... (3)}$$

From equation (2) & (3) we get

$$= \frac{dR}{R} = 2\frac{dl}{l}$$

$$= 2\left(\frac{3}{100}\right)$$

$$= \frac{6}{100}$$

$$= 0.06$$

dR = 0.06 x R = 0.06 x 10 = 0.6Ω

Now resistence = R + dR = 10 + 0.6

= 10.6Ω

2. For netural temperature.

$$\frac{de}{dt} = \propto + \beta t = 0$$

$$\therefore \quad t = \frac{-\alpha}{\beta}$$

$$\therefore \quad t = -\frac{(14)(10^{-6})}{-(0.07)(10^{-6})}$$

$$\frac{14}{7x10^{-2}}$$

t = 200°C

For invesion temperature e = 0

$$\alpha t + \beta t^2 = 0$$

$$t(\alpha + \frac{1}{\beta}t) = 0$$

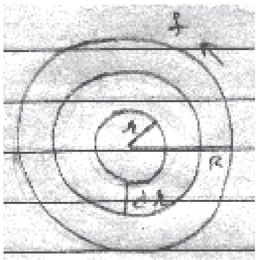
$$\alpha + \frac{1}{\beta}t = 0$$

$$t = \frac{-2\alpha}{\beta} = 2\left(-\propto/\beta\right) = 2(200)$$

$\therefore$ t = 400° C.

3. The disc can be considered to be made up of a series of rings each of width dr. One of such element ring of radius r is shown in fig.

charge per unit area of the disc $= \frac{Q}{\pi R^2}$



The charge on the elemental ring under consideration $= \frac{Q}{\pi R^2}$ x $2\pi r dr$

($\therefore$ area of ring = πr^2 = dA = $2\pi r$ d r)

When the disc is rotated, the current due to this ring is I $= \frac{Q}{\pi R^2} 2\pi r$ dr.f

Magnetic field at the centre of the disc due to this current $\frac{\mu_0 I}{2r}$

$$dB = \frac{\mu_o Q 2\pi r dr.f}{\pi R^2 2r}$$

$$B = \frac{\mu_o Q f}{R^2}\int_0^R dr$$

$$= \frac{\mu_o Q f}{R}$$

4. Mutual inductance between two coaxial solenoid is $M = \frac{\mu_o N_1 N_2 a}{l}$

$$M = \frac{4\pi x 10^{-7} x 1500 x 500 x 15 x 10^{-4}}{1.5}$$

$= 9.42 \times 10^{-4}$

M = 0.942×10^{-3} henry.

Q.4. (A) Answer in short

1. Power loss αI^2 (Power loss = I^2R)
voltage is stepped up 5 times.

then current becomes $\frac{I}{5}$

If voltage is stepped up 5 times then loss in power $= \left(\frac{I}{5}\right)^2$ R

loss in power $= \frac{x}{25}$ ($\therefore$ I^2R = x given)

2. <u>Modulation</u> :-
The sound waves are converted into electrical signals in the transmiter.

These signals cannot travel long destance. So electrical signals are carried over high frequency radio waves. As a result the amplitude of carrier wave is changed as per the variation of the sound waves. These waves are called modulated waves. These modulated waves are able to travel long distance. This process is called modulation.

3. Yes, - Optic axis of a tourmaline Plate is a direction.

4. $\frac{I_1}{I_2} = \frac{1}{4}$

$$\left(\frac{A_1}{A_2}\right)^2 = \frac{1}{4} \Rightarrow \frac{A_1}{A_2} = \frac{1}{2}$$

$$\frac{A\max}{A\min} = \frac{A_1 + A_2}{A_1 - A_2}$$

$$= \frac{3}{1}$$

$$\therefore \quad \frac{\text{Im}ax}{\text{Im}in} = \frac{9}{1} \qquad \because 1 \propto A^2$$

5. Power factor $= \cos\ \delta$

$= \cos\ \pi/3$

Power factor = 0.5

(B) Answer any three

1. Since voltage and current in A.C. circuits vary periodically with time the instantaneous power can be defined but cannot be measured. Hence in practise actual or real power is defined & measure.

→ Real power - Average value of power taken over one pariod.

→ Now instantaneous power can be givin by P =VI

$= \text{Vm}\cos\omega t \times \text{Im} \cos(\omega t-\delta)$

$= \text{VmIm} [\cos\omega t \times \cos(\omega t - \delta)]$

$= \frac{vm\text{Im}}{2} [\cos\ \delta + \cos(2\omega t-\delta)]$

Effective power

$$\text{P} = \frac{vm\text{Im}}{2}\ \frac{1}{T}\int_0^T \cos\delta dt + \frac{1}{T}\int_0^T \cos(2\omega t - \delta)dt]$$

$$\text{but} \int_0^T \cos(2wt - \delta)dt = 0$$

$$\text{P} = \frac{vm\text{Im}}{2}\frac{T}{T}\cos\delta$$

$$\text{P} = \frac{Vm}{\sqrt{2}}\frac{\text{Im}}{\sqrt{2}}\cos\delta$$

Where $\cos\ \delta$ is called power factor.

P = Vrms Irms cosδ

2. Ground waves :-

→ The radio waves of VLF, LF, and MF after being transmitted from the antenna move on the curved surface of the earth, keeping close to it and following the curvature of the surface such waves are called Ground waves.

→ The Electrical properties of the ground affect these waves much Hard oil absorbs them considerably but in sea water the absorption is very less.

→ The absorption also increases with increase in frequency.

→ Depending on the value of frequency and modulation, these waves can be sent from several kilometer distance to about (500 km.)

3. The condition of constructive interference is $\frac{xd}{D}$ where n = 1, 2, 3.......

x is distance of n^{th} bright fringe from central maximum.

D=distance of the screen from the S_1 & S_2

Now suppose Xm = distance of m^{th} bright fringe from central maximum & $(x_{m+1})^{th}$ is distance of $(m+1)^{th}$ bright fringe from central maximum

$$X_m = \frac{m\lambda D}{d}, \qquad x_{m+1} = \frac{(m+1)}{d}\lambda D$$

$\bar{x}$ = $x_{m+1} - x_m$ = distance between consecutive bright fringe.

$$= \frac{(m+1)\lambda D}{d} - \frac{m\lambda D}{d}$$

$$\bar{x} = \frac{\lambda D}{d}$$

since $\bar{x}$ does not depend on the order of fringe it can be stated that all the bright fringes have same width

4. Differential equation for charge of an A.C circuit having L-C-R in series

$$\frac{d^2Q}{dt^2} + \frac{R}{L}\frac{dQ}{dt} + \frac{Q}{Lc} = \frac{Vm\cos\omega t}{L} \text{ .... (1)}$$

Now RHS of (1) can be expressed as real part of complex voltage.

$$\frac{Vm}{L}c^{iwt} = \frac{Vm}{L}\cos\omega t.$$

$$= \text{Re}\left[\frac{Vm}{L}e^{j\omega t}\right]$$

where j = $\sqrt{-1}$

q is complex charge and can be written in complex form as

$$\frac{d^2q}{dt^2} + \frac{R}{L}\frac{dq}{dt} + \frac{q}{Lc} = \frac{Vm}{L}e^{j\omega t} \text{ .....(2)}$$

solution of (2) can be given as under

$q = q_0 e^{jwt}$(3)

$$\frac{dq}{dt} = j\omega q_O e^{j\omega t}, \quad \frac{d^2q}{dt^2} = -w^2 q_o e^{j\omega t}$$

$$-w^2 q_o e^{jwt} + \frac{R}{L} j\omega q_o e^{j\omega t} + \frac{q_o e^{jwt}}{Lc} = \frac{Vm}{L} e^{j\omega t}$$

$$q_o = \frac{Vm}{L\left(-\omega^2 + \frac{Rj\omega}{L} + \frac{1}{LC}\right)}$$

$$q_o = \frac{Vm}{L\left(-\omega^2 L + Rj\omega + \frac{1}{C}\right)}$$

substituting value in (3)

$$q = \frac{Vm}{R + j\omega L - \frac{j}{\omega L}} e^{j\omega t}$$

(C) Solve anythree

V=Vmsinωt.

Now average value of ac voltage over half cycle of period is

$$\prec V \succ = \frac{1}{1/2}\int_0^{T/2} Vm \sin \omega t . dx$$

$$= \frac{vm}{\varpi T/2}\int_0^{T/2} \sin \varpi t \ d(\varpi t.)$$

Let ωt = x

Now Change the limits

When t = 0 $\Rightarrow$ x = 0

t = I $\Rightarrow$ x = Π

$$<V> = \frac{Vm}{\pi}\int_0^{\pi} \sin x dx$$

$$= \frac{vm}{\pi}[-\cos x]^{\pi}{}_0$$

$$= \frac{-Vm}{\pi}[\cos\pi - \cos o]$$

$$= \frac{-Vm}{\pi}[-1-1]$$

$$<v> = \frac{+2Vm}{\pi} = 0.637 \text{ Vm}$$

2. (1) angular frequency = ϖo

$$\varpi o = \frac{1}{\sqrt{LC}}$$

$$= \frac{1}{\sqrt{5 \times 80 \times 10^{-6}}}$$

$$= \frac{1}{\sqrt{400x10^{-6}}}$$

$$= \frac{1}{0.02}$$

= 50 rad / sec.

At resonance impedence |z| = R

$$Irms = \frac{Vrms}{121}$$

$$= \frac{230}{40}$$

$$= \frac{23}{4}$$

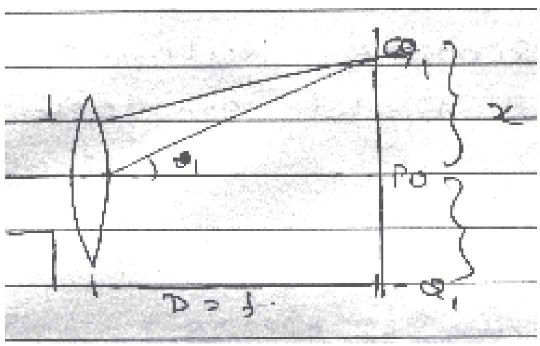
= 5.75 Amp.

Polential drop ocross inductor (V_L) = Irms ($w_o L$)

= 5.75 x 50 x 5

V_L = 1437.5 voltas.

3.



Given

d = 0.018 cm,

= 18×10^{-3} cm

f = D = 50 cm

2x = 0.45 cm

x = 0.225 cm.

m = 1

λ = ?

For m^{th} order maxima

$d\sin\theta_m = (m+\frac{1}{2})$

θ is small

$\sin\theta = \tan\theta = \frac{x}{D} \quad \Rightarrow \frac{xd}{D} = (m+\frac{1}{2})\lambda \quad (\therefore m=1)$

$\frac{dx}{D} = \frac{3\lambda}{2}$

$\lambda = \frac{2dx}{3D}$

$= \frac{2\times 0.225\times 18\times 10^{3}}{3\times 50}$

$= 54 \times 10^{-6}$ cm

$= 5400\times10^{-8}$ cm

$\lambda = 5400$ A°

4. d = 0.1 mm

$= 10^{-4}$ m

D = 1 m

$\lambda = 5400$ A°

$= 5 \times 10^{-7}$ m

$\bar{x} = ?$

In young's experiment distance between two consecutive bright or dark fringe is

$\bar{x} = \frac{\lambda D}{d}$

$= \frac{5x10^{-7}x1}{10^{-4}}$

$\bar{x} = 5 \times 10^{-3}$ m

width of the fringe $= \frac{\bar{x}}{2}$

$= \frac{5x10^{-3}}{2}$

width of the fringe = 2.5×10^{-3}m

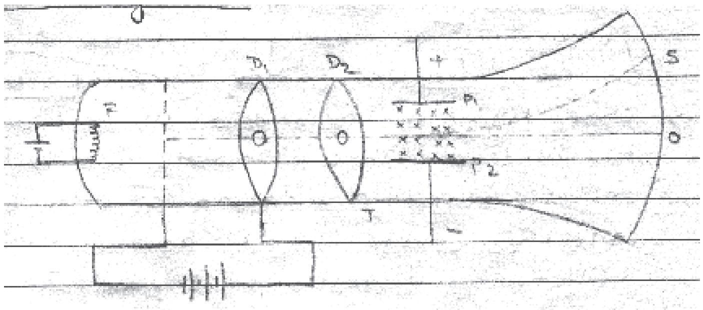
Q.5. (A) Answer in short

1. Viscous Force acting on stationary oil drop between two plates in Millikan's experiment is zero
2. Maximum Kinetic energy $= e v_o$ $= 5$ ev.
   Maximum kinetic energy emitted by electrons - 5ev.
3. To slow down Fission neutron in nuclear reactor is Moderator.
4. Binding energy per nucleon gives measure of stability of a nucleus.
5. Depletion layer.

The region close to the junction in P-N junction diode is depleted of their respective majority charge carries.This region which is empty of charge carriers is known as depletion layer.

(B) Answer any three

1.



Here displacement of electrons due to an eletric field is given by

$$y = \frac{1}{2}[\frac{Ee}{m}]\frac{l^2}{v^2}$$

Now magnetic field of intensity B is applied normal to the electric field in the direction going inward direction such that the force on the electron due to both the fields becomes equal & opposite. Therefore the bright spot comes back to 0 moving from S.

BeV = Ee

$$V = \frac{E}{B} \text{........(2)}$$

from (1) & (2) $y = \frac{1}{2}\left[\frac{E.e}{m}\right]\frac{l^2B^2}{E^2}$

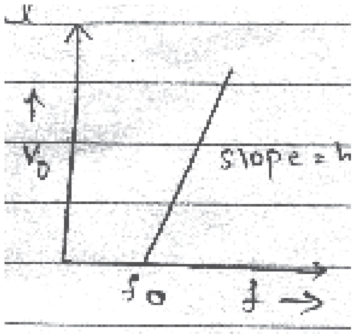
→ $\frac{e}{m} = \frac{2yE}{l^2B^2}$

→ The value of $\frac{e}{m}$ thus obtained was 1.7 x $10^{11}\frac{Coal}{kg}$ More precise value of $\frac{e}{m}$ is 1.75890 x 10^{11} c/kg.

2. According to Einstein, emission, propogation and absosption of light takes place in the form of bundles of energy known as photons. The energy of photons depends on the frequency of light i c E = h f.

→ When light is incident on metal, photons are all incident. These photons are either entirely absorbed, or donot lose any energy when an electron absorbs the photon, it gains energy h f. If this energy is greater than the binding energy of the electron only then it would be emitted.

→ If the work function of a metal is wo = hfo then out of energy hf ($f>f_0$), the energy equal to the work function of metal will be utilised in liberating the electron from the metal. The remaining will be associates with it as maximum kinetic energy.



$\frac{1}{2}Mv^2max = hf - hfo.$

If Vo is the stopping potential

then $V_o e = hf - hfo$

$$V_c = \left(\frac{h}{e}\right)f - \frac{hfo}{e}$$

Thus the graph of $V_o \rightarrow f$ is a straight line with slope $\frac{h}{e}$

These facts agree with experimental.

3. The radius of on electronic in nth arbit in a hydrogen

atom $r = \frac{n^2h^2 \in_0}{\pi m z_e^{\ 2}}$ ....(1)

Now energy of an electron

En = kinetic energy + Polential energy

$$En = \frac{1}{2}mv^2 = \frac{ze^2}{r}\frac{1}{4\Pi \in o} \quad ....(2)$$

Now centripetal force

$$\frac{1}{2}mv^2 = \frac{1}{4\Pi \in o}\frac{ze^2}{r}$$

$$\frac{1}{2}mv^2 = \frac{1}{8\Pi \in o}\frac{ze^2}{r}$$

substituting value of $\frac{1}{2}mv^2$ in ....(2)

$$En = \frac{1}{8\pi \in o}\frac{ze^2}{r} - \frac{ze^2}{r}\frac{1}{4\pi \in 0}$$

$$En = \frac{1}{8\pi \in o}\frac{ze^2}{r} \quad .... (3)$$

subsitute the values of r from eq.(1) in (3)

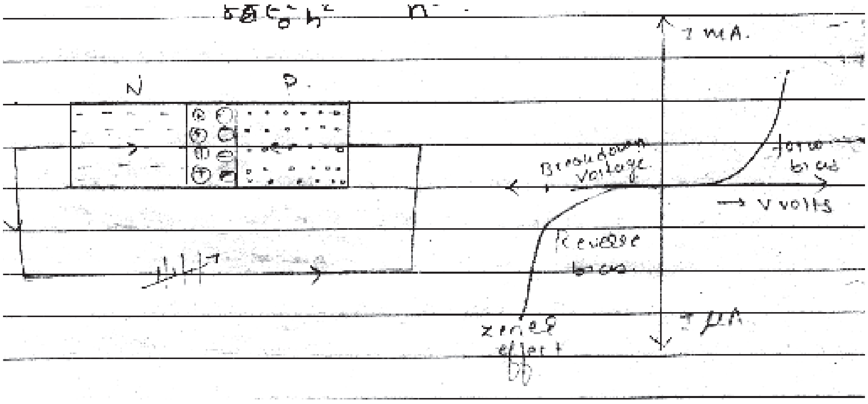
$$En = \frac{1}{8\pi \in o}\frac{ze^2}{r} - \frac{ze^2}{r}\frac{1}{4\pi \in 0}$$

$$= \frac{-z^2e^4m}{8\pi^2h^2 \in_0{}^2}$$

for hydrogen Z = 1

$$En = \left(\frac{-me^4}{8 \in^2{}_0 h^2}\right)\frac{1}{n^2}$$

4.



As shown in fig. the terminal of the battery is connected to P type & the -Ve terminal is connected to N-Type then such connection is called forward bais.

→ In such condition the emf of the battery and potential difference of the depletion layer are in opposite condition. Therefore height of potential barrier reduces of the width of the depletion layer also decreases.

Therefore Electron require less work in going from N to P. These electrons move through holes & reach the the N terminal of the battery from -Ve terminal. They again enter in N-type & consequently the current is maintained.

As shown in figure I→V relations for P - N junction diode are called the characteristics of P-N junction diode. Here current increases with increase in voltage applied.

Q.5. (A) Solve any three.

1. Force F_1 & F_2 acting on electrons in the two beams are respectively.

$F_1 = Bev_1$ and $F_2 = Bev_2$

Their trajectories are areas of circles with radi R_1 & R_2 such that.

$$F_1 = Bev_1 = \frac{mv_1{}^2}{R}$$

$\therefore \quad v_1 = \frac{BeR_1}{m}$ .... (1)

$F_2 = Bev_2 = \frac{mv_2^{\ 2}}{R_2}$

$\therefore \quad v_2 = \frac{BeR_2}{m}$ .... (2)

$\frac{\vartheta_1}{v_2} = \frac{R_1}{R_2}$ ....(3)

Electrons are in field for short time

Deviation $D_1 \propto \frac{1}{R_1}$, & $D_2 \propto \frac{1}{R_2}$

$\therefore \quad \frac{D_1}{D_2} = \frac{R_2}{R_1}$ ....(4)

from (5) & (4)

$\frac{D_1}{D_2} = \frac{V_2}{V_1} \quad = \frac{2}{1}$

2. $\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{n^2}\right)$ for Balmer series.

for $H\alpha$ line n=3 $\quad$ H_β line n=4

$\frac{1}{\lambda_\alpha} = R\left(\frac{1}{2^2} - \frac{1}{3^2}\right)$

$= R\frac{5}{36}$

$\therefore \lambda_\alpha = \frac{36}{5R}$

$\frac{1}{\lambda_\beta} = R\left(\frac{1}{2^2} - \frac{1}{4^2}\right)$

$= R\left(\frac{3}{16}\right)$

$\lambda_\beta = \frac{16}{3R}$

$\lambda_\beta = \frac{16}{3R}$

$\frac{\lambda_\beta}{\lambda\alpha} = \frac{16}{3R} \times \frac{5R}{36}$

$\lambda_\beta = \frac{80}{108} \times 6563 \times 10^{-8}$

$\lambda_\beta = 4860.44 \times 10^{-8}$

$\lambda_\beta = 4860.44^o A$

Calculation

$\log \lambda_\beta = \log 80 + \log 6563 - \log 108$

$= 1.9030 + 3.8171 - 2.0334$

$\log \lambda_\beta = 3.6866$

$\lambda_\beta = 4860.44$

3. By defination

Activity $I = \frac{dN}{dt} = \lambda N$

$\tau \frac{1}{2} = \frac{0.693}{\lambda}$

$\lambda = \frac{0.693}{\tau \frac{1}{2}}$

$\lambda = \frac{0.693}{\tau \frac{1}{2}} \times N$

$\tau \frac{1}{2} = \frac{0.693 \times N}{I}$

Now number of atoms in 226 gm. of Ra = 6.02 x 10^{23}

1 gm of Ra has $N = \frac{6.02 \times 10^{23}}{226}$

$\tau \frac{1}{2} = \frac{0.693 \times 6.02 \times 10^{23}}{226 \times 3.7 \times 10^{10}}$

= 49.89 x 10^9

$\tau \frac{1}{2} = 4.989 \times 10^{10}$ (Second)

4. Transconductance $gm = \frac{\beta ac}{ri}$

$= \frac{\delta Ic}{\delta I_B \times ri}$

$\delta V_{BE} = ri \times \delta I_B$

$gm = \frac{\delta Ic}{\delta V_{BE}}$

$= \frac{8 \times 10^{-3}}{40 \times 10^{-3}}$

(Given δV_{BE} = 4 x 10^{-3} Volt

δI_C = 8 x 10^{-3} (Amp.)

$\therefore gm = \frac{8}{40}$

$\therefore gm = \frac{1}{5}$

gm = 0.4 mho

voltage gain Av = gm R_L (neglect -ve sign)

$\therefore A_V = 0.2 \times 1000$

$A_V = 200$

• • •

Q.1. (A) Answer the following the short. (05)

1. Express kinetic energy of SHO at y=A/4 position in terms of its total mechanical energy.
2. What is importance of phase?
3. The equation of a stationary wave is given by $y = -8\sin\left(\frac{\pi x}{2}\right)\cos(20\pi t)$

   Find the wavelength of component wave. Here y is in meter.
4. Write MKS unit of resistive constant of the medium.
5. On what factors does the position of the centre of mass of a rigid body depend?

(B) Answer the following. (any three) (06)

1. Write differential equation for damped oscillations. Discuss its solution along with the graph.
2. Obtain the equation for a one dimensional harmonic progressive wave.
3. Discuss reflection of wave from a rigid support.
4. In the expression $Ma_{cm} = F$, only external forces acting on the system of particles should be taken into account, explain with an appropriate example.

(C) Solve the following. (any three) (09)

1. A given mass executing SHM has frequency equal to 50 Hz. At a particular instance its KE and PE are 1.0 J and 0.85 J. If amplitude of oscillation is 0.06 m. Find the value of mass?
2. Intial displacement of a damped oscillation is zero; and its intial velocity is v_o. Obtain the values of the constants in the expression for its displacement. Take angular frequency as ω'.
3. Two wires placed close to each other are vibrating in their firs harmonic. If the length of wires are 20.4 cm and 20 cm and the velocity of wave in the wires is 200 ms^{-1}, find the number of beats produced.
4. Distance between two particles having masses m_1 and m_2 is r. If the distances of these particles from the centre of mass of the system

are respectively are r_1 and r_2. Show that : $r_1 = r\left[\frac{m_2}{m_1+m_2}\right]$ and

$r_2 = r\left[\frac{m_1}{m_1+m_2}\right]$

Q.2. (A) Answer the following in short. (05)

1. Radial and tangential components of acceleration of a particle of rigid body change the ..... and the ...... of linear velocity of the particle. Fill in the blanks.
2. Write dimentional formula of areal velocity.
3. If the ratio of range to maximum height for a projectile is $4\sqrt{3}$. What is the angle of projection?
4. Write the relation between temperature and volume for a gas undergoing adiabatic change.
5. The emmissive power of two substance are in the ratio of 16:1. If the substance with higher emmissive power is at 527°C. What is the temperature of the other substance?

(B) Answer the following (any three) (06)

1. Explain angular momentum of a particle.
2. Why roads are banked? Draw the necessary diagram and describe forces acting on a vehicle moving through a banked road. Write the expression for the maximum safe velocity on a horizontal curved road?
3. Obtain the expression for acceleration due to gravity at a distance r (r>Re) from the centre of the earth. Obtain an expression for the changes in its value with the height.
4. What is cyclic process? Write first law of thermodynamics for its and obtain expression for its efficiency.

(C) Solve the following (any three) (09)

1. The second hand of a watch is 5 cm long. Find
   (a) linear velocity (b) the radial acceleration
   (c) the tangential accelaration
2. A metalic disc has radius 10 cm. and thickness 1 cm Find its moment of inertia about

an axis which is perpendicular to its plane and touching the edge. Density of material is 8900 kg/m^3 (Thickness of disc = 1 cm)

3. The escape velocity for a body at earth's surface is 11.2 kms/sec. If a body is projected with a velocity 2 times this velocity, obtain its velocity beyond earth's gravitational field.
4. An ideal gas is isothermally expanded so that its volume becomes double. Then it is adiabatically compressed to its original volume. Find the pressure after the adiabatic compression. (Original pressure = 1 atmosphere; $\gamma = 1.4$)

Q.3. (A) Answer the following in short. (05)

1. A 5Ω and 10Ω resistances are connected in parallel, if current passing through 10Ω resistance is 2 ampere. What is total current through the circuit. (Parallel combination is connected to a battery of negligible internal resistance)
2. A 40 W and a 60 W bulb, both rated at the same voltage are joined in parallel. Which bulb will glow more?
3. An electron revolves along a circle of radius r with velocity v, what is magnetic field created at the centre.
4. Terminal voltage of a cell is always less than its emf. State true or false with reason.
5. Define henry.

(B) Answer the following. (any three) (06)

1. Show that for a parallel combination of three resistances, $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$. Where R is equivalent resistance.
2. Draw schematic diagram of fuel cell and name oxidiser and fuel in it and also give advantage of it over other cells.
3. Define shunt and give any three uses of it in construction of an ameter.
4. Write a note on "self induction".

(C) Solve the following (any three) (09)

1. A conducting wire has a resistance of 20 ohms. Its length is now stretched to increase by 4%. Calculate the resulting value of the resistance of the wire.

2. A battery having an emf E and an internal resistance r is connected with a resistance R. Prove that the power in the external resistance R is maximum when R = r.
3. A very long straight wire carries a current of 50 amp. At what distance from this wire will the intensity of the magnetic field become 2.0 x 10^{-4} tesla?

   $$\left\{ \mu_0 = 4\pi \times 10^{-7} \frac{tesla - m}{Ampere} \right\}$$

4. A rectangular coil 20 cm long and 10 cm wide is suspended such that its area vector makes an angle 60^o with the uniform magnetic field of intensity 20 tesla. If the coil has 100 turns and current of 5 mA is passing through it. Calculate the torque. Also find the maximum torque at an appropriate inclination.

Q.4. (A) Answer the following in short. (05)

1. What will be power factor of an AC circuit having only a capacitor?
2. What will be phase difference in a L-C-R series AC circuit at resonance frequency?
3. What is modulation?
4. Define plane polarised light.
5. What is red shift?

(B) Answer the following (any three) (06)

1. What is formula for impedance of L-C-R series AC circuit? Represent it on the complex plane.
2. Explain arrangement of Hertz experiment with necessary diagram and how circuit is formed oscillatory circuit?
3. Giving necessary figure, obtain the condition for the m^{th} order maximum in Fraunhoffer diffraction at single slit.
4. Draw the figure showing plane of oscillation and plane of polarization and define them.

(C) Solve the following (any three) (09)

1. L-R series circuit is connected to a source of A.C. voltage. The maximum voltage of the source is 220 V and maximum current is 1A. Find the power and power factor. Reactance of the coil is 40Ω and $R=30\Omega$.

2. An A.C. supply of 150 V and 159.2 Hz frequency is connected to an inductance of 2H. Obtain the equation for the current in the circuit. The applied voltage $V=V_m \cos\omega t$.
3. In Young's experiment, if the separation of the slits is 0.1 mm and the light used is of 6000 A^o wave length. Find the angular distance between the central fringe and the second bright fringe.
4. A parallel beam of light is incident normally on a slit of width 0.01 cm. Its Fraunhoffer diffraction pattern is formed with a lens of 100 cm focal length on a screen. If the width of central maximum is 1 cm, find the wavelength of incident light.

Q.5. (A) Answer the following questions in very short. (05)

1. Express 5eV (electron-volt) energy in Erg.
2. What is the atomic mass unit (amu)?
3. What is multiplication factor?
4. Mention two uses of transistor.
5. Draw the circuit of half wave rectifier.

(B) Answer the following (any three) (06)

1. Mention limitations of the Bohr model.
2. Write exponential law of radio active distintegration. Obtain the expression for half life time from it.
3. What is nuclear chain reaction? Name three necessary precautions that have to be taken to get a sustained chain reaction.
4. Draw the circuit of a PN Junction in forward bias. Explain the working and diode characteristic of PN junction in forward bias.

(C) Solve the following (any three) (09)

1. How many photons of 6000 A^o wavelength of light will have the energy equal to energy of one gamma ray photon of 1.5×10^{14} m wavelength?
2. Half life of a radioactive element is 15 minutes. Find after what time its velocity becomes 64^{th} of the intial activity.
3. In a hydrogen atom, the frequency of an electron in an orbit of quantum number n is given by $f = \dfrac{me^4}{4 \in_o^2 n^3 h^3}$. Prove that for large values of quantum number n, the radiation emitted in transition from

a level (n+1) to a level n has the same frequency $R = \frac{me^4}{8 \in_o^2 ch^3}$.

4. In an NPN transistor when emitter current is 5mA, collector current is 4.9 mA. If this transistor is used as common base, calculate the currrent gain and also the current gain when it is used as common emitter.

SOLUTION

A.1. (A) 1. P.E. $= \frac{1}{2}ky^2 = \frac{1}{2}k\left(\frac{A}{4}\right)^2 = \frac{1}{16}\left(\frac{1}{2}kA^2\right) = \frac{E}{16}$

$\therefore K.E. = E - \frac{E}{16} = \frac{15}{16}E$

2. To find position of reference particle and no. of revolutions complited by it to reach that position also to find position of SHO and no. of oscillations complited by it before reaching to that position, phase is defined.

3. $y = -8\sin\left(\frac{\pi x}{2}\right)\cos(20\pi t)$

$k = \frac{\pi}{2}$,

But $k = \frac{2\pi}{\lambda} = \frac{\pi}{2}$

$\therefore \lambda = 4m$

4. F= -bv

$\therefore b = \frac{F}{v}$

$\therefore$ unit of b = $\frac{Newton - \sec}{m}$.

5. It depends on (i) shape of the body (ii) distribution of mass.

(B) 1. When ever a body perfoms oscillations in a fluid medium, resistive force of the medium acts on the oscillator. For not very large velocities, the resistive force (F_v) is found to be directly proportional to the velocity. i.e. F_v = -bv where b is a constant and is called the damping coefficient of the medium.

Thus in practice a body oscillates under the influence of two forces:

(i) restoring force = - k.y. and (ii) resistive force $F_v = -b.v = -b\frac{dy}{dt}$

Then from Newton's 2nd law of motion $m\frac{d^2y}{dt^2} = -ky - b\frac{dy}{dt}$

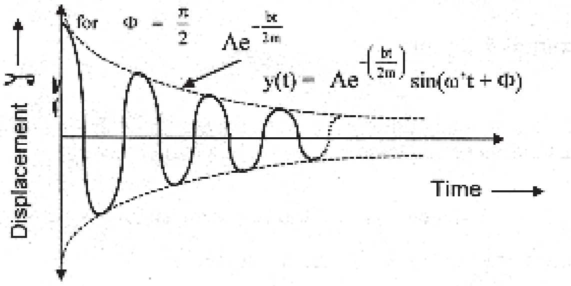
$$\frac{d^2y}{dt^2} + \frac{b}{m}\frac{dy}{dt} + \frac{k}{m}y = 0 \quad ...(1)$$

Equation (1) is called the differential equation of a damped oscillations.

Solution of equation (1) is :

$$y_{(t)} = Ae^{-\frac{bt}{2m}}\sin(\omega' t + \phi) \quad .....(2)$$

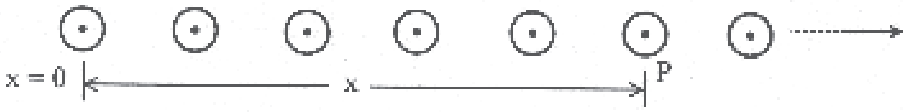
where $\omega' = \sqrt{\frac{k}{m} - \left(\frac{b}{2m}\right)^2}$ .....(3)



Equation shows that at any time 't' the amplitude of such oscillations is $A(t) = Ae^{-\frac{bt}{2m}}$ i.e. the amplitude decreases exponentially with increase in time.

The graph of displacement $y_{(t)} \rightarrow$ t for such an oscillator is shown in the figure. The dotted line shows decrease in amplitude with increase in time.

2. Consider particles of one dimensional elastic medium, at rest as shown in figure below.



Now at t=0 suppose a disturbance is produced in such a way that particle at x=0 starts its S.H.M. about its mean position with amplitude A and angular frequency ω. Here obviously $\varnothing = 0$, hence equation of displacement of particle at x=0 is given by.

$y = A\sin(\omega t)$

When the wave travels distance x, then particle P starts performing S.H.M. The phase of successive particles decreases as we go in direction of propagation.

Hence at any time the phase of particle P is less than the phase of O. The phase difference is say δ. The equation of displacement of P can be written as,

$y = A\sin(\omega t - \delta)$.....(1)

For distance between two particles equal to λ, phase difference is 2π so for distance x between two particles phase differences is equal to $\delta = \frac{2\pi x}{\lambda}$.

.....(2)

taking in equation (1) .....(3)

3. Consider a one-dimensional elastic string tied from one end with a ridig support at x=0 as shown in fig.1. Suppose a progressive harmonic wave travelling in negative x direction arrives at x=0. The incident wave is represented by .

Displacement of paricle at x=0 due to the incident wave is given by,

$y_i = A\sin(\omega t)$ .....(1)

But since this particle is firmly tied with the regid support its displacement is always zero. Now wave is reflected. If 'y_r' is the displacement of the particle at x=0 due to reflected wave then

$y_i + y_r = 0$ hence $y_i = -y_r$. $y_r = -A\sin(\omega t)$

OR

$y_r = A\sin(\omega t + \pi)$.....(2)

From equation (2) it is clear that on reflection from a rigid support phase of the wave increases by π.

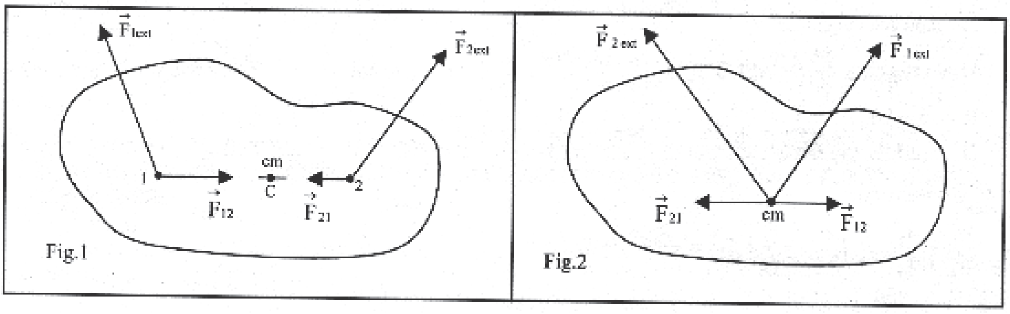
Thus after reflection from a rigid support the crest becomes through and vice versa.

For any other particle on the wave, the displacement due to reflected wave can be given by

$y_r = A\sin(\omega t + \pi - kx) = -A\sin(\omega t - kx)$

4. Two types of forces act on a system (i) external and (ii) internal forces of mutual interaction having same magnitude but opposite direction. According to Newton's third law of motion, internal forces acting among the particles are equal in magnitude and opposite in direction hence resultant of all the internal forces becomes zero. This can be easily understood with the help following example.

Consider two particles of a system. Suppose $\vec{F}_{1ext}$ and $\vec{F}_{2ext}$ are the particle 1 and particle 2 external forces acting on the two particles respectively as shown in fig. 1. Also suppose $\vec{F}_{12}$ and $\vec{F}_{21}$ are the forces of mutual attraction. All these forces can be considered to be acting on the center of mass of the system of particles as shown in fig.2.



It is clear from fig.2 that $\vec{F}_{21} + \vec{F}_{12} = 0$. Thus resultant force acting on the system is the vector sum of only external forces.

For a single particle Newton's 2nd law can be written independently of 3rd law of motion. But from above discussion it is clear that in order to derive Newton's second law of motion for a system of particles, we have to make use of Newton's third law of motion. This is known as mutual dependence of Newton's laws of motion.

(C) 1. Given Frequency f = 50 Hz;

$\therefore \omega = 2\pi f = 100\pi$ rad/sec.

But M.E. = K.E. + P.E.

E = 1.0 + 0.85 = 1.85 J.

A = 0.06m.

But

2. For a damped oscillator, ... (1)

here at

from equation (1),

Using this value of in equation (1),

$$\therefore v_{(t)} = \frac{dy_{(t)}}{dt} = Ae^{-\frac{bt}{2m}}\omega'\cos(\omega' t) + A\left(-\frac{b}{2m}\right)e^{-\frac{bt}{2m}}\sin(\omega' t)$$

but at t = 0, $v_{(t)} = v_0$, hence from above equation,

$$v_0 = Ae^0\omega'\cos(0) + A\left(-\frac{b}{2m}\right)e^0\sin(0)$$

$$\therefore v_0 = A\omega' \Rightarrow A = \frac{v_0}{\omega'}$$

3. Here, v = 200 m/s,
   $L_1 = 20 \times 10^{-2}$m,
   $L_2 = 20.4 \times 10^{-2}$ m
   Let number of beats = x.
   $f_1 - f_2 = x$.

   $$\therefore x = \frac{v}{2L_1} - \frac{v}{2L_2} = \frac{v}{2}\left(\frac{1}{L_1} - \frac{1}{L_2}\right) \qquad \left(\because f = \frac{v}{2L}\right)$$

   $$x = \frac{500}{51} \approx 10 \text{ beats.}$$

4. Given r = $r_1 + r_2$ ...... (1)
   If origin is taken on the centre of mass then r_{cm} = 0. Hence from equation $\vec{r}_{cm} = \dfrac{m_1\vec{r}_1 + m_2\vec{r}_2}{m_1 + m_2}$ we get

   $$0 = \frac{m_1\vec{r}_1 + m_2\vec{r}_2}{m_1 + m_2} \Rightarrow m_1\vec{r}_1 + m_2\vec{r}_2 = 0 \Rightarrow m_1\vec{r}_1 - m_2\vec{r}_2,$$

   (neglecting negative sign)

   Now by doing componendo

   and by using dividendo

A. 2 (A)

1. Radial and tangential components of accelaration of a particle of rigid body change the <u>direction</u> and the <u>magnitude</u> of linear velocity of the particle.

2. Areal velocity$=\frac{dA}{dt} = M^0 L^2 T^{-1}$.

3. $R = \frac{v_0^{\;2} \sin 2\theta}{g}$

   and

   $H = \frac{v_0^{\;2} \sin \theta}{2g}$

   $\therefore \frac{R}{H} = \frac{\sin 2\theta}{\frac{\sin^2 \theta}{2}} = \frac{4}{\tan \theta} = 4\sqrt{3}$

   $\therefore \tan \theta = \frac{1}{\sqrt{3}}$:

   $\therefore \theta = 30^0$

4. $TV^{\gamma - 1}$ = constant.

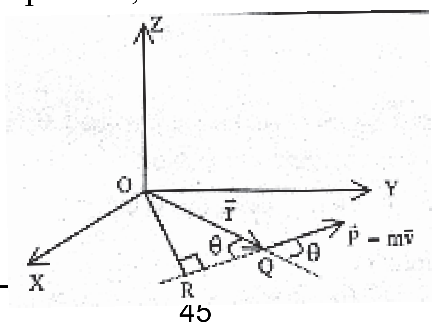
5. $\frac{W_1}{W_2} = \frac{T_1^4}{T_2^4}$

   $\therefore T_1^4 = \frac{W_1}{W_2} \times T_2^{\;4} = \frac{1}{(2)^4} \times (800)^4$

   $\left(\because T_2 = 527 + 273 = 800^0 K\right)$

   $T_1 = \frac{800}{2} = 400^0 K \quad \therefore T_1 = 400 - 273 = 127^0 C$·

(B) 1. As shown in figure suppose a particle Q having mass m has a position vector , with reference to a point O. Let be the linear velocity of this particle, so that its linear mementum is . Let be the angle between and . For convenience, we shall assume that the motion of the particle is in the (x,y) plane. The vector product of and is then defined as the angular momentum of the particle with reference to point O; i.e.



$\vec{\ell} = \vec{r} \times \vec{p}$

Unit of $\vec{\ell}$ is kg-m^2/s

(i) Direction of the vector $\vec{\ell}$ is obtained by applying the right hand screw rule to the vector product $\vec{r} \times \vec{p}$. In the case illustrated, $\vec{\ell}$ is directed along OZ.

(ii) The magnitude of $\vec{\ell}$ is $rp\sin\theta$. If θ is either 0 or π; i.e. the line of action of $\vec{p}$ passess through the reference point O; or if r=0, then the angular momentum is zero. When defining the angular momentum, one must specify the point about which it is taken.

2. When a vehicle moves on a curved path, the necessary centripetal force $\left(\frac{mv^2}{r}\right)$ is obtained from the frictional forces between the tyres and the road. For more speed at turns, sometimes such centripetal force may not be sufficient and the vehicle is thrown off the road. Hence to provide more centripetal force the roads are kept slightly inclined (banked) at the turn.

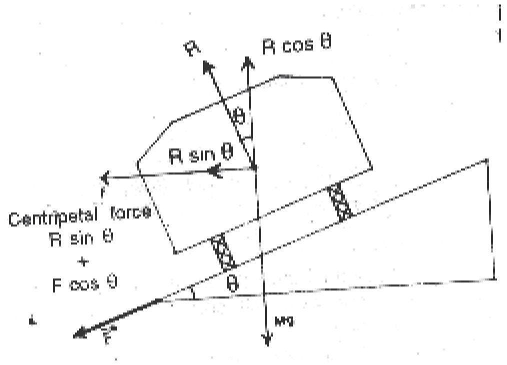


Figure shows the cross-section of a curved road having radius of curvature "r" and an angle of inclination across the road.
Let us assume that the maximum saft speed is v.
Following forces are acting on the vehicle.
(1) Weight of the vehicle Mg acting downwards.
(2) Force of the normal reaction R acting perpendicular to the surface of the road, i.e. at an angle to the vertical.
(3) Force of friction F acting parallel to the surface of the road.

For maximum safe velocity on a horizontal curved road is .

3. Acceleration produce in a body due to gravitational force of the earth on it is called gravitational acceleration.
Let mass of earth be M_e and its radius be R_e.

Let m = mass of a body and its distance from the center of the earth r ($r > R_e$) then from Newton's law of gravitation the gravitational force acting on the body due to the earth is,

$F = G\frac{M_e m}{r^2}$ .....(1)

But according to Newton's 2nd law of motion.

$F = mg$ .....(2)

From (1) and (2) $mg = G\frac{M_e m}{r^2}$ $g = \frac{GM_e}{r^2}$ ......(3)

Differentiating above equation with respect to r, $\frac{dg}{dr} = \frac{-2GM_e}{r^3}$

$\therefore dg = -2\frac{GM_e}{r^2}\frac{dr}{r} = -2g\frac{dr}{r}$.

4. Cyclic Process : "In heat engine, the working substance, starting from specific equilibrium state, is allowed to undergo a series of changes and brought back to its original state." Such a process is called Cyclic proces..

   In cyclic process, since initial and final states are same, at the end of the cyclic process change in internal energy $(\Delta U = U_2 - U_1)$ is zero.

   Thus from the 1st law of thermodynamics, $Q = (U_2 - U_1) + W$ thus Q=W ...(1)

   Now the heat lost Q_2 into the sink is of no significance hence work can be said to be done at the cost of heat Q_1. Therefore efficiency of any heat engine based on cyclic process per cycle is defined as,

   ...(3)

   But here

   Substituting the value of W from equation,

(C) 1. Give r = 5cm,

   (a) */sec.*

(b) radial acceleration = $a_r = \frac{v^2}{r} = \omega^2 r = \frac{\pi^2}{900} \times 5 \approx 0.0548 \frac{cm}{\sec^2}$

(c) tangential acceleration = 0 as ω = constant.

2. r = 10cm = 10^{-1} meter,

   thickness of disc x = 1 cm = 10^{-2} meter,

   Density ρ = 8900 kg/m^3.

   $$I = \frac{MR^2}{2} + R^2 = \frac{3}{2} MR^2$$

   $$M = V\rho = \pi R^2 x \rho = \pi \left(10^{-1}\right)^2 \times 10^{-2} \times 8900 kg$$

   $$\therefore I = \frac{3}{2} \pi R^4 \times \rho = \frac{3}{2} \times 3.14 \times 10^{-4} \times 10^{-2} \times 8900 = 4.19 \times 10^{-2} kgm^2$$

3. Suppose the body is projected with a velocity v. Its kinetic energy at the surface of earth is $= \frac{1}{2} mv^2$. Its potential energy at the surface of earth is $-\frac{GM_e m}{R_e}$ and $\frac{GM_e m}{R_e} = \frac{1}{2} m v_e^{\ 2}$

   $\therefore$ Its total energy on the surface of the earth is $= \frac{1}{2} mv^2 - \frac{GM_e}{R_e}$. (1)

   Now on leaving gravitational field of the earth velocity is v',

   so kinetic energy will be $\frac{1}{2} mv'^2$.

4. Original

...(1)

$p_1V_2^\gamma = p_3V_3^\gamma$

$\therefore p_2 2^\gamma V_1^\gamma = p_3V_1^\gamma$

$\therefore p_2 2^\gamma = p_3$

$\therefore \frac{p_1}{2}.2^\gamma = p_3$

$\therefore p_1 2^{\gamma-1} = p_3$

$\therefore \log p_1 + (\gamma - 1)\log 2 = \log p_3 \qquad \therefore (1.4-1)\log 2 = \log p_3$

$\therefore (0.4)(0.3010) = \log p_3 \qquad \therefore 0.1204 = \log p_3$

$\therefore p_3 =$ Antilog 0.1204=1.319 atmosphere.

A.3 (A) 1. $I_1 R_1 = I_2 R_2$

$\therefore 5I_1 = 10 \times 2$

$\therefore I_1 = 4A$

2. 60W bulb will glow more as power consumed in it is more.

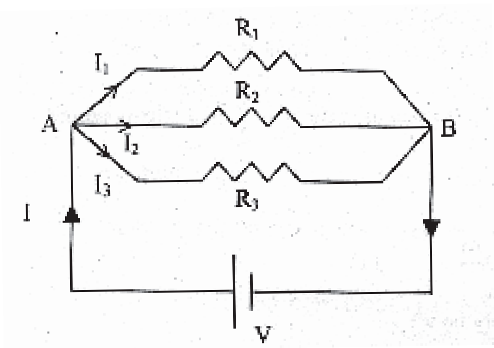
3. $B = \frac{\mu_0 ev}{4\pi r^2}$.

4. False, when a cell is charged terminal voltage becomes more than emf. [V = E + Ir].

5. If $\frac{dI}{dt} = 1\frac{amp}{\sec}$ and induced emf 1 volt, the self inductance of the circuit is 1 Henry.

(B) 1. In parallel connection one end of all the resistances meet at one point and other end at another common point.

Suppose three resistances R_1, R_2 and R_3 are connected in parallel and potential difference V is applied across them by connecting a battery.



Let I = the electric current passing through the battery. At point A this current divides into three branches.

Let I_1, I_2 and I_3 be the currents passing through resistances R_1, R_2

and R_3 respetively, then by applying Kirchhoff's first law at junction A, $I = I_1 + I_2 + I_3$ ...(1)
Now applying Kirchhoff's 2nd law in loops V-A-R_1-B-V, V-A-R_2-B-V, V-A-R_3-B-V respectively we get,

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

Similarly $I_2 = \frac{V}{R_2}$ and $I_3 = \frac{V}{R_3}$ substituting these values in equation (1),

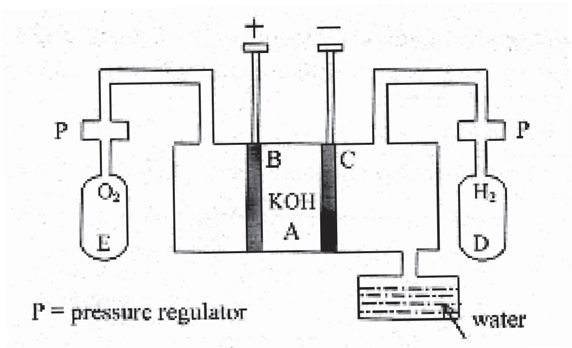
$$I = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3} \Rightarrow \frac{I}{V} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

If parallel combination of R_1, R_2 and R_3 is replaced by a single resistance R such that the current passing through the circuit remains the same then it is called equivalent resistance of the combination.
If R is the equivalent resistance of the circuit then according to the Ohm's law, $\frac{I}{V} = \frac{1}{R}$ Using this in equation (2)

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

For n such resistances in parallel $\frac{1}{R} = \sum \frac{1}{R_1}$.

2. Construction of Hydrogen - Oxygen fuel cell is shown in fig.



Fuel cell is a type of an electrochemical cell. A schematic diagram of a fuel cell using hydrogen as a fuel and oxygen as a oxisider is shown in the figure.
Advantage: In this cell it is not necessary to change chemical substance like primary cells or to recharge the cell as in case of secondary cells.

3. A small resistance connected in parallel with a galvanometer to convert it in an ammeter is called shunt.
   Uses:
   (1) It protects galvanometer
   (2) By connecting shunt, range of the ammeter can be increased
   (3) When shunt is connected resistance of the ammeter is decreasing so we can measure almost exact current.
4. Lenz's Law: If an agency generates an induced emf through its action (such as motion of the megnet) the induced emf would be such that the current produced by this emf would generate a magnetic field such as to oppose the action of the agency.
   Faraday's Law: The negative time rate of change of magnetic flux linked with a circuit is equal to the induced emf in the circuit.

(C) 1. $R_1 = 20\Omega$,

$$\frac{dR}{R}\times 100 = 2\left(\frac{dl}{l}\times 100\right)$$

so change in resistance is 8% so increase in resistance is $\frac{20\times 8}{100} = 1.6\Omega$

so final resistance will be 21.6Ω

2. Power in the external resistance = I^2R.

$$P = \left(\frac{\varepsilon}{R+r}\right)^2 R$$

$$\frac{dP}{dR} = \frac{-2\varepsilon^2 R}{(R+r)^3} + \frac{\varepsilon^2}{(R+r)^2} = 0$$

(being the condition for maximum or minimum P)

$\therefore R = r$

3. Here I=50 Amp.
   B = 2.0 x 10^{-4} T,
   y = ?

$$\mu_0 = 4\pi\times 10^{-7}\,\frac{T\times m}{Amp.}$$

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

$$\therefore 2\times 10^{-4} = \frac{4\pi\times 10^{-7}\times 50}{2\pi\times y}$$

$\therefore$y=5cm

4. Here $A = l \times b = 20 \times 10 = 200 cm^2$,

   $A = 200 \times 10^{-4} m^2$

   $\theta = 60^0$,

   $B = 20 web / m^2$

   $N = 100$,

   $I = 5 \times 10^{-3} A$,

   $\tau = ?$,

   $\tau_{max} = ?$

   $\tau = BINA \sin\theta = 20 \times 5 \times 10^{-3} \times 100 \times 200 \times 10^{-4} \sin 60^0 = 2 \times 10^{-1} \times \frac{\sqrt{3}}{2}$

   $\therefore \tau = 0.173 Nm.$

   when $\theta = 90^0$,

   $\tau_{max} = BINA \therefore \tau_{max} = 20 \times 5 \times 10^{-3} \times 100 \times 200 \times 10^{-4}$

   $\therefore \tau_{max} = 0.2 Nm.$

Q.4. (A) 1. Power factor $\cos\delta = 0$ as $\delta = -\frac{\pi}{2}$ red.

2. Phase difference, δ=0. $\left(\because \omega L - \frac{1}{\omega c} = 0 \right)$

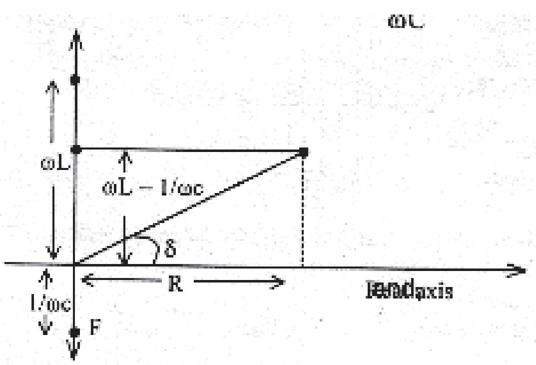
3. The technuque of impressing the audio waves on the radio frequency waves is called the modulation, and the radio waves which carry the modulation are called the carrier waves.

4. The beam of light in which the electric field intensity vectors ($\vec{E}$) are oscillating along a fixed direction is called a plane polarized light beam.

5. In the spectrum (due to some of its element) of a star moving away from the earth is observed, the lines in the spectrum would appear at frequencies which are lower then that observed for the same element in the laboratory, due to the Doppler shift; i.e. the lines would appear shifted to the red side of the spectrum. This is called the "red shift".

(B) 1. Complex impedance of L-C-R series A.C. circuit is given by equation.

.....(1)



Real part of this resistance is R which is taken on the real axis in the complex plane and it is represented by OD in the figure.

In figure, OA = ωL and OF = $\frac{1}{\omega C}$ are taken on the imaginary axis of the complex plane.

In figure, OG = $\omega L - \frac{1}{\omega C}$ = imaginary part of Z.

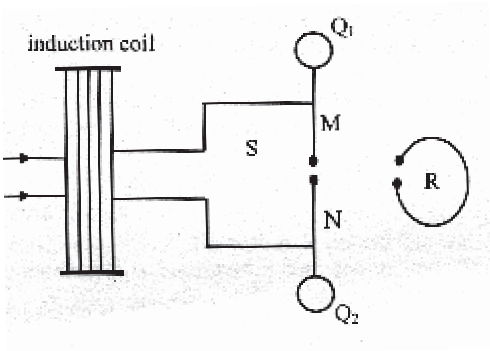
Point H in the fig. represents the complex number Z in the complex plane.

$$|Z| = \sqrt{R^2 + \left[\omega L - \frac{1}{\omega C}\right]^2} \quad .....(2)$$

Equation (2) give the magnitude of the impedance.

By following the same method δ and Z can be determined for any A.C. circuit.

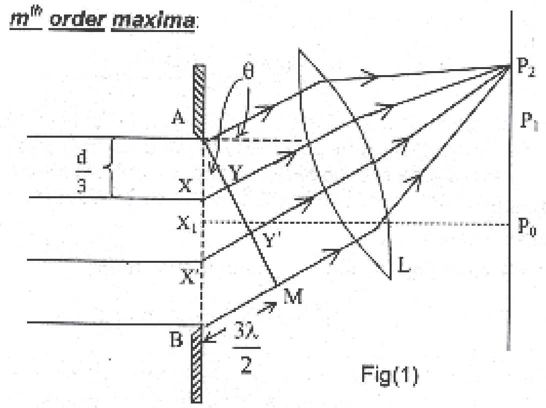
2. Hertz demonstrated production of such waves in laboratory. His arrangement is schematically shown in figure.



Here, Q_1 and Q_2 are two metallic sphereas. Joined to them are two metallic rods M and N with some space between called spark gap S. The rods are connected to the two terminals of an induction coil to provide high intermittant voltage. The spheres Q_1 and Q_2 act as capacitors and the rods acts as inductors. This arrangement therefore, acts as an oscillating circuit in which alternately Q_1 and Q_2 acquire positive and negative charge which reverse in their polarity each time a sark passes across the gap S.

3. In figure the rays going parallel to each other in a direction making angle with X Po are shown. These rays converage at point P_2 by a convex lens.

Draw AM$\perp$BL. Consider points X and X' trisecting AB. Thus AX=d/3.



Fig(1)

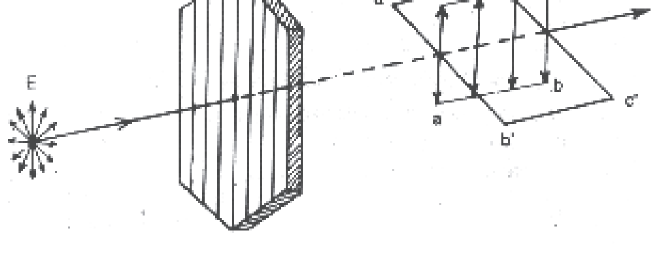
It is clear from the figure that the path difference between the rays emerging from A and X and reaching P_2 is XY. Now suppose that the angle θ is such that XY= $\lambda/2$ then X'Y'= λ and BM = $3\lambda/2$. Thus at P_2 the path difference between the rays coming from A and X is $\lambda/2$ and they interfere destructively. Similarly corresponding to every point in section AX, we can find a point in section XX' such that the path difference between the rays emerging from them is $\lambda/2$. Thus they nullify each other. But the effect of X'B section is not nullified hence there is some intensity of light at point P_2 which is very much less than at P_0. Point P_2 is called first maximum.
Now from fig., m$\angle$BAM = θ hence from, ΔAMB

=

Similarly for m[th] order maxima we can show that,

where m=1,2,3....

4. Plane of oscillations (vibration): The plane containing the direction of the beam and the direction of oscillations of the vectors is called the plane of oscillations. In the figure abcd is the plane of oscillations.



Plane of polarization: A plane containing the direction of the beam and which is perpendicular to the $\vec{E}$ vectors of a plane polarized light is called the plane of polarization. In fig. a'b'c'd' is the plane of polarization.

(C) 1. Given $V_{max} = 220V$ $X_L = 40$ ohm

$I_{max} = 1$ A R = 30 ohm

The impedance of L-R series AC circuit is

$|Z| = \sqrt{R^2 + X_L^2} = \sqrt{(30)^2 + (40)^2} = 50\Omega$

For L-R circuit, power factor is $\cos\delta = \frac{R}{|Z|} = \frac{30}{50} = 0.6$

Power $P = I_{rms} \times V_{rms} \cos\delta = \frac{I_m}{\sqrt{2}} \cdot \frac{V_m}{\sqrt{2}} \cos\delta = \frac{(1)(220)(0.6)}{2} = 66$ watt

2. Here $f = 159.2$ Hz, $V_m = 150$ Volt, L = 2H, I = ?,

$\omega = 2\pi f = 2 \times 3.14 \times 159.2 = 1000$ rad/sec.

As the circuit contains only an inductor, $\delta = \frac{\pi}{2}$ rad

$$\therefore I = \frac{V_m \cos\left(\omega t - \frac{\pi}{2}\right)}{\omega L} = \frac{150\cos\left(1000t - \frac{\pi}{2}\right)}{2000} \therefore I = 0.075\cos\left(1000t - \frac{\pi}{2}\right) Amp.$$

3. $d = 0.1mm = 10^{-4}m, \lambda = 6000A^0 = 6 \times 10^{-7}m$

here n=2,

For radian.

4.

For minima

But m = 1,

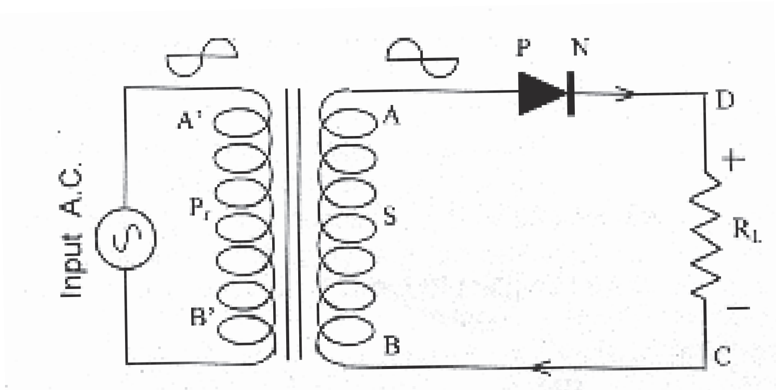
Q.5. (A) 1. erg.

2. The twelfth part of the mass of a neutral and unexcited C^{12} atom is called 1 amu.

3. The ratio of the neutrons produced to the neutrons incident at a given stage is called the multiplication factor.

4. (i) as an amplifier (ii) as an oscillator.

5.



(B) 1. i) If a single line of hydrogen spectrum is observed with a more powerful spectrometer, it appears to be consisting of more then one lines. This can not be explained by Bohr's model.

ii) The theory gives no idea about the intensity of spectral lines.

iii) Electrons are considered to be moving in circular orbits which is not necessary. Electrons can also move in elliptical orbits.

iv) The theory combines principles of quantum physics and classical mechanics which do not match with each other.

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

N = number of nuclei, which have not disintiegrated at time t.,

N_o = The number of nuclei of the element not disintegrated at t = 0 time,

λ= Decay constant for radioactive element,

e = base of natural log

when t = $\tau_{\frac{1}{2}}$, N = $\frac{N_0}{2}$ where N_o = number of nuclei present at t =0.

Substituting above values in the exponential law, N = $N_0 e^{-\lambda t}$

3. The fission of a uranium nucleus is affected by a single neutron, but more than one neutrons are released as a result of fission of a single nucleus. Under favourable circumstances, these neutrons can afect further fissions in more uranium nuclei; and thuys such a fission reaction can progress as a self sustaining chain. The energy released through such a chain reaction under controlled conditions is the source of

nuclear energy in a nuclear reactor. The important points to be taken care of is given below.

(1) The neutrons which are released during the fission are fast neutrons, and can esacpe from the volume of the reacting mass without initiating further fissions. To slow down the neutrons meterials known as "moderators" are used in the nuclear reactors. Heavy water (D_2O), carbon in the form of graphite, Berylium and ordinary water are used as moderators. To confine the neutrons to the reaction region, neutron reflecting surface are used.

(2) For the chain reaction to proceed in an uninturrupted manner, a definite mass of fissile material (material which undergoes fission) is required, which is called its "critical mass". If the mass exceeds the critical mass, the reaction may proceed too fast and can go out of control.

4. Forward bias:

Suppose the P-side of the junction is connected to the positive terminal of a battery and the N-side is connected to its negative terminal, as shown in the figure. This is called forward bias connection.

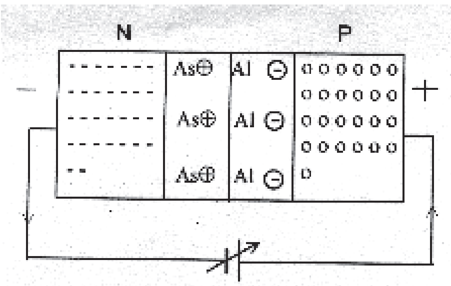


Fig.1

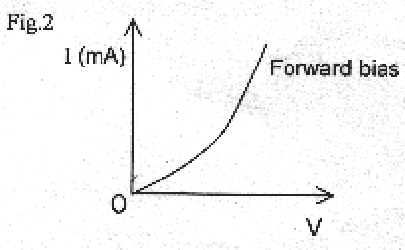


Fig.2

When connected in this way, the potential difference across the depletion layer is in a direction which is opposite to the applied voltage. Therefore, the "height" of the depletion layer potential is reduced, and its width is also simultaneously reduced. Hence the electron can now easily move from N to P side. Therefore, under the influence of the external voltage applied in this sense, the electrons move from the N side to the P-side and finally reach the positive terminal of the battery, to emerge from the negative termal and continue their circulation. Thus, a curent can be established in the circuit easily. If the voltage applied by the battery is increased, the current also increases as shown in figure. Note that the current shown in the external circuit of the figure is the conventional current which is opposite to the direction of the flow of electrons.

(C) 1. Given $\lambda = 6000 A^0 = 6\times10^{-7} m., \lambda_\gamma = 1.5\times10^{-14} m, n = ?$

Suppose n number of photons of wavelength 6000 A° have energy equal to the energy of 1 photon of γ-ray then, $E_\gamma = nE$

$\therefore hf_\gamma = nhf$

$$\Rightarrow \frac{hc}{\lambda_y} = n\frac{hc}{\lambda} \Rightarrow n = \frac{\lambda}{\lambda_\gamma} = \frac{6\times10^{-7}}{1.5\times10^{-14}} = 4\times10^7$$

2. If halflife = x minutes. Where x = 15 minute.

substituting value of   in equation (1)

3.

4.

Common base current gain

Common emitter current gain

Q.1. (A) Answer the following questions in very short as asked :- (05)

1. The displacement of a SHO is given by y=4 sint cost find its initial velocity.
2. "In damed oscillations frequency does not change with time." True OR Fasle?
3. A progressive harnonic wave is given by $y=A \sin \frac{2\pi}{\lambda}(\alpha t-x)$. Then what is α ?
4. What are stationary waves?
5. If the momentum of a particle is decreased by 20% what is the percentage decreased in its kinetic energy ?

(B) Answer the following questions in eight to ten sentences :- (Any Three) (06)

1. Write down the differential equation for forced oscillations. Obtain its solution in the absence of damping.
2. Prove the relation, $y\upsilon^2 = a(A^2 - y^2)$ between displacement, velocity and accelaration for a SHM.
3. What is a propagating harmonic wave ? Obtain the equation y = A sin(wt - kx) for one dimensional harmonic wave propagating +x in direction.
4. Explain phenomenon of beats and obtain an expression for the number of beats per second.

(C) Solve the following examples :- (Any Three) (09)

1. For simple harmonic motion prove that average value of K.E. $\langle K \rangle = \frac{1}{4}kA^2$ taken for one period of time.
2. If two tuning forks having frequency 320 H_z and 480 H_z produce waves in air having a difference of wavelength of $\frac{17}{48}$ m, find the velocity of sound.
3. Three spheres having masses m_1=m, m_2=m and m_3 = 2m are placed at the vertices of an equilateral traingle having the length of the side 4m. If the sphere of m_1 is at the origin and another of mass m_2

is on the x - axis. find the position of centre of mass of this system with respect to origin.

4. A ball of 4 kg mass hits a wall at an angle of 30^o and is then reflected making an angle of 120^o with its original direction. If the duration of contact between the ball and the wall is 0.1 sec. Calculate the force exerted on the wall. The initial and the final velocities of the ball is 1 met / sec.

Q.2.(A) Answer the following questions in very short :- (05)

1. If the angular momentum of a rotating rigid body with a stationalry axis increases by 10%. Find the percentage change in its rotational kinetic energy.
2. Write the unit of angular momentum.
3. A body is projected first at angle θ with horizontal direction and then at same angle θ with vertical direction. Will their ranges be equal ?
4. The maximum range of a proejectile is equal to 0.5 km then the initial velocity of the projectile will be .....
5. In which event heat energy is transferred through electromagnetic waves ?

(B) Answer the following questions in eight or ten sentences :- (Any Three) (06)

1. Describe the motion of a solid cylinder rolling down a slope without sliding, and obtain expression for its accelealiton.
2. Prove that the escape velocity for a body on the surface of Earth is $\sqrt{2g\,Re}$
3. Define total emissive power and give Stephen - Boltzmann law giving its mathematical expression. Write value of constants in the expression.
4. Prove Kapler's second law of planetory motion.

(C) Solve the following examples :- (Any Three) (09)

1. A ring of radius 25 cm and mass 40 kg rotates about an axis passing through its centre and perpedicular to its plane. The angular velocity of this ring is found to increase from 5 rad/sec to 25 rad/sec in 5 second calculate the work done by the force in 5 second.
2. Prove that the ratio of the change of 'g' at a height "Re" above the surface of earth to the value of g at the surface of the earth is equal to $-\frac{1}{4R_e}$

3. The efficiency of a carnot engine is 1/6. By decresing the temperature of the cooling arrangement by 65°C, its efficiency is doubled. Find initial temperature of the source and the sink.
4. In an isothermal process, the pressure of 1 mole of an ideal gas is increased and made five times its original pressure. Find the work done during the process. Temperature is 300° K. R =8.3 J/mol °K.

Q.3. (A) Answer the following questions in very short :- (05)

1. 5 mA current is following in a wire. No of electrons passing through each cross section of this wire per second is ....
2. Write Kirchhoff's second law.
3. In thermocouple, when referance junction is at 0°C and test junction is at t°c, the emf is given by $e = 4t - \frac{t^2}{20}$ then what is the neutral temperature?
4. On connecting a shunt of 40 Ω deflection of galvanometer becomes half of initial. What is the resistance of galvanometer ?
5. If the planes of two concentric coils is perpendicular to each other, then what will be the value of the mutual inductance of the system ?

(B) Answer the following questions in eight OR ten sentences (Any Three)(06)

1. Write a note on "Thermistor".
2. Write down the two laws of faraday relating to electrolysis. Discuss the second law.
3. Explain the principle of a potentiometer with a necessary circuit diagram.
4. Explain "mutual inductance".

(C) Solve the following examples :- (Any Three) (09)

1. Unkonw resistance x is joined parallel to a resistance of 20 Ω. To this connection a battery of 2 volt and resistance of 10 Ω are joined in series. If the current passing through x is 0.05 Amp. Find the value of x.
2. 4 batteries, each of 1.5 volts are connected in series so that they are helping each other. Internal resistance of each is 0.5Ω they are being charged using a direct voltage supply of 110 volts. To control the current a resistance of 49 Ω is used in the series. Obtain (i) Power drawn from the supply (ii) power dissipated as a heat.

3. The resistance of galvanometer is 18 Ω find the resistance of the shunt which when connected in paralled with the galvanometer coil allows only 10% of the total current flow through the galvanometer.
4. A conducting loop of radius r is placed concentric with another loop of a much larger radius R, so that both the loops are coplaner. Find the mutual inductance of the system of the two loops. Take R>>>r.

Q.4. (A) Answer the following questions in very short as asked :- (05)

1. In L-C-R series circuit, $\omega_0^2 LC$ = _______ in reasonance.
2. The number of turns in the primary coil is 100 and that in the secondary coil is 400. If 1.0 Amp current flows in the primary coil, then how much will be the current flowing in the secondary coil of the transformer ?
3. Indicate the wavelength in meter of the radiation having frequency 1 MHz.
4. Light waves are transverse waves. Which phenomenon gives proof of this fact ?
5. What are inductive components ?

(B) Answer the following questions in eight to ten sentences :- (Any Three) (06)

1. Derive the expression of power for L-C-R series a.c. circuit $P_{eff} = V_{rms} I_{rms} \cos\delta$.
2. State the characteristics of electromagnetic waves.
3. Explain how diffraction imposes a limit on useful magnification by lens.
4. Giving the necessary figures and obtain the condition for the minima in fraunhofer diffraction.

(C) Solve the following examples :- (Any Three) (09)

1. An a.c. circuit with L-C-R in series has voltage and current respectively given by $V = 200\sqrt{2}\ \text{Cos}\ (3000t - 55^o)$ and
   $I = 10\sqrt{2}\ \text{Cos}\ (3000t - 10^o)$
   Find the impendance of the circuit and the value of R.
2. Human eye is most sensitive for light of wavelength 5600 A°. Find the frequency of this light $c=3x10^8$ met/sec.
3. The ratio of intensities of rays emitted from two different coherent sources is α. For the interference pattern formed by them prove that

$$\frac{I_{max}+I_{Min}}{I_{max}-I_{Min}}=\frac{I+\alpha}{2\sqrt{\alpha}}$$

4. In young's double slit experament, the seperation of slits is 0.05 cm and a screen is placed at a distance of 100 cm. The seperation between centres of the third bright and Nine bright fringe is 6 mm. Find the wavelength of light.

Q.5. (A) Answer the following questions in very short as asked :- (05)

1. Dimensional formula of E/B is ______.
2. The radius r_1 of the electron of the hydrogen atom in the first orbit is equal to 0.531A° what will be the radius (r_3)of the third orbit ?
3. Write the diamonsional formula of constant K in Millikun's experiment.
4. State the electronic configuration of Germanium.
5. In common emitter N-P-N transistor circuit current gain = ______.
   (a) $\beta > 1$ (b) $\beta < 1$ (c) $\beta + 1$ (d) $\beta \leq 1$

(B) Answer the following questions in eight to ten sentences :- (Any Three) (06)

1. Give Einstein's explaination for photo - electric effect.
2. Explain the term "decay constant" giving necessary expressions. Deduce the exponential law for the radioactive decay.
3. Write the reactions involved in proton - proton fusion process, giving the values of energy released at each stage.
4. Write a note on transistor oscillator.

(C) Solve the following examples :- (any Three) (09)

1. In Milikan's oil drop experiment, radius of an oil drop is 7.25 x 10^{-7} m. It is hold stationary between two parallel plates 6.0 mm apart kept at a potential difference of 103 V. Find the charge on the drop. Density of oil is 880 kg/m^3, density of air 1.29 kg/m^3, g=9.8 m/s^2.
2. Prove that in a hydrogen atom, square of the orbital period of an electron is proporational to the cube of the radius of that orbit.
3. Half life of Na^{24} is 15 hours, in what time its 93.75% would decay ?
4. The current gain of a transistor is 0.98. It is used as power amplifier to get a power gain of 10. What is the ratio of input resistance to output resistance ?

ANSWERS

Q.1. (A) 1. v_0= 4 unit.

2. Yes
3. α= Wave Velocity v
4. Waves travelling in the mutually opposite directions and having same amplitudes, same frequencies, same wavelengths and experienceing superposition, lose the property of progressiveness as the resultant effect. Thus the waves obtained in such a way are called stationary waves.
5. 36%.

(B) 1. $\frac{d^2y}{dt^2}+r\frac{dy}{dt}+\omega_o{}^2y=a_0\,sin(\omega t)$

In absence of dumping (r=0)

$\frac{d^2y}{dt^2}+\omega_0{}^2y=a_0\,sin(\omega t)$ ......(1)

Let the solution of above eq^{-n} be

y = A sin (ωt) ...... (2)

$\therefore\frac{dy}{dt}$ = Aω Cos (ωt) ..... (3)

$\therefore\frac{d^2y}{dt^2}$ = -Aω^2 Sin (ωt) ..... (4)

Substituting equation (4), (3) and (2) in equation (1), we get

- $A\omega^2Sin(\omega t)+\omega_0^2ASin(\omega t)=a_0Sin(\omega t)$

dividing above eq^n by Sin(ωt)

$\therefore\ A\omega^2+\omega_0^2A=a_0$

$\therefore\ A[\omega_0{}^2-\omega^2]=a_0$

$\therefore\ A=\frac{a_0}{\omega_0^2-\omega^2}$ .... (5)

Substituting equation (5) in equation (2), we get

$y=A\,sin(\omega t)$

$\therefore y=\frac{a_0}{\omega_0{}^2-\omega^2}$ Sin (ωt) .... (4)

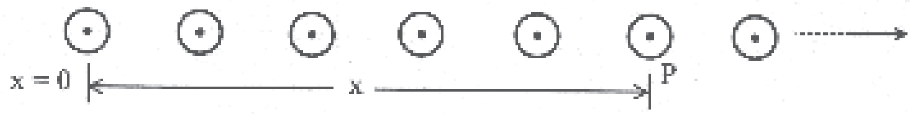
2. $v = \pm\omega\sqrt{A^2 - y^2}$

$a = \omega^2 y \Rightarrow \omega = \pm\sqrt{a/y}$

$v = \sqrt{a/y}\ \ \sqrt{A^2 - y^2}$

$\therefore yv^2 = a(A^2 - y^2)$

3. The wave form generated is a sinusoidal type and the waves continiously moving ahead in the medium, are called propagating harmonic wave.



Let the particle located at x=0 start the SHO at time t=0, with phase equal to zero.

The equation of motion of this particle will be

y = A sin (ωt) .... (1)

The wave orginating at t=0 covers a distance x, at that time the particle located at x begins its oscillations and its phase will be lagging behind the phase of oscillations of the particle at x then located x=0 by an amount δ. The eqn of oscillations of particle at x=x is

$y = A\sin(\omega t - \delta)$ .... (2)

Let λ be the wave length associated with this wave. At λ seperation the corresponding phase difference is 2π . Hence the particle located at a distance x from x=0 will have less phase by $\frac{2\pi x}{\lambda}$.

$\therefore \delta = \frac{2\pi x}{\lambda}$ .... (3)

Sub. eqn. - 3 in eqn. (2)

$y = A\sin\left(\omega t - \frac{2\pi x}{\lambda}\right)$

$but\ \frac{2\pi}{\lambda} = k$ (wave vector)

$\therefore y = A\sin(\omega t - kx)$

4. Consider two harmonic waves with their frequencies differing by a small amount, passing through the same region of a medium.

$y_1 = ASin(\omega_1 t)$ and $y_2 = ASin(\omega_2 t)$

where $\omega_1 = 2\pi f_1$ and $\omega_2 = 2\pi f_2$

(Here both the waves having same Amplitude)

Above two waves are superposed at a point, so according to the superposition theroem.

$$y = y_1 + y_2$$

$$A\left[Sin(\omega_1 t) + Sin(\omega_2 t)\right]$$

$$y = 2ACos\left(\frac{\omega_1 - \omega_2}{2}\right)^2 \bullet Sin\left(\frac{\omega_1 - \omega_2}{2}\right)^t \quad \text{........... (1)}$$

From Eqn.1 we can say, the resultant wave is having angular frequency $\frac{\omega_1 - \omega_2}{2}$ and the Amplitude of the wave changes periodically with angular frequency $\left(\frac{\omega_1 - \omega_2}{2}\right)$

$\therefore$ the period $T = \frac{2\pi}{\omega} = \frac{2\pi(2)}{\omega_1 - \omega_2} = \frac{2}{f_1 - f_2}$

From above eqn. we can say that the Amplitude of the resultant wave becomes

two times. MAXIMUM and two times MINIMUM, and correspondingly the loudness of the sound is also changes periodically.

$\therefore$ The no. of beats heard in 1 Sec. is $(f_1 - f_2)$

Def. : The phenomenon of periodic increase and decrease occuring in the londness of sound, when two sound waves having same amplitude and a small difference of frequency are superposed, is called Beats.

<u>Beats</u> : The phenomenon of periodic increase and decrease occuring in the loundness of sound, when two sound waves having same amplitude and a small difference of freq. are superposed is called the Beats.

(C) 1. $K = \frac{1}{2}mv^2 = \frac{1}{2}mA^2\omega^{-1}Cos^2\omega t$

$K = E\,cos^2\,\omega t \qquad (\because E = \frac{1}{2}kA^2)$

$$<K> = \int_o^T \frac{ECos^2\omega t}{T}dt = \frac{E}{T}\int_0^T \frac{(1+cos\,2\omega t)}{2}dt$$

$$<K> = \frac{E}{2T}\left[t + \frac{Sin2\omega t}{2\omega}\right]_0^T$$

$$= \frac{E}{2T}\left[T + \frac{Sin2\omega t}{2\omega}\right]$$

$$= \frac{E}{2T}[T]$$

$$<K> = \frac{E}{2}$$

$$<K> = \frac{1}{4}KA^2$$

2. Here $\lambda_1 - \lambda_2 = \frac{17}{48}$

but $v = f\lambda \Rightarrow \lambda = v/f$

$$\frac{v}{f_1} - \frac{v}{f_2} = \frac{17}{48}$$

$$v\left(\frac{1}{f_1} - \frac{1}{f_2}\right) = \frac{17}{48}$$

$$v = \frac{17 \times 320 \times 480}{160 \times 48}$$

$$v = 340m/s$$

3. m$_1$ = m kg. $\qquad \vec{r}_1 = 0$

m$_2$ = m kg. $\qquad \vec{r}_2 = 4\hat{i}$

m$_3$ = 2m kg. $\qquad \vec{r}_3 = 2\hat{i} + 2\sqrt{3}\hat{j}$

$$\vec{r}_{em} = \frac{m_1\vec{r}_1 + m_2\vec{r}_2 + m_3\vec{r}_3}{m_1 + m_2 + m_3}$$

$$= \frac{m(0)+m(4\hat{i})+2m(2\hat{i}+2\sqrt{3}\hat{j})}{4m}$$

$$= (2\hat{i}+\sqrt{3}\hat{j})m$$

4. $\vec{P}_1 = (mvSin30\hat{i} + mvCos30\hat{i})$ N.Sec.

$\vec{P}_2 = (-mvSin30\hat{i} + mvCos30\hat{j})$ N.Sec.

Change in Momentum of Sphare $d\vec{p} = -2mvSin30\,\hat{i}$

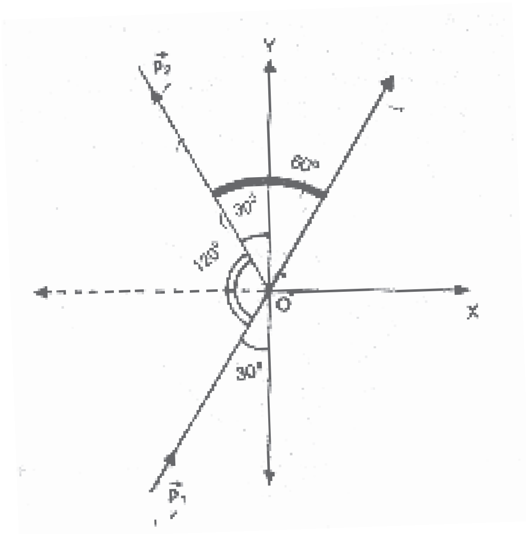
$= -2\ (4)\ (1)\ (1/2)\ \hat{i}$

$= -4\ \hat{i}$ N.Sec.

Change in momamtum of Wall $= 4\ \hat{i}$ but $\vec{F} = \frac{d\vec{p}}{dt}$

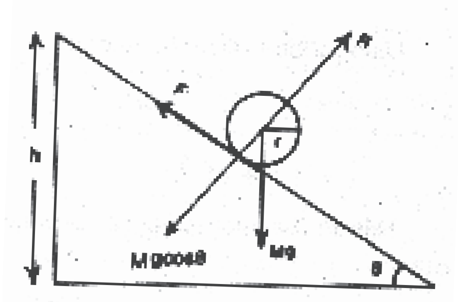
Force $= \frac{4\hat{i}}{0.1}$

$= 40\ \hat{i}$ N.



Q.2. (A) 1. 21 %
2. Joule - Second
3. Yes
4. 70 m/sec.
5. Thermal Radiation

(B) 1.



As shown in fig. consider a solid cylinder, rolling down a slope of heigh h, without sliding. Let the radius of the cylinder be r and θ be the agnel of inclination.

Here, as the cylinder is rolling down its kinetic energy is partly in rotational and partly in the linear motion.

The centre of mass of the cylinder is executing a linear motion, and the cylinder is rotating about its geometrical axis. These two motions can be treated independently.

Potential energy lost by the cylinder when it reaches the bottom of the slope = Mgh.

Let the linear velocity of the centre of mass be v when the cylinder has reached the bottom, and let ω be its angular velocity at that time.

$\therefore$ Kinetic energy at the bottom $= \frac{1}{2}Mv^2 + \frac{1}{2}I\omega^2$

Applying the principle of conservation of the mechanical energy

$Mgh = \frac{1}{2}Mv^2 + \frac{1}{2}I\omega^2$ .... (1)

Substituting $\omega = \frac{v}{r}$ and using $I = \frac{1}{2}Mr^2$ for a solid cylinder, we get from eqn. (1)

$v^2 = \frac{4}{3}gh$ .... (2)

If the length of the slope is d; the cylinder starting from zero velocity attains a velocity v after moving over the distance d.

v^2 = 2ad, a being its linear acceleration.

But $\frac{h}{d} = sin\theta \Rightarrow d = \frac{h}{sin\theta}$ .... (3)

$\therefore v^2 = 2a \cdot h / \sin\theta$ .... (4)

Substituting this value for v^2 in the eqn. (2)

$\frac{2ah}{sin\theta} = \frac{4}{3}gh$ .... (5)

$\therefore a = \frac{2}{3}g \ sin\theta$

2. Particle of mass m has a gravitational potential energy ($-Gm_e m/R_e$) on the surface of the earth, and its gravitational potential energy is zero at the infinite distance. This particle has to be taken to an infinite distance from the earth, starting from its stationary position on the surface of the arth, it must be given kinetic energy equal to +($Gm_e m/R_e$). This energy is called the escape energy (E_e).

$$\therefore E_e = \frac{GM_e \cdot m}{R_e} \qquad \text{.......... (1)}$$

If a body of mass m stationary on the surface of the earth is given this amount of energy, it will escape from the field of gravitation of earth.

Let the corresponding velocity needed the V_e. Then Ve is called the escape velocity.

Now $$\frac{1}{2} m v_e^2 = \frac{GM_e m}{R_e} \qquad \text{.......... (2)}$$

$$\therefore v_e = \sqrt{\frac{2GM_e}{R_e}}$$

Now $$g = \frac{2GM_e}{{R_e}^2}$$

$$\therefore V_e = \sqrt{\frac{2GM_e R_e}{R_e \times R_e}} = \sqrt{2\left(\frac{GM_e}{{R_e}^2}\right) R_e}$$

$$= \sqrt{2g\,Re}$$

3. The amount of energy radiated per second per unit area at a given temperature is called the total emissive power.

Stephen experimentally showed that "the amount of energy radiated by a surface, in the form of power of its absolute temperature". This is called Stephen - Boltzmann Law.

$$W = e\sigma\, T^4$$

Here T, is the absolute temperature, e is known as the emmissivity of the radiating surface. σ is called the Stephen - Boltzmann constant.

It is a universal constant and have value of $\sigma = 5.67 \times 10^{-8}$ watt/met^2 • K^4

4.

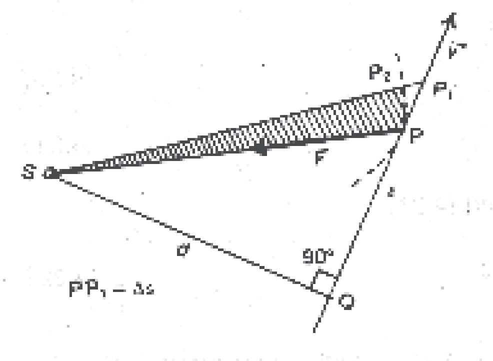


Figure shows, by a broken line, a part of the orbit of a planet going around the sun S. Let the linear velocity of the planet be $\vec{v}$ when it is at a position P. The perpendicular distance between the sun S and the direction of $\vec{v}$ is d. Let m be the mass of the planet. Angular momentum of the planet with reference to the point S is given by

L = mvd .... (1)

Now area of the traingle SQP is given by

$$A = \frac{1}{2}(SQ)\,(PQ)$$

$$= \frac{1}{2}(d)s \qquad (\because PQ = s)$$

$\therefore$ The area swept by the planet in time dt is

$$dA = \frac{1}{2}(d)\ ds$$

$$\therefore \frac{dA}{dt} = \frac{1}{2}(d)\frac{ds}{dt} = \frac{1}{2}(d)v$$

Multiplying both sides by m, we get

$$m\frac{dA}{dt} = \frac{1}{2}mvd \qquad \text{........... (2)}$$

Substituting the value of mvd from the eqn. (1) into equ. (2)

$$m\frac{dA}{dt} = \frac{1}{2}L \qquad \text{......... (3)}$$

Now, the force of gravitation due to sun on the planet is always directed along the line joining the sun and the planet. Hence the torque due to this force taken about the sun is always zero. Therefore the angular momentum of the planet is its orbital motion will be conserved.

$\therefore \frac{dA}{dt}$ = constant .... (4)

Kepler's statement of second law for the planetary motion is "The line joining the planet and the sun sweeps equal area in equal time, as the planet moves in its orbit around the sun". The rate at which area is swept is called the "areal velocity". That is proved.

(C) 1. $r = 25cm = 25 \times 10^{-2} m$

$M = 40Kg$

$\omega_0 = 5\frac{rad}{sec}$

$\omega_0 = 25\frac{rad}{sec}$

+ = 5 Sec

$\theta = \left(\frac{w + wo}{2}\right)t$

$\theta = 75rad$

$\alpha = \frac{\omega - \omega_0}{t} = \frac{25-5}{5}$

$\alpha = 4rad / s^2$

$I = Mr^2 = 25 \times 10^{-2} \times 25 \times 10^{-2} \times 40 = 2.5\,Kg\,m^2$

$\theta = \left(\frac{\omega + \omega_0}{2}\right)t$

$= \left(\frac{25+5}{2}\right)5$

= 75 rad.

W = τ. θ

= (I α) θ $(\because \tau = 1\alpha)$

= 2.5 x 4 x 75

$\therefore$ W = 750 Joule

2. The acceleration due to gravity "g" is

$$g_{(r)} = \frac{GM_e}{r^2}$$

$$\frac{dg_{(r)}}{dr} = \frac{-2GM_e}{r^3}$$

At $r = 2R_e$

$$\therefore \left(\frac{dg_{(r)}}{dr}\right)_{2R_e} = \frac{-2GM_e}{8R_e^{\,2} \bullet R_e} = -\frac{1}{4}\frac{g}{R_e}$$

$$\therefore \frac{\left(\frac{dg_{(r)}}{dr}\right)_{2R_e}}{g} = -\frac{1}{4R_e}$$

3. $n_1 = 1 - \frac{T_2}{T_1}$

$$\frac{1}{6} = 1 - \frac{T_2}{T_1} \qquad .... (1)$$

$n_2 = 1 - \frac{T_2^1}{T_1}$ from data. $T_2^1 = T_2 - 65$

$$\frac{1}{3} = 1 - \frac{(T_2 - 65)}{T_1}$$

$\frac{1}{3} = \left(1 - \frac{T_2}{T_1}\right) + \frac{65}{T_1}$ from Eqn. (1)

$\frac{1}{3} = \frac{1}{6} + \frac{65}{T_1}$ $(\because \frac{1}{6} = 1 - \frac{T_2}{T_1})$

$$\therefore T_1 = 390\ K$$

$$\frac{1}{6} = 1 - \frac{T_2}{390}$$

$$\frac{T_2}{390} = \frac{5}{6}$$

$$T_2 = 325^0\,K$$

4. $P_1V_1 = P_2V_2 \Rightarrow \frac{V_2}{V_1} = \frac{P_1}{P_2}$

$$W = 2.303nRT \log\left(\frac{P_1}{P_2}\right)$$

$= 2.303 \times 1 \times 83 \times 300 \times \log(1/5)$

= -4008 Joule

Q.3. (A) 1. $5 \times 6.25 \times 10^{15}$

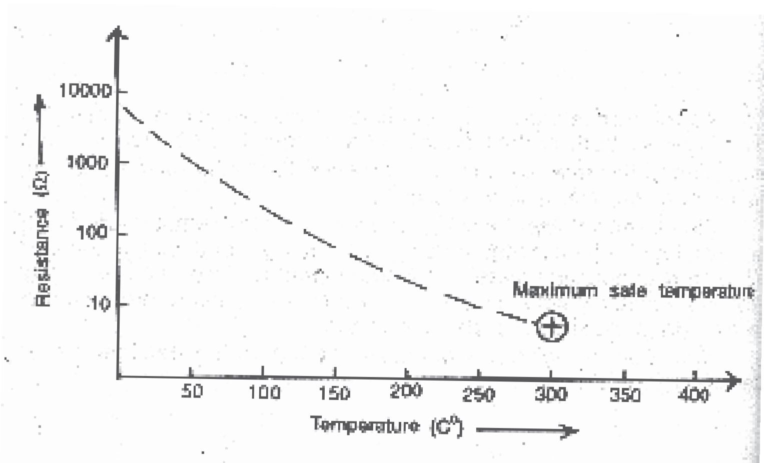
$= 31.25 \times 10^{15}$

2. Kirchoofs Second Rule

In a closed circuit, the algebraic sum of the products of resistances with the corresponding values of currents flowing through them is equal to the algebraic sum of the emfs appliied in the Loop."

3. $t = 40^o$ C
4. 40 Ω
5. Zero

(B) 1. On increasing the temp. of semi conductor 3^oC near the room temp. its resistance decreases by about 13%. It is a special type semi-conductor. It is made up two words thermal and resistor.
- Thermistor are made from mixture of oxides of manganese, nickle, cobalt, copper, iron and uranium.
- beads about 0.015 cm to 0.25 cm diameter.
- Thermisters are available in range of resistance 100 Ω to 10 m Ω fig.



Graph of resistance vs. temperature (log scale) for a typical thermistor

This property makes thermistors useful in controlling temperatures in the industrial applications. It has been possible to achieve a control of temperature to a precision of $\pm 0.0005^0 C$.

The temperature co-efficient of a thermistor is given by :

$$\alpha = \frac{1}{R_0}\frac{\Delta R}{\Delta T}(^0C)^{-1}$$

Here R_o is the resistance of the thermistor at 25oC with no current flowing through it.

2. Faraday's first law :
The mass "m" of an element deposited on the cathode on passing an electric current through electrolyte is directly proportional to the amount of charge passing through the electrolyte.

Faraday's second law

When the same amount of current is passed for the same time, (i.e. the same amount of charge is conducted) through different electrolytes, the masses of elements deposited from the electrolytes, the masses of elements deposited from the electrolytes are in proportion to their respective chemical equivalents. The chemical equivalent is the ratio of the atomic weight of the element to its valency.

Thus, from Faraday's second law, when equal currents are passed through two eleccrochemical cells for the same time, the masses m_1 and m_2 of the elements are proportional to their respective chemical equivalents and e_1 and e_2. That is

$$\frac{m_1}{m_2} = \frac{e_1}{e_2} \qquad \text{............. (1)}$$

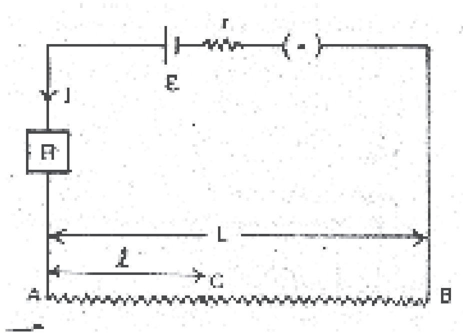
$$\frac{m_1}{m_2} = \frac{e_1}{e_2} = \frac{It\, Z_1}{It\; Z_2}$$

$$\therefore \frac{e_1}{e_2} = \frac{z_1}{z_2} \qquad \text{........... (2)}$$

$$\therefore \frac{e_1}{z_1} = \frac{e_2}{z_2} \qquad \text{............ (3)}$$

Equation (3) shows that for all elements the ratio of the chemical equivalent to the electrochemical equivalent has a constant value. This constant is called the Faraday constant. Its value is 96,500 coulomb/mole.

3. Circuit diagram



The principle of a Potentiometer : Consider a circuit such as the one shown in fig. Here, a battery of emf ε and an internal resistance r is connected in series with a resistance box R, and a conducting (resistive) wire having a uniform crossection.

Suppose that the length of wire is L and its resistance per unit length is ρ; so that the total resistance of the wire is Lρ. If the resistance in the resistance box is R, the current through the wire is

$$I = \frac{\varepsilon}{R + L\rho + r} \qquad \text{........ (1)}$$

If the length of the wire from A to C is l, then the difference of potential between A and C will I/ρ. Writing this as V_1.

$$V_1 = I\rho l \qquad \text{........... (2)}$$

Substituting for I from the equn. (1)

$$V_l = \left[\frac{\varepsilon\rho}{R + L\rho + r}\right] l \qquad \text{............. (3)}$$

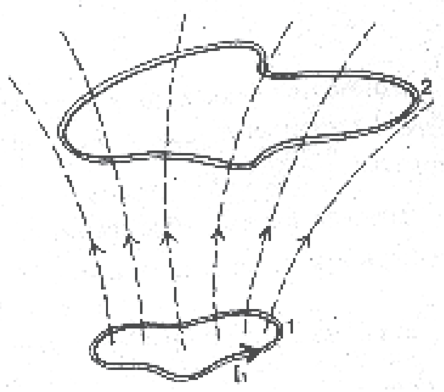
The potential difference per unit length of the wire $\frac{V_l}{l}$ is called its potential gradient and is represented by σ.

$$\therefore V_l = \sigma\ell$$

$\therefore V_l \alpha \ell$

Principle : The potential difference bet[n] any two points of the potentiometer wire is directly proportional to the distance bet[n] them.

4.



Consider two conducting coils having arbitary shapes, placed near each other as shown in Fg. The coils may also have an arbitary inclination with respect to each other.

Suppose that the coil 1 has N_1 turns and the coil 2 has N_2 turns. Now when a current I_1 is passed through the coil 1, some of the magnetic flux generated by the coil 1 will be lined with the coil 2. Also, for any specified position of the coils, it readily follows from Biot-Savart Law, that the flux Φ_2 likned with the coil 2 will be proportional to the current in the coil 1.

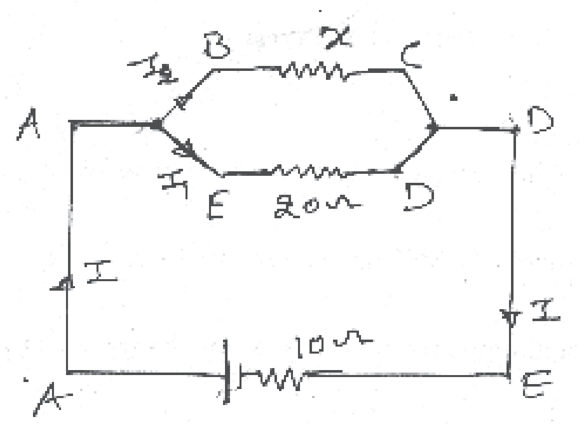
$\therefore \Phi_2 \ \alpha \ I_1$

$\therefore \Phi_2 = M_{21} I_1$ .... (1)

The constant of proportionality M_{21} which appears in the equations is termed as the mutual inductance of the system formed by the two coils.

Taking I1 = 1 unit in the equation, $\Phi_2 = M_{21}$. So one can define the mutual inductance of the system formed by the two coils as the amount of flux linked with the other coild when a unit current passes through one of the coils.

(C) 1.



In ABCDEA $- 20I_1 - 10 I = -2$

$20 (I - 0.05) + 10 I = 2$ $(\because I_1 = 1 - 0.05)$

$20 I - 1 + 10 I = 2$

$30 I = 2 + 1 = 3$

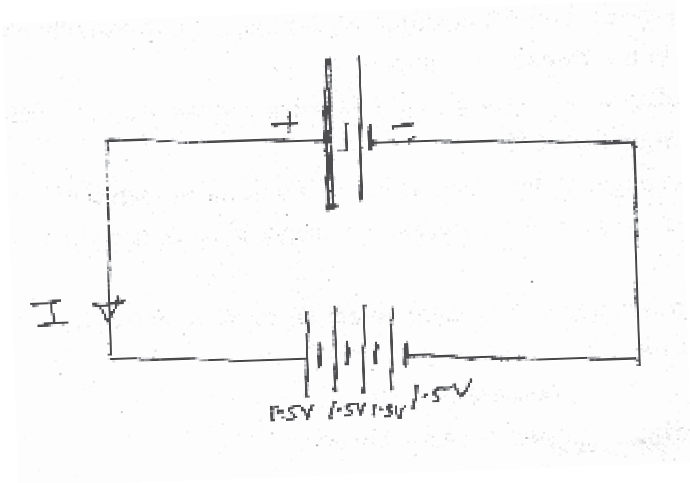
$I = 0.1$ Amp.

In BCDEB $-20 I1 + 0.05 x = 0$

$$x = \frac{20I}{0.05} = \frac{20 \times 0.05}{0.05}$$

$$x = 20\Omega$$

2.



$V = 4\varepsilon + 4Ir + 1R$

$$\therefore \quad I = \frac{V - 4\varepsilon}{4r + R} I_1$$

$\therefore \quad I = \dfrac{110-(4\times1.5)}{4\times0.5+49} = \dfrac{104}{51}$

$\therefore$ I = 2.039 Amp.

$\therefore$ Power drawn from the suppy P = V1

= 110 x 2.039

P = 224.3 Watt

Power dissipated in the circuit } $P = 4I^2r + I^2R$

$= 4\,(2.039)^2 \times 0.5 + (2.039)^3 \times 49$

= 8.315 + 203.7

P = 212.0 Watt

3. G = 18 Ω

$I_g = \dfrac{10I}{100}$

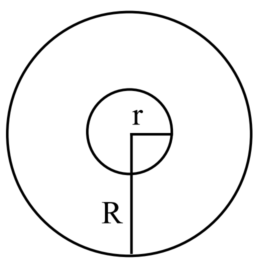
$\therefore I_g = 0.1I$

$\therefore \; S = G\dfrac{I_g}{I-I_g}$

$\therefore \; S = 18\dfrac{0.1I}{I-0.1I}$

$= 18\times\dfrac{0.1}{0.9}$ = 2 Ω

4.



Consider a current I passing through the larget loop. The magnetic field at the center of this loops due to this current is

$$B = \frac{\mu_0 1 R^2}{2(R^2)^{3/2}} = \frac{\mu_0 1}{2R}$$

It is given that R > > r. $\therefore$ The filed in the region of the smaller loop can be considered to be uniform and of the above value.

$\therefore$ The flux linked with the smaller loop is given by

$$\Phi = \frac{\mu_0 1}{2R}.\pi r^2 = \frac{\mu_0 1 r^2}{2R}$$

$$\therefore M = \frac{\Phi}{I} = \frac{\mu_0 \pi r^2}{2R}$$

Q.4. (A) 1. 1

2. 0.25 Ampere
3. 300 m
4. Polarisation
5. Near the oscillator the phase difference bet^n $\vec{E}$ & $\vec{B}$ is $\pi/2$ and their Values decrease rapidly according to $1/r^3$ with distance. Such components of field are called inductive component.

(B) 1. For example in a L - C - R circuit, instantaneous power is

P = VI

= $V_m \cos\omega t. \quad I_m \cos(\omega t - \delta)$

= $V_m I_m \cos\omega t \cos(\omega t - \delta)$

But $\cos\omega t \cos(\omega t - \delta)$

$$= \frac{1}{2}\cos\delta + \frac{1}{2}\cos(2\omega t - \delta)$$

$\therefore$ Instantneous power

$$P = \frac{V_m I_m}{2}[Cos\delta + Cos(2\omega t - \delta)]$$

$\therefore$ Effective power

$$P = \frac{V_m I_m}{2}\left[\frac{1}{T}\int_0^T Cos\delta dt + \frac{1}{T}\int_0^T Cos(2\omega t - \delta)dt\right]$$

$$P = \frac{V_m I_m}{2}Cos\delta \qquad \left[\because \int_0^T Cos(2\omega t - \delta)dt = 0\right]$$

$$P = \frac{V_m}{\sqrt{2}}\frac{I_m}{\sqrt{2}}Cos\delta$$

P = $V_{rms} I_{rms} \cos\delta$

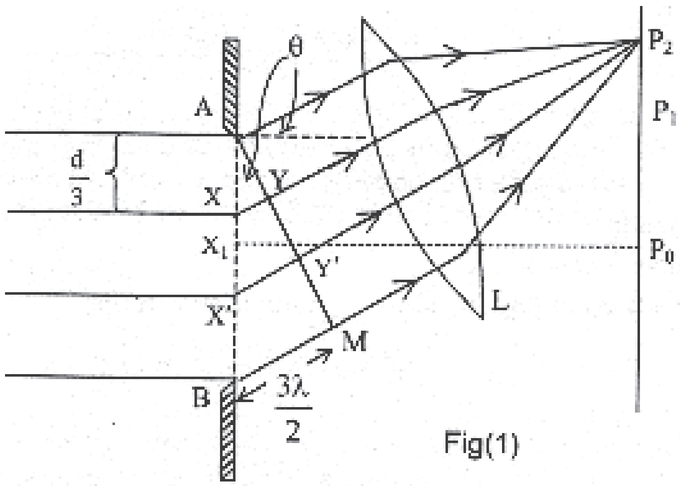
Where $\cos \delta$ = power factor.

2. (1) At region far from the source the electric and the magnetic field vectors oscillate in the same phase.
   (2) The directions of oscillations of the electric and the magnetic field are mutually propendicular and are in a plane perpendicular to the direction of propagaztion of the wave.
   (3) These waves are non-mechanical and of transverse type
   (4) $C = \frac{1}{\sqrt{\mu_0 \in_o}}$ Velocity
   (5) The velocity of electromegnetic waves depends upon the electromagnetic properties of that medium.

3. When an image of an object is formed with a lens, only a limited portion of the wavefront of light passes through the lens, to form an image. This "limitation of the wavefront produces diffraction effects as explained earlier, and to that extent, sharpness of the image is reduced.
Usually one uses a convex lens to obtain a magnified image, and it is normally disired to have both magnified and a sharp. (i.e. clear) image.

For more magnification, focal length of the lens used must be smaller but a smaller focal length in general also means smaller size (i.e. diameter) for the lens. The smaller diameter d will increase the value of $\frac{\lambda}{d}$ so that there is more diffraction, which reduces the sharpness of the image obtained. Thus, we see that one cannot indefinitely reduce the focal length to obtain increased magnification and at the same time maintain the sharpness of the image - such a magnification is not useful. Thus, we see that diffraction imposes a limit on useful magnification by a lens.

4.



Fig(1)

Consider a set of parallel rays associated with the secondary waves emerging from the incident wavefront at AB, with their direction of propagation at an angle θ to the central line XP_o. The optical path difference between these rays can be calculated as follows :

Let us divide the slit into two equal parts.
From A, draw AM perpendicular to the ray BL.
This perpendicular intersects the central ray XP_1 at Y.
Now the optical path lengths for the sections AP_1, YP_1, MP_1, are all equal.
So the path difference between the rays AP_1 and BP_1 is equal to BM;
and the path difference between AP_1 and XP_1 is XY.
Suppose the angle θ selected is such that BM = λ.

$\therefore \frac{BM}{AB} = \frac{\lambda}{d} = \sin\theta \qquad \therefore \lambda = d\sin\theta \quad (\because AB = d)$

and $XY = \frac{\lambda}{d}$; X being the midpoint of AB.
So, generalising this formula for m[th] order minimum.

$$\sin\theta_m = \frac{m\lambda}{d}$$

where m = 1, 2, 3 ....

(C) 1. $\delta = 45 \qquad \therefore \tan\delta = 1$

$$\therefore \tan\delta = \frac{\omega L - \frac{1}{\omega C}}{R} = 1$$

$$\therefore R = \omega L - \frac{1}{\omega C}$$

$$\therefore |z| = \sqrt{R^2 + (\omega L - \frac{1}{\omega C})^2}$$

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

$$\therefore |z| = \frac{Vm}{Im} = \frac{20}{1} = 20\Omega$$

$$\therefore R\sqrt{2} = 20\Omega$$

$$\therefore R = 14.14\Omega$$

2. $C = \lambda f$

$$\therefore f = \frac{C}{\lambda}$$

$$= \frac{3\times10^8}{5600\times10^{-10}}$$

$\therefore\ f = 5.357 \times 10^{14}\ H_z$

3. $\dfrac{I_1}{I_2} = \alpha$ *and* $\therefore\ I \alpha A^2$

$\therefore\ \dfrac{I_1}{I_2} = \dfrac{A_1^{\ 2}}{A_2^{\ 2}} = \alpha \qquad \Rightarrow\ \dfrac{A_1}{A_2} = \dfrac{\sqrt{\alpha}}{1}$

For Constructive Intorfarance $A_1 + A_2 = \sqrt{\alpha} + 1$

$\therefore\ A_1 - A_2 = \sqrt{\alpha} - 1$ *(For destructive Interference)*

$\therefore\ I_{max}\ \alpha\ (A_1 + A_2)^2 \alpha (\sqrt{\alpha} - 1)^2$

$\therefore\ I_{min}\ \alpha\ (A1 - A2)^2 \alpha (\sqrt{\alpha} - 1)^2$

$\therefore\ \dfrac{I_{max}}{I_{min}} = \dfrac{(\sqrt{\alpha} + 1)^2}{(\sqrt{\alpha} - 1)^2} = \dfrac{\alpha + 2\sqrt{\alpha} + 1}{\alpha - 2\sqrt{\alpha} + 1}$

$\therefore\ \dfrac{I_{max} + I_{min}}{I_{max} - I_{min}} = \dfrac{2\alpha + 2}{4\sqrt{\alpha}} = \dfrac{2(\alpha + 1)}{4\sqrt{\alpha}} = \dfrac{1 + \alpha}{2\sqrt{\alpha}}$ *by taking Comp. and dividen.*

4. $x_3 = \dfrac{3\lambda D}{d}$ $\qquad x_9 = \dfrac{9\lambda D}{d}$

$x_9 - x_3 = \dfrac{\lambda D}{d}(9 - 3)$

$0.6 = \dfrac{\lambda \times 100}{0.05} \times 6$

$\lambda = \dfrac{0.6 \times 0.05}{100 \times 6}$

$\lambda = 5000 A^o$

Q.5. (A) 1. $M^0 L^1 T^{-1}$

2. 4.779 A^o

3. $M^1 L^0 T^{-1}$

4. $1S^2\ 2S^2\ 2P^6\ 3S^2\ 3P^6\ 3d^{10}\ 4S^2\ 4P^2$

5. $\beta > 1$

(B) 1. Planck had proposed that the electromagnetic radiation is emitted in discrete quanta of energy but it propagates only as waves. Einstein went further to propose that the electromagnetic radiation propagates in form of particles which he callled photons.

Suppose the incident electromagnetic radiation (light) is of frequency

f. So energy of its photon is hf. When this photon in incident on a metal either if gets entirely absorbed or it does not lose any energy. If an electron in the metal absorbs a photon it will gain an energy hf. Out of this energy it will use an amount equal to its binding energy in coming out of the metal, and the remaining will be the kinetic energy with which it is emitted.

If work function of a metal is W_0 (=hf_0), only those electrons wchich can be liberated on acquiring energy equal to the work function will be emitted witht he maximum kinetic energy.

$\therefore \frac{1}{2}mv_{max}^2 = hf - W_0$ .... (1)

$\therefore eV_0 = hf - hf_0$ .... (2)

$\therefore V_0 = \left(\frac{h}{e}\right)f - \frac{hf_0}{e} = \left(\frac{h}{e}\right)(f - f_0)$ .... (3)

This equation shows that the graph of V_0 vs f should be a straight line graph with a slope of $\frac{h}{e}$ and an intercept along f-axis equal to f_o. This conclusion is in a perfect agreemtn with he observations.

2. Suppose thre are N nuclei of a radioactive element at time t. Let dN of them decay in time (dt) Then

$\frac{dN}{dt}$ is called the decay rate of that element (or its activity).

This rate is proportional to the existing number of nuclei of that element at that time.

$\therefore \frac{dN}{dt} \alpha - N$ (-ve) sign means that the number decreases with time)

$\therefore \frac{dN}{dt} = -\lambda N$

Here λ is a constant called the "radioactive constant" or the "decay constant" of that element.

Integrating this equation

$\therefore \int \frac{dN}{N} = -\lambda \int dt$

$\therefore ln\, N = -\lambda t + C$

At $t = 0 \Rightarrow N = No$

$\therefore lnN_0 = C$

$\therefore \ln N = -\lambda t + \ell n N_0$

$\therefore \ell n \frac{N}{N_0} = -\lambda t$

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

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

3. Sun's centre is at a temp. of about 20 million degrees. Sun preduces energy mostly through the following sequence of reaction. Which is called fusion.

$_1H^1 + _1H^2 \rightarrow _2He^3 + 5 Mev.$

Two of such reactions are then followed by

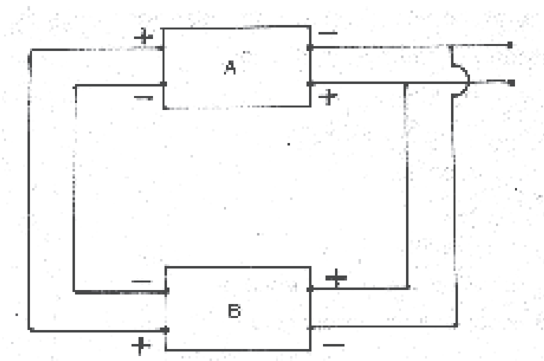
$_2He^3 + _2He^3 \rightarrow _2He^4 + 2(_1H^1) + 12.9 Mev.$

So total energy released 2 (0.4) + 2(5.5) + 12.9 = 24.9 Mev.

The stars with central temp. as in the sun or somewhat lower produce the fusion energy through the above reaction called proton - proton reaction.

The stars with central temp. significantly higher than that at the centre of Sun produce energy by another reaction called C-N cycle.

4.



- Such oscillations are generated by folding part of the output of an ampitified back to its input using an appropriate netwrok.
- For transistor oscillator circuit it is not necessary that the input a.c. signal should be given to the oscillator.
- Part of the output signal of an amplifier A is fed to suitable L-C network B and then fed back to the input amplifier A.
- Such electronic oscillators generate oscillatory voltage with precise

and steady freq.

- The oscillation freq. can be obtained ranging from few Hz to 10^9 Hz.
- Useful in communication, T. V. and radio receivers and transmitters.

(C) 1. mg = m_0g + qE

$$q = \frac{g}{E}(m - mo)$$

$$q = \frac{g}{\frac{V}{d}}\left[\frac{4}{3}\pi r^3\rho - \frac{4}{3}\pi r^3\rho_0\right]$$

$$q = \frac{9.8\times 6\times 10^{-3}}{10^3}\times\frac{4}{3}\times 3.14\times(7.25\times 10^{-7})^3\times(880 - I - 29)$$

$$q = 8.003\times 10^{-19}\, C$$

2. $$\frac{mv^2}{r} = \frac{1}{4\pi\in_0}\frac{2e^2}{r^2}$$

$$\therefore \frac{mr^2\omega^2}{r} = \frac{1}{4\pi\in_0}\cdot\frac{e^2}{r^2}$$

$$\therefore \omega^2 = \frac{1}{4\pi\in_0}\cdot\frac{e^2}{mr^3}$$

$$\therefore \frac{4\pi^2}{T^2} = \frac{1}{4\pi\in_0}\frac{e^2}{mr^3}$$

$$\therefore T^2 = \left(\frac{16\pi^3\in_0 m}{e^2}\right)r^3$$

$$\therefore T^2\alpha r^3 \quad where \quad \frac{16\pi^3\in_0 m}{e^2} = cons\tan t.$$

3. t = 0 100% present

15 Hour 50 % Present

30 Hour 25 % present

45 Hour 12.5% present

60 Hour 6.24% present

100 - 6.25 = 93.75% decay.

Power Gain : Voltage gain x Current gain

$$10 = \frac{\delta V_{CE}}{\delta V_{BE}} \times 0.98$$

$$\therefore 10 = \frac{R_L \delta I_C}{r_i \delta I_B} \times 0.98$$

$$\therefore \frac{r_i}{R_L} = \frac{0.98 \times 0.98}{10}$$

$$\therefore \quad \frac{r_i}{R_L} = 0.096$$

● ● ●

Q.1 (A) Answer in brief. (05)

1. A spring of force constant k is stretched so that its length becomes double. Its Force constant will be _______.
2. The equation of stationary wave is $Y=-10 \sin \frac{\pi x}{3} \cos 20\pi t$. CGS units then what is wave length and frequency of the component waves ?
3. Write dimensional formula of wave intensity.
4. No work is done when a stationary bomb explodes without any external force acting on it. Then why does kinetic energy of its fragments change after explosion ?
5. Two particles of mass m and 3m are separated by 12cm distance. What will be the distance of the particles from their center of mass ?

(B) Answer in eight to ten sentence. (Any 3) (06)

1. Show that for massless elastic spring $k = \frac{mg}{\Delta l}$ and write the unit of k and define k.
2. Write the equation of displacement of S.H.O. differentiating it obtain the equation of acceleration in term of displacement. State where the accelertion is maximum ? What is the slope of the graph of acceleration $\rightarrow$ displacement ?
3. Write the general equation of the frequency experienced by a listener in Doppler's effect. State the sign convention used in it. Write the equation of the frequency of sound experienced by (1) a thief when a police blowing whistles is running after him. (2) A listener when listens a source are going away from each other.
4. Define center of mass for a system of particles, there by obtain $\vec{P} = M\vec{V}cm$.

(C) Solve. (Any 3) (09)

1. For damped oscillations, find the time for decreasing of the amplitude to $\frac{A}{2^n}$.
2. Prove that for a wave propagating in a medium, the ratio of the instantaneous velocity of a particle of the medium to the

wave velocity is equal to the negative value of the slope of the wave form at that point.

3. In a lake, a person is standing on a stationary raft. The distance between the person and the bank is 20m. Mass of the person is 50 kg. and that of the raft is 40 kg. The person now starts running towards the bank with a velocity of 2.5 m/s with respect to the raft. How far will ther person be from the bank after 1 sec ?
4. A ball of 6kg. Mass hits a wall at an angle of 40^o and is then reflected making an angle of 80^o with its original direction of the duration of contact between the ball and the wall is 0.1 sec. Calculate the force exerted on the wall. The initial and the final Velocities of the ball are 2m/s.

Q.2 (A) Answer in brief. (05)

1. Define Torque.
2. Write units and dimensional equation of momentum of ineritia.
3. Why is total energy of a satellite negative ?
4. Heat is flowing through two cylindrical rods of the same material. The diameter of the rods are in the ratio 1:2 and their length are in the ratio 2:1 of the temperature difference between their ends is the same then the ratio of heat currents through them is _______.
5. Give two examples of irreversible processes.

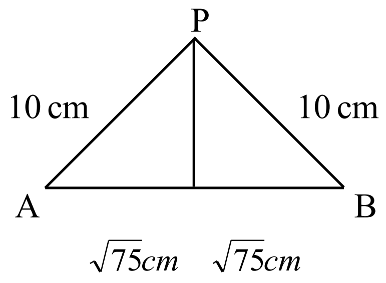
(B) Answer in eight to ten sentences. (Any 3) (06)

1. Draw the diagram of a simple pendulum showing the forces acting on its bob in a displaced position and hence derive $\frac{d^2\theta}{dt^2} + \varpi^2\theta = 0$ for it.
2. Define inertial mass and gravitational mass and write the formulas to obtain them.
3. Write the stages of Carnot's cycle and state the relation between pressure and volume of each stage.
4. Identify the different terms in $\frac{dQ}{dt} = -kA\frac{dT}{dx}$ and define them.

(C) Solve. (Any 3) (09)

1. A rigid body experiences an angular displacement of 300 radians is 6 secnds, and attains an angular velocity of 1000 rad/sec. Find its initial angular velocity and its angular acceleration (assumed to be constant).

2. Prove that the ratio of the linear orbital velocity of a satellite orbiting close to the surface of the earth, to the escape velocity of a stationary body on the earth is $\frac{1}{\sqrt{2}}$.
3. Two sheres each of mass equal to 6 kg. Are placed at points A and B as shown in the figure.



If a small sphere of 10 gm is placed at a point P, what will be the acceleration experienced by it due to the gravitational forces of masses only the force due to gravitation of masses A and B.

4. One mole of ideal gas at NTP is expanded adiabatically to twice its initial volume and its temperature becomes 250 k. Calculate the change in the internal energy of the gas during this expansion. (Use γ=1.4, R=8.3 Joule/mole k).

Q.3 (A) Answer in brief. (05)

1. A carbon register has only three bands of color. What will be its tolerance ?
2. Under what condition will the EMF of a cell become equal to its terminal voltage.
3. What is the unit of magnetic flux ?
4. What is Inductor ?
5. One square coil has area of 10^{-2} met^2 ? It is kept perpendicular to uniform magnetic field of intensity 10^3 tesla. The flux passing through the coil will be _______.

(B) Answer in eight to ten sentence. (06)

1. By accepting single valuedness of electropotential in an appropriate circuit diagram, derive kirchoffs second rule.
2. Write an explain Faraday's second law of electrolysis and also define chemical equivlent.
3. A stright conductor of infinite length, carries electric current I along X-axis. Derive the formula for the magnetic field at a point laying on X-Y plane whose position co-ordinates are (x,y).
4. On what factor does mutual Inductance of a system of two coil depends.

(C) Solve. (Any 3) (09)

1. When a circuit is completed by connecting a resistance of 10 ohms to an electrical cell, a current of 5mA is obtained. Now if an unknown resistance X is connected in series. With the 10 ohm resistance the current obtained is 4mA. Find the value of X. (neglect internal resistance of the cell).
2. A DC motor is connected to a 110V direct voltage supply and draw 5amp. current. If its mechanical efficiency is 40% find the resistance of its windings.
3. A circular coil havig a average radius of 6cm has 1000 turns. A current of 5 amp passes through it. Find the magnetic field at a point on its axis 8 cm from the center $\left(\mu_0 = 4\pi \times 10^{-7} \frac{tesla-meter}{Amp}\right)$.
4. Flux linked per each turn of a coil of N turns changes from $\phi_1 \; to \, \phi_2$ If the total resistance of the circuit including the coil, is R, Prove that charge Q induces is given by $Q = \frac{N(\phi_2 - \phi_1)}{R}$

Q.4 (A) Answer in brief. (05)

1. If the phase lag between V and I in and a.c. circuit is δ, what is the time lag ?
2. The ratio of the number of turns in primary coil to that in the secondary coil is 5:1 if the current in the primary coil is 200mA then the current in the secondary coil will be _______.
3. What is the frequency of waves generated in Hertz Experiment ?
4. Define plane of Oscillations.
5. The ratio of amplitude of two interfering waves is 3:2 what is the ratio of maximum resultant intensity to the minimum resultant intensity ?

(B) Answer in eight to ten sentences. (Any 3) (06)

1. Draw a neat diagram of A.C. dynamo or generator. Derive expression of flux linked with the coil at time 't'.
2. Explain the generation of oscillating eletric and magnetic fields in Hertz experiment.
3. Explain 'sky waves' and 'space wave' with necessary figure.
4. State the condition for m^{th} order minima and maximum in fraunhoffer diffraction by a single slit and plot graph of intensity.

(C) Solve. (Any 3) (09)

1. For an A.C. generator V=0 at t=0 and V=2 volt at $t = \frac{1}{100\pi}$ second.

The voltage reaches a peak value of 100 volt. Find the frequency of voltage.

2. Velocity of electromagnetic waves in vaccum is $3x10^{s}$ km/sec. If the permeability of vacuum is $4\pi \times 10^{-7}$ Weber / amp-met. Find its permittivity.
3. In young's double slit experiment the separation of slits is 0.05cm and a screen is placed at a distance of 100cm. Find the separation between centers of the third bright and the fifth dark fringes. For light of wave length 5000 A.
4. The ratio of intensities of rays emitted from two different coherent sources is α. For the interference pattern formed by them prove that : $\frac{Imax + Imin}{Imax - Imin} = \frac{\alpha + 1}{2\sqrt{\alpha}}$, I max = maximum of intensity in the interference pringes, I min = minimum of intensity in the interference fringe.

Q.5 (A) Answer in brief. (05)

1. The electric and magnetic field applied in Thomson's experiment of e/m are 4900 v/m and 3.5×10^{-4} tesla. What is the horizontal velocity of electrons.
2. The ratio of velocity of cathode ray in Thomson's experiment to that of velocity of light in vacuum is _______.
3. What idea regarding the nucleus is obtained from the binding energy per nucleon ?
4. What is avalanche current in. Reverse bias condition of PN junction diode.
5. α=0.98 for a transistor if I_c=4.9mA then find base current.

(B) Answer in eight to ten sentences. (Any 3) (06)

1. Describe the apparatus of Millikan's experiment of finding charge of an electron with necessary diagram.
2. Obtain the equation of the radius of the orbit of electron in n^{th} orbit in Bohr model.
3. Derive exponential law of radioactive disintegration. Using the equation draw the decay curve.
4. Draw the circuit diagram of half wave rectifier and explain the process of rectification taking place during one complete cycle of Input A.C.

(C) Solve. (Any 3) (09)

1. A 100 watt bulb converts 5% of electrical energy consumed by it into light energy of the wagelength emitted by the bulb is 6625 A^o, Calculate number of photons emitted per second. [$h=6.625x10^{-34}$ joule-sec, $c = 3x10^{8}$ m/sec].

2. Show that in a hydrogen atom angular speed of an electron is given by $\omega = \dfrac{\pi m e^4}{2\varepsilon_0^2 n^3 h^3}$

3. At a specific time the rate of radioactive decay of a substance is 8000 nuclei/sec. At that time the undecayed number of nuclei is 8×10^7. Find the decay constant and the half-life.

4. If the collector current of an NPN common emitter amplifier shows a change in its collector current by 4.5mA when the input voltage changes by 25 milli volt. Find its Tranconductance.

• • •

SOLUTION

Q.1 (A) 1. 2K

2. $k = \frac{\pi}{3} \Rightarrow \frac{2\pi}{\lambda} = \frac{\pi}{3} \Rightarrow \lambda = 6cm,$

$w = 20\pi \Rightarrow 2\pi f \Rightarrow f = 10Hz.$

3. $M^1L^0T^{-3}$.

4. Because internal energy associated with the chemical bonding is released which appears in the form of Kintu energy of its pragments.

5. $m_1 = m; m_2 = 3m$

$|\vec{r}_{cm}| = \frac{m_1|\vec{r}_1| + m_2|\vec{r}_2|}{m_1 + m_2}$ (Taking center of mass as origin).

$0 = \frac{m_1|\vec{r}_1| + m_2|\vec{r}_2|}{m_1 + m_2}$

$0 = m(r_1) + 3m(r_2)$ (ignoring negative sign)

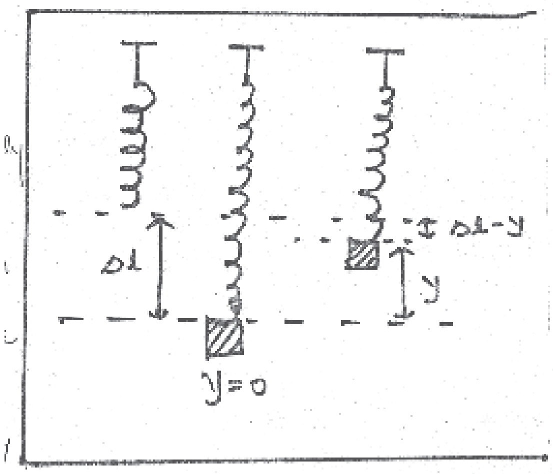
$\therefore r_1 = 3r_2$

but $r_1 + r_2 = 12cm$

$3r_2 + r_2 = 12$

$r_2 = 3cm$ *and* $r_1 = 9cm$ $(\because r_1 + r_2 = 12)$

(B) 1. A mass-less plastic spring obeying Hooke's law, is suspended in normal position, vertically from a rigid support as shown in Fig.



* When a body of mass in is suspended from its lower end, length of the spring increase by Δl under the influence of weight (mg) and the body comes into equilibrium.

* The suspended mass is acted upon the two forces.
  (i) Its weight mg acting down ward and
  (ii) The restoring force (KΔl) due to the elasticity of the spring acting upwards.

* For the equilibrium condition mg = KΔl where K = force constant of the spring.

Definition :

The force required (OR restoring force produced in the spring) per unit change in the legnth of the spring is called force constant (k) of the spring. Unit of K= N/m (MKS) dyne/cm in C.G.S. system.

2. The displacement of a S.H.O. is given by

$y = A\sin(\omega t+\phi)$ ...(1)

velocity of S.H.O.; $v = \frac{dy}{dt}$

$= d\frac{[A\sin(\omega t+\phi)]}{dt}$

$A\omega\cos(wt+\phi)$ ... (2)

the time derivative of velocity of SHO is called acceleration.

$a = \frac{dv}{dt}$

$a = \frac{d[Aw\cos(\omega t+\phi)]}{dt}$ $\rightarrow$ from eqp. .....(2)

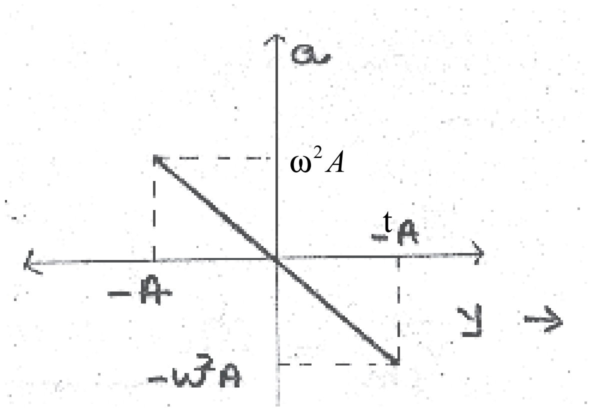
$a = -\omega^2 ASin(\omega t+\varphi)$ - from eq. ...(1)

$a = -w^2 . y$ ...(3)

Eq. (3) shows that $a \alpha - y$, i.e. the acceleration is directly proportional to the displacement and it is in opp. direction.

Graph of Acceleration $\rightarrow$ displacement. :

Slope of the graph is $-\omega^2$



3. Sign convention :-

Velocity in the direction from listener to the source is considered positive and velocity in opposite direction is considered negative. "Velocity of sound is always positive".

$\frac{f_L}{V+V_L} = \frac{f_S}{V+V_S}$ ....(1)

V = velocity of sound in still air.

V_S = velocity of the source.

V_L = Velocity of the listener to the source.
f_S = Frequency of sound waves emitted by the source.

(i) Both listerner and source are moving away from each other. the frequency of sound heared by the listener is smaller than the frequency emitted by the source. $f_L = \left(\frac{V - V_L}{V + V_S}\right) fs$

(ii) Frequency of sound heared by a thief when a policeman is blowing whistle and running after him. Here the thief is the listener and policeman is the source of sound. $f_L = \left(\frac{V - V_L}{V + V_S}\right) fs$.

4. Consider a system n particles of mass $M_1, M_2, M_3 ....M_n$. If $\vec{r}_1, \vec{r}_2, \vec{r}_3, ... \vec{r}_n$ are their respetive position vectors with respects to some origin then the center of mass of the system is defined as a point whose position vector $\vec{r}_{cm}$ is given by the following equation.

$$\vec{r}_{cm} = \frac{M_1\vec{r}_1 + M_2\vec{r}_2 + ... + M_n\vec{r}_n}{M_1 + M_2 + ... + M_n} \quad ....(1)$$

Taking $M_1 + M_2 + M_3 + ...M_n$=M=total mass of the system then from above equation.

$$M\vec{r}_{cm} = M_1\vec{r}_1 + M_2\vec{r}_2 + ... + M_n\vec{r}_n$$

differentiating above equation with respect to time, taking masses constant.

$$M\frac{d\vec{r}_{cm}}{dt} = M_1\frac{d\vec{r}_1}{dt} + M_2\frac{d\vec{r}_2}{dt} + ... + M_n\frac{d\vec{r}_n}{dt}$$

But $\frac{d\vec{r}_1}{dt} = \vec{V}_1 \; \frac{d\vec{r}_2}{dt} = \vec{V}_2 .... \frac{d\vec{r}_n}{dt} - \vec{V}_n$

and $\frac{d\vec{r}_n}{dt} - \vec{V}_{cm}$ velocity of the center of mass then.

$M\vec{V}_{cm} = M_1\vec{V}_1 + M_2\vec{V}_2 + ... + M_n\vec{V}_n;$

$M_1\vec{V}_1 = \vec{P}_1 .... M_n\vec{V}_n = \vec{P}_n$

are the linear momenter of n particles resp. and

$M\vec{V}_{cm} = \vec{P}$ = linear momentum.

$\therefore M\vec{V}_{cm} = \vec{P} = \vec{P}_1 + \vec{P}_2 + ... \vec{P}_n$

Thus linear momentum of center of mass of a system of particles is equal to the vector sum of linear momentum of all particles and it is equal to the product of total mass and velocity of center of mass.

(C) 1. $A(t) = Ae \text{ -btn} = A \exp\left(-\frac{bt}{2m}\right)$

$$\frac{A}{2^n} = A\exp\left(\frac{-btn}{Qm}\right) \quad \therefore 2^{-n} = \text{Exp}\left(-\frac{btn}{Qm}\right)$$

$$n\ln 2 = \frac{btn}{2m} \quad \therefore tn = \frac{2m}{b} n.\ln 2$$

$$tn = \left(\frac{2m}{b}\right)(n)(2.303)\log 2$$

$$tn = \left(\frac{2m}{b}\right)(n)(0.693)$$

2. The equation of propagating harmonic wave is y = A sin (ωt - *kx*)
Instantaneous velocity of particle is given by

$\vartheta_p = \frac{dy}{dt}$ = Aω cos (wt - kx) 1

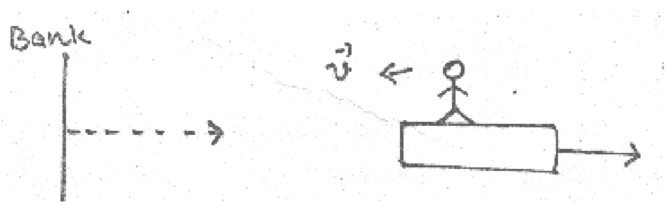
Slope of the wave form is given by $\frac{dy}{dx}$ = -A(k) cos (ωt - *kx*) ....(2)

from eq. (1) $\div$ (2)

$\frac{\vartheta_p}{slope} = -\frac{w}{k}$ But, $\frac{w}{k} = \vartheta$ = wave velocity

$\therefore \frac{\vartheta_p}{slope} = -v$ $\therefore \frac{\vartheta_p}{v} = -slope$

3.



Here no external force is acting on the system comprising of the pason and the raft. Therefore momentum of this system is conserved. As shown in figure, let $\vec{\vartheta}$ be the velocity of the person relative of the raft. A let $\vec{\vartheta}$ be the velocity of the raft relative to the bank.

Velocity of the person relative to the bank = $\vec{\vartheta} - \vec{v}$

Momentum of the person with respect

to the bank = M ($\vec{\vartheta} - \vec{v}$)

M = mass of the person.

Momentum of the raft = M $\vec{v}$ (M being the mass of the raft)

Acc to law of convervation of linear momentium m ($\vec{\vartheta} - \vec{v}$) = M$\vec{v}$

M$\vec{v}$= (m + M) $\vec{v}$ $\therefore$ 50 x 2.5 = (50 + 40)

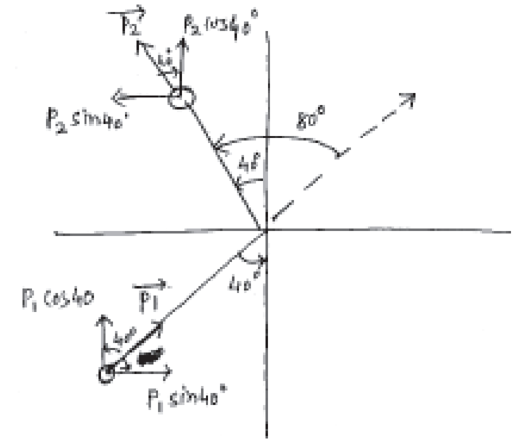
$\therefore$ V = 1.38 m/sec.

Velocity of person with respect to bank = (2.5 - 1.38) = 1.12 met/sec.

Initially the person is 20 m away from the bank.

After 1 second he will be 20 - 1.12 = 18.87 meter away from the bank.

4.



Initial momentum $\vec{P_1} = P_1 \sin 40°\,\hat{i} + P_1 \cos 40°\,\hat{j}$

$= MV_1 \sin 40\,\hat{i} + MV_1 \cos 40\,\hat{j}$ — (1)

Final momentum $\vec{P_2} = -P_2 \sin 40\,\hat{i} + P_2 \cos 40\,\hat{j}$

$= -MV_2 \sin 40\,\hat{i} + MV_2 \cos 40\,\hat{j}$ — (2)

∴ change in momentum $\Delta \vec{p} = \vec{P_2} - \vec{P_1}$ $(\because V_1 = V_2)$

$= -2MV \sin 40°\,\hat{i}$

$= -2 \times 6 \times 2 \times 0.6428$

$= -15.427\,\hat{i}$ N.S

∴ momentum imparted to the wall $= -15.427\,\hat{i}$ N.S

∴ Force on the wall $= \dfrac{\text{momentum imparted}}{\text{Contact time}}$

$= \dfrac{-15.43\,\hat{i}}{0.1}$

$= -154.3\,\hat{i}$ Newton.

∴ the wall will experience a force of +154.3 Newton in +Ve x- direction.

Q.2 (A) 1. The cross product of position vector of a particle with respect to a reference point and force acting on it is called torque acting on the particle.

2. Unit : kg - m^2 dimensional equatio $M^1L^2T^0$.

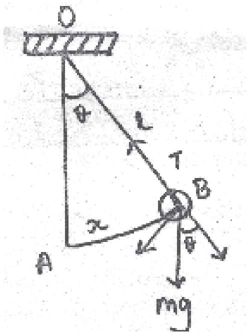
3. Because its negative potential energy is more than its kinetic energy.

4. $$\frac{d\theta}{dt} = -kA\frac{\Delta T}{\Delta x} = -k\pi r^2 \frac{\Delta T}{l}$$

$$\frac{(d\theta/dt)_1}{(d\theta/dt)_2} = \left(\frac{r_1}{r_2}\right)^2 \frac{l_2}{l_1} = \left(\frac{1}{2}\right)^2 \frac{1}{2} = \frac{1}{8}$$

5. Rusting of iron and errosion of the rocks.

(B) 1. Consider simple pendulum as shown in pig. let m - mass of the bob $\bar{l} = OA = OB$ length of the pendulum.



B = displaced position.
(i) mg = weight of the bob is vertically downword direction
(ii) T = tension in the string acting parallel to string.
the line of action of the tension T passes through the point of suspension, hence the toque due to it is zero.

$\vec{\tau} = \vec{l} \times m\vec{g}$

$\tau = -mgl \sin\theta$

-ve sign shows that torque is in oppditn to the angular displacement θ of the bob,

$$\tau = I\alpha = I\frac{dw}{dt} = I\frac{d^2\theta}{d^2\theta} \ and \ I = ml^2$$

$$ml^2\frac{d^2\theta}{dt^2} = -lmg\sin\theta$$

$$\Rightarrow \frac{d^2\theta}{dt^2} = -\frac{g\sin\theta}{l}$$

- Angular displacement is very small then $Sin\theta \cong \theta$

hence $\frac{d^2\theta}{dt^2} = -\frac{g}{l}\theta$

substituting $\frac{-g}{l} by = \omega^2$

we get

$$\frac{d^2\theta}{dt^2} + w^2\theta = 0$$

This is the diff. Eqn. of angular harmonic motion.

2. In Newton's second law of motion. Force = Mass x accelaation the term "mass" appears as a parameter, which "opposes" the action of applied force. Accl^n, which represents the change in the state of motion, is inversely proportionaly to this mass.

- "The mass which tends to oppose the change in the state of Motion of a body is called the inertial mass of the body. "The enertial mass is denoted by m_i and is give by equation;

  F = Mi x a 1

- The force acting on a body in the gravitional field of another body is proportional to its mass. This force acting on the body is given by

$$F = \frac{GMemg}{\text{Re}^2} \quad ....2$$

m_g in the above equation is called gravitational mass.

3. Four stages of carnot's cyclic process & their corresponding equation are as follows :-

1. Isothermal expansion : $Q_1 = nRT_1 \ell n \frac{V_2}{V_1}$ 1

   and $P_1V_1 = P_2V_2$ 2
2. Adiabatic Expansion :

   $$P_2\gamma_2 = P_3\gamma_3 \quad ......3$$
3. Isothermal Compression :

   $$Q_2 = nRT_2 \ell n \frac{V_3}{V_4} \quad ......4$$

   $$P_3\gamma_3 = P_4\gamma_4 \quad ......5$$
4. Adiabatu compression : $P_4\gamma_4 = P_1\gamma_1$ 6

4. In equation $\frac{dQ}{dt} = -kA\frac{dT}{dx}$

K = Thermal conductivity of the substance at a given temp.

A = Area of coss section.

$\frac{dT}{dx}$ = temp gradient at distance x from the hot end.

Defination : "The temp deference (or change in temp) per unit length (distance)"

- V_e sign indicates that as x increases, the temp of successive part descrease.

$\frac{dQ}{dt}$ = rate of heat flow or heat current.

Defination : The amount of heat energy passing normally through a unit area of cross section in the unit length is called heat current in the rod.

(C) 1. θ = 300 radians. $\theta = \left(\frac{w + w0}{2}\right)t$

t = 6 Sec. $300 = \left(\frac{100 + w0}{2}\right)6$

w = 100 rad/sec. $\therefore 100 = 100 + wo$

wo = ? $\therefore wo = 0 rad / sec.$

α = ?

$$\alpha = \frac{w - wo}{t} = \alpha = \frac{100 - 0}{6} = \frac{100}{6} = 16.6 rad / \sec^2$$

2. $\frac{MV^2}{Re} = \frac{GMem}{Re^2} = gm$

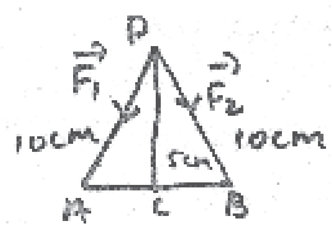
$\therefore$ Orbital velocity $V = \sqrt{g\,Re}$

Escape Velocity on surface of the earth is

$$v = \sqrt{\frac{2GMe}{Re}} = \sqrt{\frac{2GMe\,Re}{Re^2}} = \sqrt{g\,Re}$$

$$\frac{v}{v_e} = \frac{1}{\sqrt{2}}$$

3. $M_1 = M_2 = 6$Kg. = Masses of two spheres of points A & B.



M = 10 x 10^{-3} Kg = Mass of the sphere at PtP.

r = 0.1m = 10^{-1}m

G = 6.67 x 10-11 Nm^2/Kg^2

Suppose F_1 & F_2 are force acting on melue to M_1 & M_2 respectively.

$$F_1 = \frac{GM_1M}{r^2} \ \& \ F_2 = \frac{GM_2M}{r^2} \qquad (m_1 = m_2)$$

$$F_1 = F_2 = \frac{6.67\times10^{-11}\times6\times10\times10^{-3}}{10^{-2}} = 4.00\times10^{-10}\,N.$$

From Pig ΔPCA $Cos\theta = \frac{5}{10} = \frac{1}{2}$ $\therefore \theta = 60^0$

$\therefore$ angle between $\vec{F_1}$ & $\vec{F_2}$ is $2\theta = 120^0$

resultant porce $\vec{F} = \vec{F_1} + \vec{F_2}$

$$\therefore F = \sqrt{\vec{F_1} + \vec{F_2} + 2F_1F_2Cos120^0}$$

$$F = \sqrt{F_1^2 + F_2^2 + 2F_1(-\frac{1}{2})} \qquad (\because F_1 = F_2)$$

$F = 4.00\times10^{-10}\,N.$

Now,

$$a = \frac{F}{M} = \frac{4.00\times10^{-10}}{10\times10^{-3}} = 40.0\times10^{-9}$$

$$a = 40.0\times10^{-9}\,\frac{meter}{\sec^2}$$

4. Here n=1, $V_2 = 2V_1$, $T_1 = 27^oC = 300$ K

$T_2 = 250$ K $\qquad \gamma = 1.4 \qquad$ R = 8.3 J/mole

K Δ U = ?

The equation of work done during an adiabatic process is

$$w = \frac{nR}{\gamma - 1}\left[T_1 - T_2\right] = \frac{1\times8.3}{0.4}(300-250) = \frac{8.3\times50}{0.4}$$

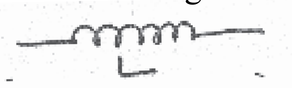
$= 8.3 \times 125 = 1037.5$ Joule

Now for an adiabatic process $\Delta Q = 0$ $\therefore$ from 1st law of thermodynamics.

$\Delta u = -Dw$ $\therefore$ $\Delta u = -1037.5$ J

$\Delta u = -1037$ x 5J i.e. the internal energy decrease by 1037.53.

Q.3. (A) 1. 20%

2. When no current is flowing.
3. Unit of magnetic flux is weber.
4. 

a component which has self inductance is called an "inductor"
5. $A = 10^{-2}$ mt^2

$B = 10^3$ tesla

$\phi = ?$

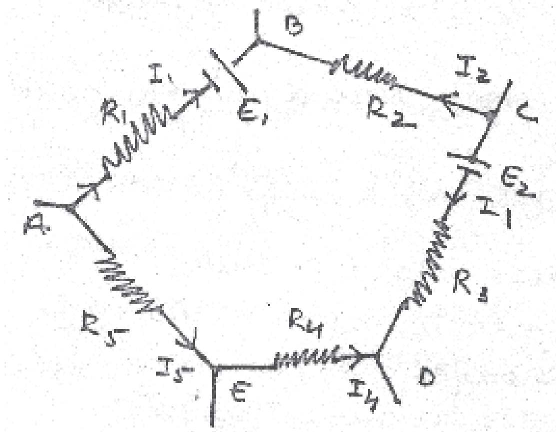
ϕ = area x magnetic field.

$\phi = 10^{-2} \times 10^3$

ϕ = 10 weber.

(B) 1. Consider a loop ABCDEFA as shown in fig.

The loop is formal by resistance R_1, R_2, R_3, R_4 & R_5 and batteries of e.m.f., E_1, & E_2. Suppose electric potential at Pt A is VA.



Suppose positive change are moved in the loop in clock wise direction. The value of electric potential increases or decrease according to the direction of current the connection of cells.

On the direction of current potential decreases IR after passing through resistance R in opposite directon of the current the potential increases by IR.

Insasteadly circuit due to single valued ness of electripotential, value of potential becomes equal to VA again.

using

$$VA = I_1R_1 + \in_1 + I_2R_2 - \in_2 - I_3R_3 + I_uR_u + I_5R_5 = VA$$

$$\sum IR = \sum \in$$

These equation represent kirchhof's second law.

Kirchhoff's Second Law :- "Along aclosed circuit loop the algebraic sum of the product of resistance with the corresponsding value of current flowing through them is equal to the algebraic sum of the e.m.f. applied along the loop."

2. Law : 2

"When same current is passed for same time through different electrolytes the masses of elements deposided from the electrolytes are in proportion to the chemical requivalents.

Chemical equivalent of any element is the ratio of atomic weight the valency of that element :

$$e = \frac{atomicweight}{valancy}$$

Wt M_1 & M_2 be masses of two substance liberated at the electrodes when same current I is passed theough two chemical cells, for same time interval e_1, e_2 are their chemical equivalents resp. then according to Faraday's Second law of electrolyses.

$$\frac{M_1}{M_2} = \frac{e_1}{e_2} \qquad \text{........ 1}$$

3. In equation

$$\vec{B} = \frac{\mu_0 I}{4\pi} \int_{\infty}^{\infty} \frac{ydx}{(x^2 + y^2)^{3/2}} \hat{K}$$

$$x = y\,tan\,\theta$$

$$dx = y\,sec^2\,\theta d\theta$$

$$x = -\infty \Rightarrow \frac{-\pi}{2}$$

$$x = \infty \Rightarrow \frac{\pi}{2}$$

$$\vec{B} = \frac{\mu_0 I}{4\pi} \int_{-\pi/2}^{\pi/2} \frac{ySec^2\theta d\theta}{(y^2 \tan^2\theta + y^2)^{3/2}} \hat{K}$$

$$= \frac{\mu_0 I}{4\pi} \int_{-\pi/2}^{+\pi/2} \frac{y^2 Sec^2\theta}{y^3 Sec^3\theta} d\theta \hat{K}$$

$$= \frac{\mu_0 I}{4\pi y} \int_{-\pi/2}^{\pi/2} Cos\theta \bullet d\theta$$

$$= \frac{\mu_0 I}{4\pi y} [Sin\theta]_{-\pi/2}^{\pi/2} \hat{K}$$

$$= \frac{\mu_0 I}{4\pi y} [1 + 1] \hat{K}$$

$$|\vec{B}| = \frac{\mu_0 I}{2\pi y}$$

4. Mutual inductance of a coild depends upon
   1. Shapes of the coil
   2. Size of the coil
   3. Number of lines of the coil
   4. Distance between them.
   5. Their mutual encilination angle.
   6. Material on which they are wound.

Q.5. (A) 1. R_1 = 10 ohm R_2 = (10 + x) ohm
I_1 = 5 Milliamp. I_2 = 4 milliamp
= 5 x 10^{-3} amp. x = ?

$I_1 R_1 = I_2 R_2$

$5 \times 10^{-3} \times 10 = 4 \times 10^{-3} \times (10 + x)$

5.0 = 40 + 4x

4x = 10

x = 2.5 Ohm.

2. V = 110 Volt, Mechanical efficiency = 40 %
I = 5 amp = 0.4 R = ?
Power being consumed P = VI = (110) (5)
= 550 watt
Mechanical Power = Efficiency electric power
0.4 x 550 = 220 Watt.
Power dissipated in the form of heat
= 550 - 220 = 330 Watt.
R = Resistance of Motor Windeng's

$$R = \frac{330}{25} = 13.2\Omega$$

3. a = 6 cm = 10^{-2}m.
N = 1000
I = 5A
x = 8 cm = 8 x 10^{-2} m.

$r_0 = 4T \times 10^{-7}\, T - m / A$

B = ?

$$= \quad B = \frac{\mu_0 I a^2 N}{2(a^2 + x^2)^{3/2}} = \frac{4\pi \times 10^{-7} \times 5 \times 36 \times 10^{-4} \times 1000}{\left\{2C36 \times 10^{-4} + 64 \times 10^{-4}\right\}^{3/2}}$$

$$= \quad 11.3 \times 10^{-3}\, T$$

4. $$\in = \frac{N\Delta\phi}{\Delta t}$$

We ingnore the negative sign in the problem)

$$\in = \frac{N(\varnothing_2 - \varnothing_1)}{Dt}$$

$\therefore I = \frac{\in}{R} = \frac{N(\varnothing_2 - \varnothing_1)}{Rt}$

Q = It

$= \quad N\frac{(\varnothing_2 - \varnothing_1)}{R}$

Q $= \quad \frac{N(\varnothing_2 - \varnothing_1)}{R}$

Hence proneel.

(B) 1. Time lag is $\frac{\delta}{\omega}$.

2. $\frac{N_1}{N_2} = \frac{5}{1}; I_1, = 200 \times 10^{-3}$ amp

$I_2 = \frac{N_1}{N_2} = \frac{5}{1}; I_1, = 5 \times 200 \times 10^{-3} = 1$ amp.

3. The frequency of the waves generate is same as the frequency of the oscillation of the change between the spheres. (along the spark gap)

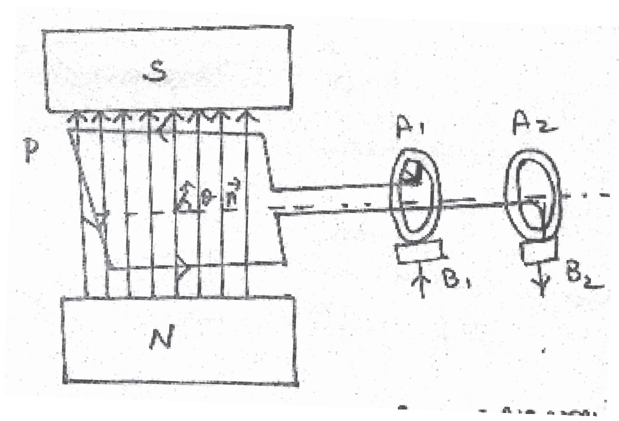
4. The plane containing the direction of the beam and the direction of the $\vec{E}$ vectors of plane polarized light is called the plane of oscillation.

5. $\frac{A_1}{A_2} = \frac{3}{2} \therefore \frac{A max}{A min} = \frac{A_1 + A_2}{A_1 - A_2} = \frac{5}{1}$

$\Rightarrow \frac{Imax}{Imin} = \left(\frac{A max}{A min}\right)^2 = \frac{25}{1}$

$\therefore Imax : Imin = 25 : 1$

(B) 1.



A.C. Dynamo or A.C. generator.

* Conducting coil PQRS having N then is kept in a uniform magnetic field $\vec{B}$.
* The coil is rotating with uniform angular speed to about x-axis.
* Mangite field ($\vec{B}$) is directed along y-axis.
* A_1 and A_2 are slip rings connected with the two ends of the coil, making sliding contacts with Bruches B_1 and B_2.

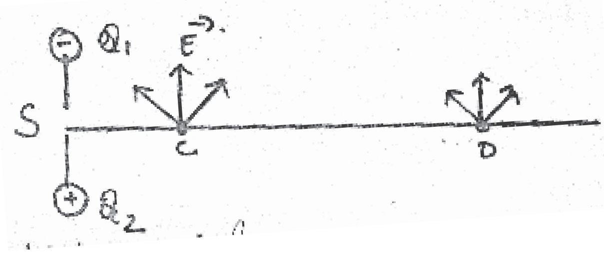
If ever vector $\vec{A}$ of the coil makes angle with magnite field $\vec{B}$ at time t=0 then the magnetic flux linked with the coil at t=0 is

$\phi_o = NAB \cos 0 = NAB$

If the coil is rotating with angular velocity to then at time 't' $\phi = \omega t$ hence the magneti flux at time 't' can be given by.

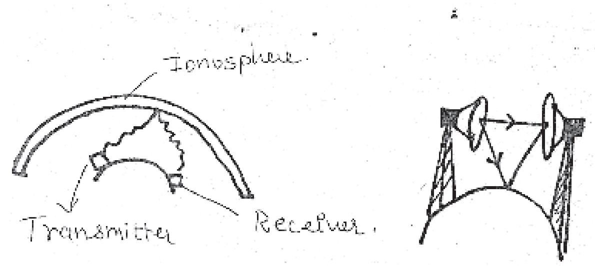
$\phi = NAB cos\omega t$

2.



* As shown in figure suppose sphere Q_1 in the appratus of Hertz's experiment is negatively changed and Q_2 is positively charged at an instant.
* The intensity of electric field at points C and D are in upward direction as shown in fig.
* When the spark passes through S the electrons on Q_1 are transferred to Q_2.
* The oscillating electrons from periodically changing electric current which gives rise to Periodically changing magnetic fields at point C and D.

3.

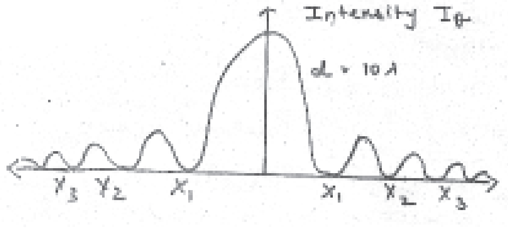


Sky Waves :- HF waves gets absorbed by the soil. But the part of these waves entering the atmosphere gets reflected back by the ionosphere and can be received by the receiver. Such wave are called Sky Waves.

Space Waves :- The VHF and frequencies more propagates on straight path from the transmitter to the receiver as shown in figure where as some waves reach the receive after being reflected from earth surface.

4. For m^{th} order minimum we can show that $\sin\phi m = \frac{m\lambda}{d}$ where m = 1,2,3....

The graph of intensity $I\phi \rightarrow \phi$ for different points on the screen is shown in the fig.



(C) 1. Here, $t = \frac{1}{100\pi} sec, v = 2volt, v_m = 100volt, f = ?$ here value of

$t = \frac{1}{100\pi}$ is small then value of ω_t is small. Then $Sin\omega t = \omega t$.

Now, V $= V_m Sin\omega t$

V $= V_m\ cot$

$$\omega = \frac{V}{V_m t} = 2\pi f \Rightarrow f = \frac{V}{2\pi V_m t}$$

$$= \frac{2}{2\times\pi\times100} \times \frac{1}{100\pi}$$

$\therefore f = 1Hz.$

2. Given C = 3 x 10^5 km/sec Co = 4π x 10^{-7} weber/amp mt.

= 3 x 10^8 m/sec

$$C = \frac{1}{\sqrt{\mu_0 \in_0}} \Rightarrow 3\times10^8 = \frac{1}{\sqrt{4\pi\times10^{-7}}}$$

$$\therefore (3\times10^8) = \frac{1}{4\pi\times10^{-1} \in 0}$$

$$\in_0 = \frac{1}{9\times10^{16}\times4\pi\times10^{-7}} = \frac{1}{36\times3.14}\times10^{-9}$$

$\log \in_0 = \left[log 1 - (log 36 - 1 log 3.145\right]\times10^{-9}$

$= [0.0000 - (1.5563 + 0.4969)]\times10^{-9}$

$= [0.0 - 2.0532]\times10^{-9}$

$= [\bar{3}.9468]\times10^{-9}$

$\in_0 = anti\ log[\bar{3}.9468]\times10^{-9}$

$= 0.008847\times10^{-9}$

$\in_0 = 8.847\times10^{-12} coulonub^2 / N.mt^2$

3. Given d = 0.05 cm = 5 x 10^{-4} m

D = 100 cm = 1m; $\lambda = 5000\times10^{-10} m$

n = 3 (Bright f); 1 = 5 x 10^{-7} m.

n = 5 (Dark f); x_5 - x_3 = ?

$\rightarrow$ n = 3

$$\frac{xnd}{D} = n\lambda \Rightarrow x_3 = \frac{3\lambda D}{d}$$

n = 5

$$\frac{xnd}{D} = (2n-1)\frac{\lambda}{2} \Rightarrow x_5 = \frac{9\lambda D}{rd} = \frac{4.5\lambda D}{d}$$

Distance between 3rd 5th fringe.

$$x_5 - x_3 = 4.5\frac{\lambda D}{d} - \frac{3\lambda D}{d}$$

$$= \frac{\lambda D}{d}(4.5-3) = 1.5$$

$$= 1.5 \times \frac{5\times10^{-7}\times1}{5\times10^{-4}} = 1.5\times10^{-3}m$$

$$x_5 - x_3 = 1.5\times10^{-3}m$$

4. Given $\frac{I_1}{I_2} = \alpha;$

$$\frac{I_1}{I_2} = \frac{A^2{}_1}{A^2{}_2} = \alpha; \frac{A_1}{A_2} = \sqrt{\alpha}$$

$$\frac{A_1 + A_2}{A_1 + A_2} = \frac{1+\sqrt{\alpha}}{\sqrt{\alpha}-1}; \frac{A max}{A min} = \frac{1+\sqrt{\alpha}}{\sqrt{\alpha}-1}$$

$$\rightarrow \frac{Imax}{Imin} = \frac{A^2\,max}{A^2\,min} = \frac{(1+\sqrt{2})^2}{(\sqrt{\alpha}-1)^2} = \frac{1+2\sqrt{2}+2}{\alpha-2\sqrt{2}+1}$$

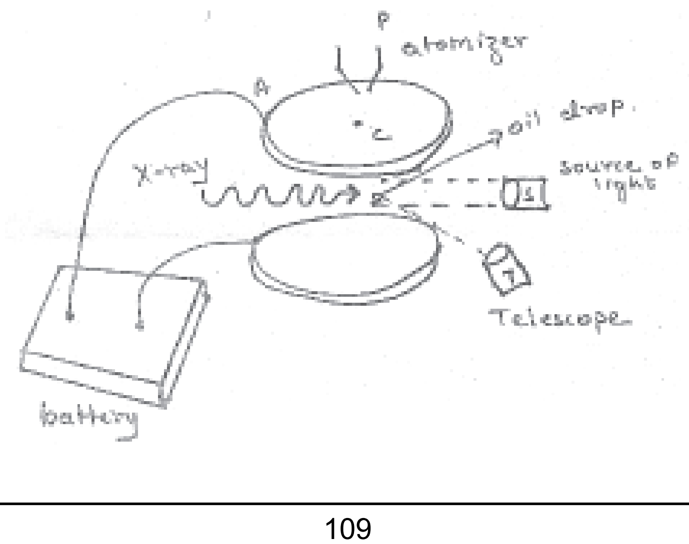
$$\frac{Imax+Imin}{Imax-Imin} = \frac{1+2\sqrt{2}+\alpha+2-2\sqrt{2}+1}{1-2\sqrt{\alpha}+\alpha+2-C+2\sqrt{2}-1}$$

$$= \frac{2(\alpha+1)}{4\sqrt{\alpha}} = \frac{\alpha+1}{\alpha\sqrt{2}}$$

Q.5 (A) 1. Velocity $V = \frac{E}{B} = \frac{4900}{3.5\times10^{-4}} = 1.4\times10^7$ *Met / Sec.*

2. 1:10
3. Binding energy per nucleons is a measure of the stability of the nucleus.
4. The sudden increase in the current at breakdown voltage in reverse based R N junction diode is known as avalenche.
5. 0.1 mA.

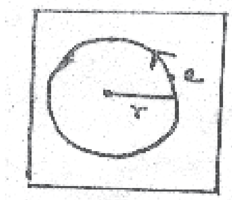
(B) 1.



A & B are circular metallic disc of diameter about 22cm aranged parallel to each other at a distance 1.5 cm. At the center of the upper dis.

- P is an atomizer with the help of which a liquid can be sprayed.
- The region bet^n the hoo plates can be illuminated with a light source S. The shinning drop of liquid can be observed with the help of a telescope T.

2. A showin Fig. electron moving around the nucleus in a hydrogen atom suppose



M = mass
r = radius of the orbit of electron
v = linear velocity resp.
e = value of charge on 1 electron
Ze = Change of the nucleus.

$\therefore \frac{Mv^2}{r} = \frac{1}{4\pi \in_0} \frac{Zc^2}{r^2}$ 1

$\in_0$ = the permittivity of vaccum.

Acc to Bohr's first postulate.

$Mvr = \frac{nh}{2\pi}$, n = 1,2, 3.............

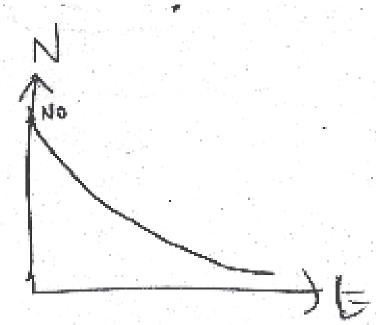
Principle quantum Number

$M^2V^2r^2 = \frac{n^2h^2}{4\pi^2}$ 3

Eliminating V from equation

$r = \frac{n^2h^2 \in 0}{M\pi Ze^2}$ 4

3. Instantaneous activity of a radioactive element



$\frac{dN}{dt} = -\lambda N$ 1

λ = radioactive constant of given element.

$\therefore \frac{dN}{dt} = -\lambda dt$

Integrating on both sides,

$\ell nN = -\lambda t + C$ 2

C = Constant of integration

Now N = No at t=0

we get

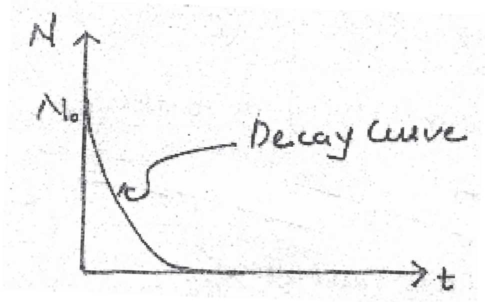
$\ell nN = C$ 3

$\ell nN = \lambda t + \ell nNo$

$\ell nN - \ell No = -\lambda t$

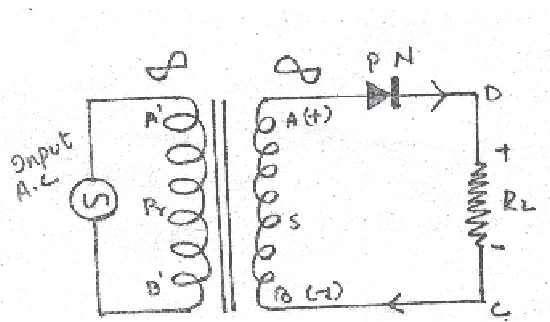
$N = Noe^{-\lambda t}$

$I = Ioe^{-\lambda t}$ 4

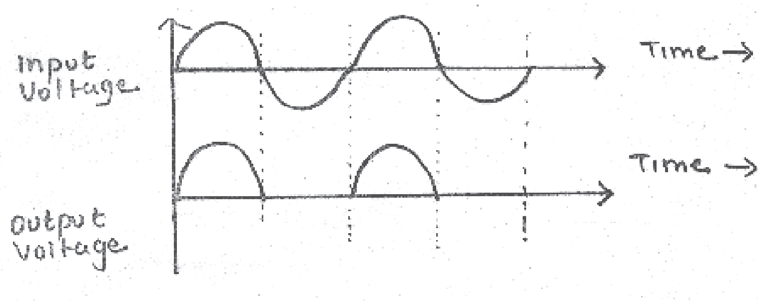


Equation [4] is called the exponential law of radioactive dis integration. The graph of N $\rightarrow$ t is shown in fig. which is called decen / culve.

4.



- The primary coit of a lense former is connected to the source of A.C. Voltage (Mains). One of the terminals of the secondary coil (Scy A) is connected to the anode and the terminal B to the cathode via the resistor RL working.



(C) 1. $E = nhf = nh\dfrac{c}{\lambda}$

$n = \dfrac{E\lambda}{hc} = \dfrac{5}{3} \times 10^{34-15}$

$= 1.66 \text{ x } 10^{17}$ Photons

2. $\dfrac{Mv^2}{r} = \dfrac{1}{4\pi \in 0} \dfrac{Ze^2}{r^2}$ For Z = 1 hydrogen atom.

$\dfrac{Mr^2w^2}{r} = \dfrac{1}{4\pi \in 0} \dfrac{Ze^2}{r^2}$

$\omega^2 = \dfrac{1}{4\pi \in 0} \dfrac{Ze^2}{mr^3}$ 1

Now $Mrv = \frac{nh}{2\pi}; mr^2\omega = \frac{nh}{2\pi}$

$$r^2 = \frac{nh}{2\pi m\omega}$$

$$r^3 = \left[\frac{nh}{2\pi m\omega}\right]^{3/2}$$

Putting this in Eq. (1) we get

$$\omega = \frac{4\pi me^4}{2\in_o^2 n^3h^3}$$

3. $\frac{dN}{dt} = \lambda N$ (-ve sign ignored)

$$\lambda = \frac{\frac{dN}{dt}}{N} = \frac{8000}{8\times10^7} = 10^{-4} Sec^{-1}$$

$$\overline{C}_{\frac{1}{2}} = \frac{0.693}{\lambda} = \frac{0.693}{10^{-4}} = 6930 Sec.$$

4. Given $\delta V_{BE} = 25$ milivolt
$= 25 \times 10^{-3}$ volt
$\delta Ic = 4.5$ Mili Amp. = 4.5×10^{-3} Amp.
gm = ?

$Av = -\frac{Rl\delta Ic}{\delta V_{BE}}$ $A_v = -g_m R_L$

$g_m = -\frac{\delta Ic}{\delta V_{BE}} = \frac{4.5\times10^{-3}}{25\times10^{-3}} = 0.18$ Mho.

$g_m = 0.18$ mho.

ജജജജജ

1.(A) Answer the following questions in very short. **5**

1. When the velocity of S.H. oscillator becomes half of its maximum velocity, than the displacement will be y = __________ (Answer in terms of amplitude)
2. Periodic time of a body of mass m attached on a spring hung vertically from a rigid support is T_1 on the earth, now this is taken to the moon so periodic time is found T_2 find relation between T_1 and T_2.
3. What is the phase difference between any two points on a wave front?
4. What is distance of first antinode which is coming from x= 0 (one end of the string)?
5. 5Kg body is moving with 7m/s velocity and 7 Kg body is moving with 4m/s velocity, so that it is difficult to stop _______Kg body.

(B) Answer any three of the following questions in eight to ten lines **6**

1. Write note on “center of mass of a rigid body.”
2. Give Newton’s second law of motion for a system of particles and from it give law of conservation of lineal momentum. What is its importance?
3. Write the equation of Stationery wave. From that define antinodes and obtain the necessary equation for it.
4. Write differential equation for forced oscillations. Give its solution when damped forces are present and also define resonance.

(C) Attempt any three of the following examples **9**

1. The velocity vector of three " particles" of masses 1 Kg, 2 Kg and 3Kg are respectively (1,2,3),(3,4,5) and (6,7,8). Find the velocity vector of the center of mass. The velocity vector components are in met/sec.
2. Write down the equations for the two component waves generating a stationary wave $y = -20 \sin 2\pi x \cdot \cos 2\pi t$. Also find the value of maximum displacement at a point x = 0.25meter on this stationary wave. (x and y in meters)
3. Interval between two sound frequencies is $\frac{21}{20}$. If they generates 5 beats per second, find the frequencies.

4. When displacement of a simple harmonic oscillator is 3 cm, its velocity is 4 cm/sec; and when the displacement is 4 cm its velocity is 3 cm/sec. Find its (1) amplitude (2) angular frequency and (3) periodic time.

2.(A) Answer the following questions in very short. **5**

1. Particle is moving on a straight path which is not on action line of position vector so will it have any angular momentum? If yes will it be constant?

2. Give Max Planck's statements of the second law of thermodynamics.

3. The time taken by a body thrown in vertical direction to reach the highest point is one second. Its initial velocity will be v_o = ___________m/s

4. What will happen to gravitational attraction between two masses if distance between them is doubled?

5. In an engine the working substance absorbs heat Q_1 and releases heat Q_2 in its sink, the mechanical work obtained from practical point of view is ________. In terms of Q_1 and

(B) Answer any three of the following questions in eight to ten lines **6**

1. Define isothermal process. Obtain the formula for work done during isothermal process.

2. What do you mean by internal combustion engine? Draw the line diagram of one such engine showing each part of it. Draw the graph of the cyclic process in internal combustion engine. Give information about its intake stroke.

3. Show two components of initial velocity of the projectile with suitable diagram. Prove that the path of the projectile is a Parabola.

4. Draw the figure of simple pendulum showing the forces acting on it. Obtain the formula for torque and also obtain formula $\frac{d^2\theta}{dt^2} + \omega^2\theta = 0$.

(C) Attempt any three of the following examples **9**

1. A thin circular disc is rolling down a slope without sliding. Taking $I = \frac{2}{3}MR^2$ (M = mass, R = radius) for the moment of inertia of the disc obtain its linear acceleration parallel to the surface of the slope.

2. A rigid body experience an angular displacement of 300 radians in 6 seconds, and attains an angular velocity of 100 rad/sec. Find its initial angular velocity and its angular acceleration. (assumed to be constant).

3. In a Carnot engine, the temperature of sink is 27^0C. Its efficiency is 25%. Find the temperature of the source. If one wants to have 40% efficiency with the same sink temperature, how much increase in temperature for the source is required?

4. If the earth were made of gold with a uniform density equal to 19.3 x 10^3 kg/m^3 , what would be the acceleration due to gravity on its surface? Radius of the earth = 6400 Km.

3.(A) Answer the following questions in very short. **5**

1. In one nenocoulomb charge number of electrons is _________.

2. Ten wires of 10 Ω resistance are connected in parallel. What is equivalent resistance?

3. An electric bulb is rated 200V and 100W. Power consumed by it when operated on 100V is ---------.

4. What is use of soft iron cylinder in galvanometer?

5. What is 'Electromagnetic induction' ?

(B) Answer any three of the following questions in eight to ten lines **6**

1. Explain self induction and on which factors self inductance depend?

2. Prove that a conductor of length "*l*" having potential difference "*V*" volts across its two ends the Electric field developed is $E = nve\rho$.

3. What is Joule's effect and Joule's heat? Explain the reason behind Joule's heat.

4. Write construction of a galvanometer.

(C) Attempt any three of the following examples **9**

1. Diameter of a conducting wire is 0.04 cm. Resistivity of the material of wire is 3.14×10^{-5} Ohm-meter. If a current of 4 amp is flowing through it, calculate the strength of the electric field prevailing in the wire.

2. A and B are two electric bulbs with their ratings respectively 40 W, 110 V and 100 W, 110 V. Find their respective filament resistances. If the bulbs are connected in series with a supply of 220V, which bulb will fuse?

3. A very long linear wire carries a current of 10 amp. What distance from this wire will the intensity of the magnetic field become $0.5 \text{x } 10^{-4}$tesla? $\left[\mu_0 = 4\pi \times 10^{-7} \frac{\text{Tesla - meter}}{\text{A}}\right]$

4. A coil having 100 turns has a surface area $15 \text{ x } 10^{-2}$ met^2. The area vector of the coil is kept parallel to a flux of 0.5 weber/met If the coil is now given a rotation of 90 in 0.05 second at a uniform rate. What is the average emf. induced in the coil?

4.(A) Answer the following questions in very short. **5**

1. In Fraunhoffer's diffraction at single slit if $\lambda = d$, what will happen ?

2. Which electormagnetic waves will suffer maximum diffraction when they pass through a given slit?

3. The waveslength of electromagnetic waves which get absorbed in the ozone layer is smaller than ________ m.

4. Which of the following radiation will have wavelength of about $1A^o$?

5. In only inductor a.c. circuit what is phase difference between voltage and current?

(B) Answer any three of the following questions in eight to ten lines **6**

1.Explain the inductive and the radiated components with figures.

2.Write a short note on a starter.

3. Write the condition for the constructive and destructive interferences in terms of the path difference and the phase difference obtained in 'Ripple tank experiment'.
4. Accepting A.C. voltage $V = V_m \sin \omega t$ obtain its r.m.s value.

(C) Attempt any three of the following examples **9**

1. An inductance of 0.1 H, capacitance of 100 μF and a resistance of 50 Ω are connected in series with an a.c. supply. Find the complex impedence of the circuit if the supply has an angular frequency of 314 rad/sec.
2. An a.c. supply of V_m = 100 volt and 159.2 Hz frequency is connected to an inductance of 1 henry, Obtain the equation for the current in the circuit. The applied voltage is $V = V_m \cos \omega t$.
3. In the Fraunhofer diffraction pattern of slit, the angle at which the first order minimum is observed for the wavelength 6000A^0 is also the one at which the first order maximum is observed for a wave length λ'. Find λ'.
4. Taking the units of μ_0 and ε_0 as known, prove that the expression $\frac{1}{\sqrt{\mu_0 \varepsilon_0}}$ has the unit of velocity.

5.(A) Answer the following questions in very short. **5**

1. An electron is projected in the direction perpendicular to magnetic field. How will its motion be affected due to magnetic force ?
2. What is the effect of intensity of incident light on the number of photo-electrons or photo-electric current ?
3. Complete the reaction : ${}_{92}U^{235} + {}_{0}n^{1} \rightarrow$ ______ $+ {}_{41}Nb^{99} +$ ________
4. Arrange α,β and γ rays in the decreasing order of their penetrating power.
5. What is the unit of trans-conductance?

(B) Answer any three of the following questions in eight to ten lines **6**

1. Describe phenomenon observed at high potential difference and pressure in the discharge tube.

2. Explain what is good conductor, bad conductor and pure semiconductor?

3. Write note on “Photo cell”

4. Describe Bohr model for atom.

(C) Attempt any three of the following examples **9**

1. The H_α line in the Balmer series of the Hydrogen spectrum has a wave length of 6563 A^0 from this calculate the wavelength for the first line of the Lymen series. (Ly-α).

2. If $_{84}Po^{210}$ is the end product of decay of $_{92}U^{238}$. Find the number of particles and β–particles emitted in the sequence of reactions involved.

3. Voltage gain of a common emitter amplifier is 1200 and its input voltage is 40 millivolt. Find the change in the output current if the load resistance is 4000 Ω.

4. Calculate the energy of the photon of X- ray having 3 A^0 wavelength c =3 x 10 met/sec h 6.62 x 10^{-34} Joule/sec.

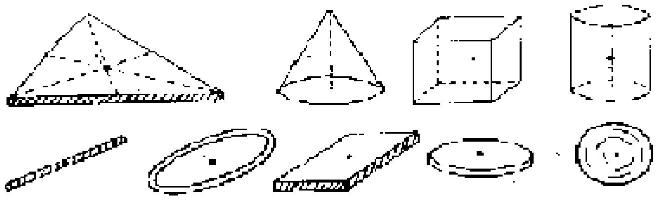
1. (A)

1. $y = \frac{\sqrt{3}}{2} A$.
2. $T_1 = T_2$. Here periodic time does not depend length.
3. Zero. Because all particles on a wave front have same phase.
4. $\frac{\lambda}{4}$
5. 5 kg body as its momentum is more.

(B)

1. Location of center of mass of a body depends upon its shape and distribution of mass within it.

For example, a circular disc of uniform density has its center of mass located at the center of the disc which is inside the body, but for a ring of uniform density it is at the center of the body, which is outside the material of the body. Center of mass of a rod of uniform density and cross-section, is located at its geometrical center. Center of mass of rigid bodies having symmetrical shapes and are of uniform density can be calculated mathematically; but to calculate it for a body which is not symmetric, it can be a difficult job. Figure 2 shows centers of mass for some symmetric bodies.



2. As we know $\frac{d\vec{p}}{dt} = \vec{F}$, so if $\vec{F} = 0$ $M \vec{a}_{cm} = \frac{d\vec{p}}{dt} = \vec{F} = 0$ Which means that $\vec{p} = \vec{p}_1 + \vec{p}_2 + ... + \vec{p}_1 =$ constant.

$$\therefore \vec{a}_{cm} = 0$$

In other words the velocity of the center of mass remains constant

The statement " If the resultant of the external forces acting on a system is zero, its linear momentum remains constant " is known as the law of conservation linear momentum. When resultant force $\vec{F} = 0$.

$\vec{p_1}$, $\vec{p_2}$,... etc. can still change individually but those changes must be such that the vector sum of $\vec{p_1} + \vec{p_2} + ... + \vec{p_1}$ remains constant.

The law of conservation of linear momentum is quite general and fundamental. It is equally true for microscopic systems made of particles like electrons and protons; as of very large systems like planetary systems.

When the resultant force is zero then $\vec{a_{cm}} = 0$, so center of mass is stationery will remain stationery and if it is moving, it will continue to move with constant velocity.

3. The equation of the Stationary wave is y = - 2A sin *kx* cos ωt...... (1)

Now, in equation (1) the term cosine of this equation indicates that each particle of the string executes simple harmonic motion but its amplitude depends on the position of the particle according to 2A sin *kx.*

Now those particles, whose position can be given by

sin kx = ± 1 ⇒ kx = (2n – 1) π/2,

⇒ x = (2n – 1) π/2κ = (2n – 1) λ/4.

Where n = 1,2,3,4,.........etc.

Oscillate with maximum amplitude. Such points are known as antinodes.

Thus antinodes are situated at distance x = $\frac{\lambda}{4}, \frac{3\lambda}{4,}., \frac{5\lambda}{4}.,$........... respectively from x = 0 end of the string. Thus the distance between consecutive node and antinodes is λ/4.

4.

$$\therefore \frac{d^2y}{dt^2} + \frac{b}{m}\text{v} + \omega^2 \text{y} = \frac{F_0}{m}\sin \omega t = a_0 \sin \omega t \quad \text{.................................(1)}$$

This is the differential equation for the forced oscillations with damping.

If b is not zero in equation (1) its solution would have been.

$$A = \frac{a_0}{[(\omega_0^2 - \omega^2)^2 + r^2\omega^2]} \quad \text{...(2)}$$

This equation shows that the amplitude of forced oscillations with damping depends on the damping coefficient (b) also.

When $\omega_0 = \omega$ then the amplitude of forced oscillations of the system becomes maximum, This phenomenon is known as resonance.

.

(C)

1. Here $\vec{v}_1 = \hat{i} + 2\hat{j} + 3\hat{k}$;

$$\vec{v}_2 = 3\hat{i} + 4\hat{j} + 5\hat{k} \quad \text{and}$$

$$\vec{v}_3 = 6\hat{i} + 7\hat{j} + 8\hat{k}$$

and $m_1 + m_2 + m_3 = 6$ kg

But $\vec{v}_{cm} = \dfrac{m_1\vec{v}_1 + m_2\vec{v}_2 + m_3\vec{v}_3}{m_1 + m_2 + m_3}$

$$\therefore \vec{v}_{cm} = \frac{(\hat{i} + 2\hat{j} + 3\hat{k}) + 2(3\hat{i} + 4\hat{j} + 5\hat{k}) + 3(6\hat{i} + 7\hat{j} + 8\hat{k})}{6}$$

$$\therefore \vec{v}_{cm} = \frac{1}{6}\left[25\hat{i} + 31\hat{j} + 37\hat{k}\right]\frac{m}{s}$$

2. Comparing $y = -20 \sin(2\pi x)\cos(2\pi t)$

withu $\quad y = -2A\sin(kx)\cos(\omega t)$

Here $x = 0.25\ m$;

$A = 10\ m\ ;\ k = 2\ \pi \frac{rad}{met}\ ;\ \omega = 2\pi\ \frac{rad}{5}$

$\therefore$ Component waves of $y = -\ 2\ A\ \sin\ (kx)\ \cos\ (\omega t)$ are

Putting these values in $y_1 = A\ \sin\ (\omega t - kx)$ and $y_2 = -A\sin(\omega t + kx)$

$y_1 = 10\ \sin\ (2\ \pi\ t - 2\ \pi x)$ and $y_2 = -\ 10\ \sin\ (2\ \pi t + 2\ \pi x)$

Maximum displacement

$= 20\ \sin\ 2\ \pi x$

$= 20\ \sin\ (2\ \pi \times 0.25)$

$= 20\ \sin\ \frac{\pi}{2} = 20\ m.$

3. If two frequencies are f_1 and f_2.

$\therefore$ Interval $= \frac{f_1}{f_2} = \frac{21}{20}$

$\therefore\ f_1 = \frac{21}{20}\ f_2$

$\therefore$ so $f_1 > f_2$

$\therefore\ f_1 - f_2 = 5$ (Beats)

$\therefore \frac{21}{20}\ f_2 - f_2 = 5$

$\therefore 21 f_2 - 20 f_2 = 100$

$\therefore f_2 = 100\ Hz$

4. Here $y_1 = 3\ cm$,

$v_1 = 4\ \frac{cm}{5}$;

$y_2 = 4\ cm$,

$v_2 = 3\ \frac{cm}{5}$;

A = ?

T = ?

For a SHO, $v = \pm\ \omega\ \sqrt{A^2 - y^2}$

$\therefore 16 = \omega^2\ \left(A^2 - 9\right)$......(1)

and

$9 = \omega^2\ \left(A^2 - 16\right)$......(2)

$\therefore \frac{16}{9} = \frac{A^2 - 9}{A^2 - 16}$

$\therefore 16\ A^2 - 256 = 9\,A^2 - 81$

$\therefore 7\ A^2 = 175$

$\therefore A^2 = 25$

$\therefore$ A = 5cm

$\therefore\ 16 = \omega^2\ \left(25 - 9\right) = 16\omega^2$

By putting value in equation 1,

$\therefore \omega = 1\ \frac{rad}{s}$

$\therefore \frac{2\pi}{T} = 1$

$\therefore T = 2\pi$ S

2.(A)

1. Yes, it will have angular momentum and will be constant.

2. The statement of Max Planck **:** It is impossible to construct a heat engine based on the cyclic process, which by absorbing heat from one body only and without making any change in the working system can convert it (the heat) completely into the mechanical energy.

3. The time taken by a body thrown in vertical direction to reach the highest point is one second. Its initial velocity will be v_o = 9.8 m/s

4. Gravitational attraction is reduced to quarter.

5. $Q_1 - Q_2$

(B).

1. In an isothermal process temperature remains constant. Imagine the expansion of *n*-mole ideal gas, in the isothermal process as the ideal gas obeys Boyle's law

$$\therefore pV = nRT$$

$$\therefore p = \frac{nRT}{V} \qquad \text{............(1)}$$

Suppose *V* changes by a very small amount *ΔV*. Further, this change is so small that the pressure *p* can be considered almost constant during this change. Therefore, the work done during this minute change is $\Delta W = p\,\Delta V$.

If the a result of a series of such small changes, the volume of the gas change from V_1 to V_2 work done can be calculated as

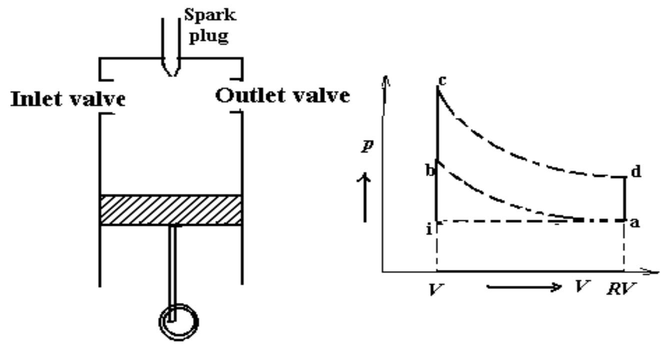
$$W = \int_{V_1}^{V_2} p\,dV = \int_{V_1}^{V_2} \frac{nRT}{V} dV$$

$$\therefore W = nRT\left[\ln V\right]_{V_1}^{V_2}$$

$$\therefore W = n\,RT\left[\ln V_2 - \ln V_1\right]$$

$$\therefore W = nRT\ln\left(\frac{V_2}{V_1}\right) \text{.........} \qquad (2)$$

2. In internal combustion engines, the fuel is burnt inside the piston cylinder device itself and the heat energy is obtained. Hence, such engines are known as internal combustion heat engines.



In such an engines, the arrangement of the piston cylinder and inlet and the outlet valve is there.

Here four processes take place. Each process is known as ***stroke***.

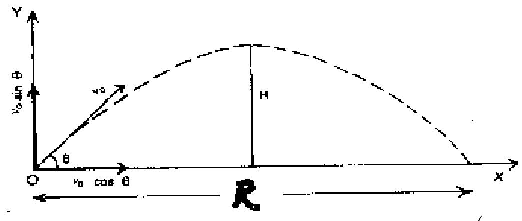
1.*Intake Stroke*: In this process, the inlet valve is open and the outlet valve is close. The mixture of air and the vapor of the petrol enter form the inlet valve into the cylinder and the piston moves downwards. The pressure of the air and the petrol vapor is maintained constant. This process is shown in *ia* on the *p-V* diagram in the figure (1). During this process, the volume of the working substance become *RV* from V. *R* is known as the compression ratio.

3. As shown in figure suppose a body is projected with a velocity v_0 in a direction making an angle θ with the x-axis from O, the origin.

Consider, the components of in the X,Y direction, as $v_o \cos\theta$ and $v_o \sin\theta$ respectively.

Here earth's gravitational force being acting only in the vertical direction, the horizontal component $v_o \cos\theta$ remains constant during the entire motion. Thus, the motion in the horizontal direction is with uniform velocity.

For the motion in the vertical direction, the initial velocity is $v_o \sin\theta$ and the acceleration is g.



Here both the motions being mutually perpendicular their independent (separate) description can be made.

Horizontal motion : If the horizontal distance is x = velocity × time $\therefore x = (v_o \cos\theta)t$ . .....(1)

Vertical motion : If the distance covered by the body in time t in vertical direction is y then by substituting $v_o \sin\theta$ in place of v_o and – g in place of a in the equation of motion

$$d = v_o t + \frac{1}{2} a t^2 \qquad \text{.......(2)}$$

But, from equation (1) $t = \dfrac{x}{v_o \cos\theta}$ .... (3)

substituting this value of t in equation (3)

$$y = (v_o \sin\theta)\frac{x}{v_o \cos\theta} - \frac{1}{2} g \left(\frac{x}{v_o \cos\theta}\right)^2$$

$$= x \tan\theta - \frac{1}{2} g \frac{x^2}{v_o^2 \cos^2\theta} \qquad \text{.............(4)}$$

Here, v_o and g being constant, this equation is a form of $y = ax - bx^2$ for a given θ this equation is the equation of a parabola. Hence the path of the projectile is a parabola.

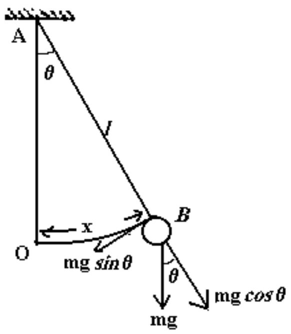
4. Suppose the length of pendulum is l and the mass of its bob is m.

So weight of the sphere is mg in the downward direction.

Here since the line of action of the tension T passes through the point of suspension of the pendulum, the torque obtained due to T with respect to the point of suspension becomes zero.

Now, the torque due to the weight mg of the sphere (with respect to the point of suspension.)

$$\vec{\tau} = \vec{l} \times \vec{mg} \quad ......(1)$$



The angular displacement of the sphere due to this torque being of decreasing value it (the torque) is taken as negative.

$$\therefore \tau = -\, l\, mg \sin\theta` ....(2)$$ But

$$\tau = I\alpha = I\,\frac{d\omega}{dt} = I\,\frac{d^2\theta}{dt^2} \quad .... (3)$$

$$\therefore I\,\frac{d^2\theta}{dt^2} = -\, l\; mg \sin\theta$$

Moreover, $I = ml^2$

$$\therefore ml^2\,\frac{d^2\theta}{dt^2} = -\, l\; mg\; \sin\,\theta \quad ....(4)$$

If the angular displacement of the sphere is small and x is the linear displacement of the bob on the curved path, then sin $\theta \approx \theta$

Making use of this fact in equation (4)

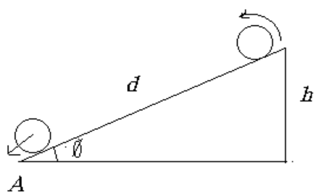
$$\frac{d^2\theta}{dt^2} + \omega^2\theta = 0 \quad .... (5)$$

(C).

1. As shown in the figure suppose that the thin spherical shell starts rolling from point A.

At a point A all energy of the shell is in the form of potential energy.

$\therefore$ Initial energy = mgh



At the bottom, all the potential energy is transferred into rolling kinetic energy and traslational K.E..

But, kinetic energy of a rolling body = Linear kinetic energy + Rotational kinetic energy.

$$= \frac{1}{2} mv^2 + \frac{1}{2} I\omega^2 = \frac{1}{2} mv^2 + \frac{1}{2} \times \frac{2}{3} mR^2 v^2$$

$$= \frac{1}{2} mv^2 + \frac{1}{3} mv^2 = \frac{5}{6} mv^2 \quad \text{........(2)}$$

By the law of conservation of mechanical energy, we have initial P.E. = Final total K.E.

$$mgh = \frac{5}{6} mv^2$$

$$\therefore v^2 = \frac{6}{5} gh$$

Now from equation $v^2 - v_0^2 = 2ad$

$$\therefore 2ad = \frac{6}{5} gh$$

$$\therefore a = \frac{3}{5} g \left(\frac{d}{h}\right)$$

But $\sin\theta = \frac{d}{h}$

$$\therefore a = 0.6g \sin\theta$$

This way acceleration parallel to the surface of the slope $= 0.6\ g\ \sin\theta$

2. Here t = 6 sec;

$\theta = 300$ radian;

$\omega_o = 100$ radian/sec;

$\alpha = ?$

As $\theta = \left(\frac{\omega + \omega_o}{2}\right) t$

$\therefore\ 300 = \left(\frac{100 + \omega_o}{2}\right) 6$

$\therefore 100 = 100 + \omega_o$

$\therefore \omega_o = 0 \frac{rad}{\sec}$

Now $\alpha = \frac{\omega - \omega_o}{t} = \frac{100 - 0}{6}$

$\therefore \alpha = 16.67 \frac{rad}{s^2}$

3. Given $T_2 = 27^oC = 300^oK$

$\eta_1 = 25\% = \frac{1}{4}$;

$\eta_2 = 40\ \% = 2/5$

$T_1 = ?$

$T_1' = ?$

Efficiency $\eta_1 = 1 - \frac{T_2}{T_1}$

$\therefore \frac{1}{4} = 1 - \frac{300}{T_1}$

$\therefore \dfrac{300}{T_1} = \dfrac{3}{4}$

$\therefore \; T_1 = 400^0K;$

Now, $\eta_2 = 1 - \dfrac{T_2}{T_1^{'}} = 1 - \dfrac{300}{T_1^{'}}$

$\therefore \dfrac{300}{T_1^{'}} = \dfrac{3}{5}$

$\therefore T_1 = 500^0 \; K$

so increase in temperature required is $T_1^{`} - T_1 = 100\,K$

4. Here, Re = 6400 km

$= 6400 \times 10^3 \; Meter$

$\rho = 19.3 \; \times 10^3 \dfrac{Kg}{m^3}$

$G = 6.67 \; \times 10^{-11} \; MKS$

Acceleration due to gravity on the surface of the earth is given by

$g = \dfrac{G\ Me}{\mathrm{Re}^2}$

But mass of the earth = volume x density.

$\therefore M_e = \dfrac{4}{3} \pi \,\mathrm{Re}^3 \; \rho$

Now $g = \dfrac{G\ M_e}{R_e^{\ 2}}$

$\therefore g = \dfrac{G \frac{4}{3} \pi R_e^{\ 3} \rho}{R_e^{\ 2}}$

$= \dfrac{4}{3} \pi R_e \, \rho \; G$

$$\therefore g = \frac{4 \times 3.14 \times 64 \times 10^{5} \times 19.3 \times 10^{3} \times 6.67 \times 10^{-11}}{3} = \frac{103.48}{3}$$

$$\therefore g = 34.49 \frac{m}{S^2}$$

3. (A)

1. 6.25×10^{9}
2. 1 Ω.
3. 25W.

   Here $P = V^2/R$ and $P' = V'^2/R$

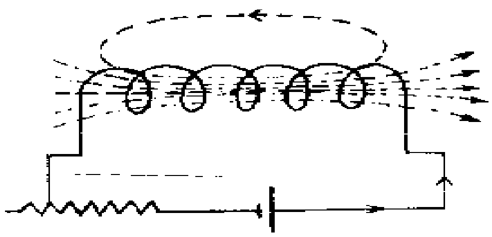
   Here R remains same but V' = V/2

   so P' = P/4 = 100/4 =25W.
4. To produce arial magnetic field so even after some deflection magnetic flux passing through coil remains same and deflection directly proportional to current passing through it.
5. Electromagnetic induction : " When the magnetic flux linked with a coil changes, the electromotive force is produced in it." This phenomenon is called electromagnetic induction.

(B).

1. When a current passes through a coil, magnetic field is created so that the coil itself behaves like a magnetic.

   The magnetic flux produced by the current in the coil is linked with the coil itself (fig.) and when the current in the coil changes this flux linked with the coil also changes.



Under such circumstances also there would be an emf induced in the coil which is called the self induced emf. This phenomenon is called self induction.

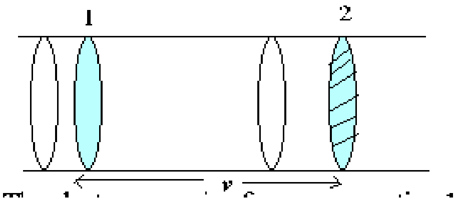
Its value of self induction depends upon the size and shape of the coil as well as the number of turns. If also depends upon the magnetic property of the medium of the space within the coil.

2. If this voltage V is applied on a conductor of length l and area of cross section A, the intensity of the electric field in the conductor is

$$E = \frac{V}{l} = \frac{IR}{l} \qquad (1)$$

$$\therefore E = \frac{I\rho l}{Al} \quad \text{......................(2)} \qquad (\because R = \rho \frac{l}{A})$$

$$\therefore E = \frac{I\rho}{A} \quad \text{...........................(3)}$$



Now, electric current I is generated due to the drift velocity v of the electrons. All the electrons passing through a cross section in one second with velocity v will be present in the v length of the conductor. Hence, if the number of electrons per unit volume in the conductor be n then the number of electrons in length v of the conductor is nAv.

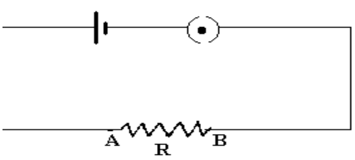
Total electric charge of these electrons is $nAve$ .... (4)

As the amount of electric charge passes through a cross section of the conductor in one second is current I = $nAve$ ....(5)

Substituting this result in equation (4)

$$\therefore E = \frac{I\rho}{A} = \frac{nAve\rho}{A} = nev\rho \quad \text{..(6)}$$

3. In the figure the circuit is shown completed by joining a battery (having terminal voltage V) and the resistance R.



Here point A has V joule energy per unit positive electric charge.

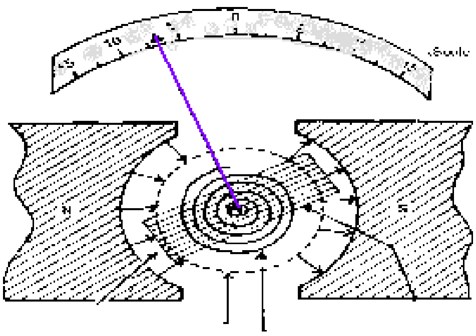
Now if the electric current is considered to form due to the motion of the electrons then unit negative electric charge at point B is said to have V joule electrical energy.

An electron passes through the conductor, they collides with positive ions (executing oscillations) of the conductor. During such collisions ions receive a certain part of the energy of the electron. Consequently the oscillations of the ions become more repaid and more random and the energy obtained by ions in this way appears in the form of heat energy.

Thus, the heat energy obtained by passing electric current through the conductor is known as joule heat and this effect is known as joule effect.

Write construction, principle and working of a galvanometer.

4. A galvanometer is used to measure very small electric current. Figure shows a galvanometer .



In a galvanometer, between two cylindrical poles of a permanent magnet a light rectangular frame possessing winding of thin copper wire is suspended on frictionless pivot.

To produce uniform radial magnetic field, a small cylindrical soft iron piece is kept on

In a galvanometer, between two cylindrical poles of a permanent magnet a light rectangular frame possessing winding of thin copper wire is suspended on frictionless pivot.

To produce uniform radial magnetic field, a small cylindrical soft iron piece is kept on the axis of the coil (untouched to it).

When electric current is passed through the coil, it experiences a torque and undergoes deflection. Because of the springs kept at the two ends of the coil it experiences a restoring torque resulting in a steady deflection. The steady deflection of the coil is found out with the help of a pointer attached to it. Here the pointer is arranged to move on a proper scale.

The electric current passing through the coil is known from the position of the pointer on the scale.

(C).

1..

Given r = 0.02cm = 2x 10^{-4}m

ρ = 3.14 x 10^{-5}Ohm-meter

I = 4 Ampere

E = ?

Electric field intensity in the conductor

$$E = \frac{L\rho}{A}$$

$$\therefore E = \frac{I\rho}{\pi r^2} = \frac{4 \times 3.14 \times 10^{-5}}{3.14 \times \left(2 \times 10^{-4}\right)^2}$$

$$= 10^3 \ \frac{Volt}{meter}$$

E is also known as potential gradient.

2. For bulb A

P_1 = 40W

V_1 = 110V

For bulb B

P_2 = 100W

V_2 = 110V

Power $P = \frac{V^2}{R}$ ylu P = VI

$$\therefore R = \frac{V^2}{P}$$

Resistance of bulb A $R_1 = \dfrac{V_1^2}{P_1}$

$\therefore\ R_1 = \dfrac{110 \times 110}{40} = 302.5$ Ohm

Current $I_1 = \dfrac{P_1}{V_1} = \dfrac{40}{110} = 0.3636A$

Resistance of bulb B $R_2 = \dfrac{V_2^2}{P_2} = \dfrac{110 \times 110}{100} = 121$ Ohm

Current $I_2 = \dfrac{P_2}{V_2} = \dfrac{100}{110} = .909A$

These bulbs are connected in series with 220V supply.

$\therefore$ equivalent resistance of the circuit $R = R_1 + R_2 = 3.02.5 + 121 = 423.5$

So current in each bulb $I = \dfrac{V}{R_1 + R_2} = \dfrac{220}{423.5} = 0.5195A$

$\therefore I > I_1$ but $I < I_2 \quad \therefore\ A$ will fuse.

3. I = 10 Ampere

$B = 0.5 \times 10^{-4}$ Tesla

$y = ?$

$$B = \frac{\mu_o I}{2\pi y}$$

$$\therefore y = \frac{\mu_o}{2\pi}\frac{I}{B} = \frac{4\pi \times 10^{-7}}{2\pi} \times \frac{10}{0.5 \times 10^{-4}} \text{ meter}$$

$$\therefore y = 4 \times 10^{-2} \text{ meter}$$

4. Given,

$A = 15 \times 10^{-2}\ m^2$;

$N = 100$;

$B = 0.5\ weber/m^2$;

$\Delta t = 0.05$ second;

$\Delta\theta = 90^0$;

In beginning area vector of the coil $\vec{A}$ is

Making angle 60^0 with magnetic field $\vec{B}$

$\therefore$ angle between them $\theta_1 = 60^0$

Now, rotation is given to the coil and

$\therefore$ angle between them $\theta_1 = 120^0$

$\phi_1 = A\ B\cos\theta_1 = AB\cos 60^0$

$\phi_2 = A\ B\cos\theta_2 = AB\cos 120^0$

$\therefore$ Average induced emf $\varepsilon = N\dfrac{\Delta\phi}{\Delta t}$

$$\therefore \qquad \varepsilon = \frac{NAB}{\Delta t} = \frac{100 \times 15 \times 10^{-2} \times 0.5}{0.05}$$

= 150Volt

4. (A)

1. Central maximum will spread all over the screen.

2. Radio waves suffer maximum diffraction because they have maximum wave length in the electromagnetic spectrum.

3. 3×10^{-7}

4. X-ray

5. Current is lagging behind voltage in phase by $\pi/2$ rad.

(B).

1. Mathematical studies show that only near the oscillator, the phase difference between $\vec{E}$ and $\vec{B}$ is $\frac{\pi}{2}$ and their amplitudes (values) decrease as $\frac{1}{r^3}$; r being the distance from the source from the source. These components are called the "Inductive components".

In the distance region from the source $\vec{E}$ and $\vec{B}$ have the same phase and their amplitudes diminish more slowly, as $\frac{1}{r}$. These fields components are called the "radiated components".

2. In a starter, two metallic plates and helium gas at low pressure is contained in a glass bulb. The circuit of the tube light is such that upon putting the switch on, the entire supply voltage reaches the plates of the starter. As a result, the plates get heated up and bent causing a contact between the plates. Because of this, current passes through the filaments of the tube.

But, as the palates are in contact, the voltage between them reduces to zero and they start getting cooled resulting in their separation. This sudden break of current in the choke gives a large induced voltage pulse across the tube, starting a discharge through it.

3. The condition of constructive interference in terms of path difference : "If at any point the path difference between two superposing waves is $n\lambda$, where n = 0, 1, 2, ..., etc; then constructive interference will take place at that point".

The condition of constructive interference in terms of phase difference : "If any point the two superposing waves have a phase difference of $2n\pi$, where n = 0, 1, 2, ..., etc; then constructive interference will take place at that point".

The condition of destructive interference in terms of phase difference : "If the any point the two superposing waves have a phase difference of $(2n-l)\frac{\lambda}{2}$, where n = 1, 2, 3, ... etc; then destructive interference take place at that point".

The condition of destructive interference in terms of phase difference : "If the phase difference between two superposing waves have a point is $(2n-l)$, where n = 1, 2, 3 ...., etc; then destructive interference take place at that point".

4. The r.m.s. value of $V = V_m \sin \omega t$ is to be found out. For this, average of V_2 over one complete periodic time $T = \frac{2\pi}{\omega}$ should be obtained first and thereafter its square root be evaluated.

$$\therefore \text{ Average } V^2 \equiv < V^2 > = \frac{1}{T}\int_0^T V_m^2 \cos^2 \omega t.dt \qquad = \frac{V_m^{\ 2}}{T\omega}\int_0^T \cos^2 \omega t.d(\omega t)$$

$$= \frac{V_m^{\ 2}}{\frac{2\pi}{\omega}.\omega}\int_0^T \cos^2 x.dx \quad where\, \omega t = x$$

When $t = 0, \Rightarrow \omega t = x = 0$ and when $t = T = \frac{2\pi}{\omega} \Rightarrow \omega t = \omega T = \omega.\frac{2\pi}{\omega} = 2\pi = x.$

Thus, in the above integration, the limits of x are 0 and 2π.

$$\therefore < V^2 > = \frac{V_m^{\ 2}}{2\pi}\int_0^{2T} \cos^2 x.dx = \frac{V_m^{\ 2}}{2\pi}\left[\frac{\sin 2x}{4} + \frac{x}{2}\right]_0^{2\pi} = \frac{V_m^{\ 2}}{2\pi}\left[\frac{\sin 4x}{4} + \frac{2x}{2}\right] = \frac{V_m^{\ 2}}{2}$$

$$\therefore Vr.m.s = \sqrt{< V^2 >} = \frac{V_m}{\sqrt{2}} = 0.707\ V_m$$

(C).

1. Given,

L = 0.1 H

C = 100 μ F $= 100 \times 10^{-6} = 10^{-4}$ farad

R = 50 Ω

ω = 314 rad/sec

Z = ?

If complex impedence is Z then,

$$Z = R + j\omega L - \frac{j}{\omega C}$$

$$= R + j\left(\omega L - \frac{1}{\omega C}\right)$$

$$= 50 + j\left(314 \times 0.1 - \frac{1}{314 \times 10^{-4}}\right)$$

$$= 50 + j(31.4 - 31.84)$$

$$= 50 - j0.44 \text{ Ohm}$$

2. Given,

V_m = 100 volt

$\omega = 2\pi f = 6.28 \times 159.2 = 1000$ rad/sec

f = 159.2 Hz

L = 1 henry

I = ?

Now, $V = V_m \cos \omega t$

But, An a.c. circuit containing only inductor I lags behind V in phase by, $\frac{\pi}{2}$

$$\therefore I = I_m \cos\left(\omega t - \frac{\pi}{2}\right)$$

$$= \frac{V_m}{X_L} \cos\left(\omega t - \frac{\pi}{2}\right)$$

$$= \frac{V_m}{\omega L} \cos\left(\omega t - \frac{\pi}{2}\right)$$

$$= \frac{100}{1000 \times 1} \cos\left(100\, t - \frac{\pi}{2}\right)$$

$\therefore I = 0.1\cos\left(100t - \frac{\pi}{2}\right)$ ampere.

3. First order minimum for λ =6000 A^0 is at $d\sin\theta = 6000$; and the first order minimum for λ' is at $\frac{3\lambda^/}{2} = d\sin\theta.$

$\therefore \frac{3\lambda^/}{2}$ =6000

$\therefore$ λ =4000 A^0

4. Unit of $\mu_o = \frac{Tesla\ meter}{ampere} = \frac{Newton\ .\ \sec ond\ \ .\ meter}{coulomb\ .\ meter\ .\ ampere} = \frac{Newton}{Ampere^2}$

Unit of $\varepsilon_0 = \frac{coulomb^2}{newton\,(meter)^2}$

$$\therefore \frac{1}{\sqrt{\mu_0\,\varepsilon_0}} = \frac{1}{\sqrt{\frac{newton}{ampere^2}\cdot\frac{coulomb^2}{newton\,(meter)^2}}}.$$

$$= \frac{1}{\sqrt{\frac{ampere^2\,(\sec ond)^2}{ampere^2\,(meter)^2}}}$$

$$= \frac{meter}{\sec ond}$$

5.(A)

1. As magnetic force is perpendicular to the velocity, it provides centripetal froce and produces circular motion.

2. As intensity of incident light increases, the number of emitted photo electrons also increases. So photo-electric current increases.

3. $_{92}U^{235} + {}_0n^1 \rightarrow {}_{51}Sb^{133} + {}_{41}Nb^{99} + 4\,{}_0n^1.$

4. γ ,β,and α.

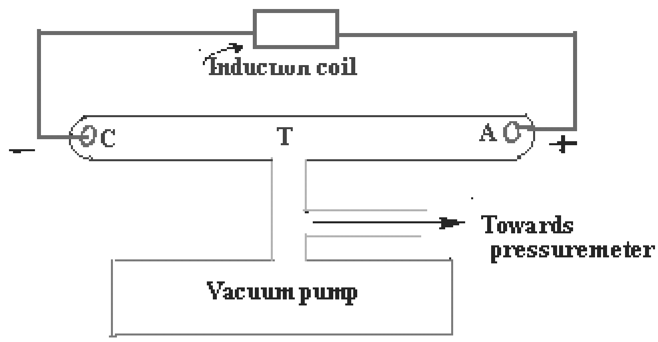
5. The unit of trans-conductance is mho.

(B)

1. A gas is filled in a Pyrex glass tube of about 40cm length.

Pressure of gas in the tube can be adjusted by means of a vacuum pump.

C and A are circular metal discs inside the tube, connected to electrical leads. Anode is A at high positive voltage with respect to cathode C.



Potential difference of few kilovolts (obtained from an induction coil) is applied between the terminals A and C at normal pressures. The gas is found non conducting at this pressure.

But when the pressure is reduced much below the atmospheric pressure a discharge takes place between A and C and due to which a glow is observed in the tube.

Color of discharge is characteristic of the gas in the tube. (such as the red glow observed for neon in the advertising tubes.)

When the pressure is reduced to about 2 Pascal (Newton/met) the glow disappears and the space between the terminals A and C becomes dark.

2. Metallic elements located in the first three groups of the periodic table are good conductors of electricity. These include alkali metals, noble metals, aluminum copper etc. These metals conduct electricity very well because of their free electrons.

Nonmetals are practically bad conductors. They do not have free electrons and such materials have very large resistivity.

The elements like Si and Ge that are in the fourth group of the periodic table, have electrical resistivity more than that of metals but less than that of bad conductors. Such materials are called semiconductors.

The mode of electrical conduction differs in metals and semiconductors.

Semiconductors in their pure form practically behave, as non-conductors at the absolute zero of temperature.

Increase in the temperature of a good conductor results in the increase in its resistivity, but in crease in the temperature of a semiconductor (within certain range) results in a decrease in its resistivity.

A semiconductor, irradiated by electromagnetic radiation of an appropriate frequency often results in an increase in its conductivity.

3. A photocell works on the principle of photoelectric effect, its construction is similar to the phototube.

When light falls on the sensitive surface of the device, accurate of the order of few microamperes is produced.

Thus, it can detect and measure intensity of light.

It is used to measure intensity of light spectra, temperatures of stars, temperatures of furnaces etc. Photocells are also widely used in fire alarms, many industrial control systems devices to automatically measure vehicle speeds, photo finish recording of athletic events recording of cine sound etc. Remote control of furnace temperatures also is use photoelectric sensors.

4. Bohr model is as follows

Hypothesis 1: Of all classically possible orbits that an electron can have,

The electron can exist only in such orbits where its orbital angular momentum has value equal to an integral multiple of $\frac{h}{2\pi}$.

Where h is a universal constant known as Plank constant. Such orbits are called stable orbits does not radiate energy.

Hypothesis 2: When an electron makes a transition from a stable orbit with a lower energy E_k to a stable orbit with a higher energy E_i the difference of the energy $E_i - E_k$ is radiated away as a quantum of electromagnetic energy with a frequency f such that $E_i - E_k = hf$. Similarly when an electron the orbit of energy E_k absorbes a quantum of energy $hf = E_i - E_k$;; it makes a transition from the orbit of lower energy E_k to that of a higher energy E_i.

(C)

1. For Balmer series wavelength λ_2 for H_2 line,

$$\frac{1}{\lambda_2} = R\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = R\left(\frac{1}{4} - \frac{1}{9}\right) = \frac{5R}{36} \text{ .. ..(1)}$$

If wavelength is λ for first line in Lymen series

$$\frac{1}{\lambda} = R\left(\frac{1}{1^2} - \frac{1}{2^2}\right) = R\left(\frac{1}{1} - \frac{1}{4}\right) = \frac{3R}{4} \text{.... ....(2)}$$

By taking ratio of equation (1) and (2)

$$\frac{\lambda}{\lambda_\alpha} = \frac{5R}{36} \times \frac{4}{3R} = \frac{5}{27}$$

$$\therefore \lambda = \frac{5}{27} \times \lambda_\alpha$$

But $\lambda_\alpha = 6563 \ A^0$

$$\therefore \lambda = \frac{5}{27} \times 6563 = 1215\, A^\circ$$

2. If x is the no. of α-particles and y is the no. of β-particles

$${}_{92}U^{238} \rightarrow {}_{84}Po^{210} + x\ {}_{2}He^{4} + y\ {}_{-1}e^{0}$$

Comparing A on both the sides

$238 = 210 + 4x$

$\therefore x = 7$

so 7 α - particles are emitted

By comparing (Z) $92 = 84 + 2x - y$

But $x = 7$

$\therefore 92 = 84 + 14 - y$

$\therefore y = 6$

so 6 β - particles are emitted.

3. $A_v = 1200$;

$\delta V_{BE} = 40 \times 10^{-3}$ Volt;

$R_L = 4000$ Ohm;

$\delta I_C = ?$;

$$\therefore A_v = \frac{\delta V_{CE}}{\delta V_{BE}} = -\frac{R_L \delta I_c}{\delta V_{BE}}$$

$$\therefore 1200 = \frac{4000 \delta I_c}{40 \times 10^{-3}} \quad \text{(Numerically)}$$

$$\delta I_c = 12 \times 10^{-3}\, amp$$

4. $\lambda = 3A^0 = 3 \times 10^{-10}$m;

$c = 3 \times 10^{8}$met/sec;

$h = 6.62 \times 10^{-34}$J-s;

But $E = \frac{hc}{\lambda} = \frac{6.62 \times 10^{-34} \times 3 \times 10^{8}}{3 \times 10^{-10}} = 6.62 \times 10^{16}$ J.

• • •