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 $\frac{2\pi}{\lambda}(\alpha t\text{-}x)$. 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. $<K> = \frac{1}{4}kA^2$ 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 acceleariton.
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^o. 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^o 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. $\frac{d^2y}{dt^2} + r\frac{dy}{dt} + \omega_o{}^2 y = a_0 \, sin(\omega t)$

In absence of dumping (r=0)

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

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

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

$$\therefore \frac{dy}{dt} = A\omega \text{ Cos } (\omega t) \quad ..... (3)$$

$$\therefore \frac{d^2y}{dt^2} = -A\omega^2 \text{ Sin } (\omega t) \quad ..... (4)$$

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

$$- \; A\omega^2 Sin(\omega t) + \omega_0^2 A Sin(\omega t) = a_0 Sin(\omega t)$$

dividing above eq^n by Sin(ωt)

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

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

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

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

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

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

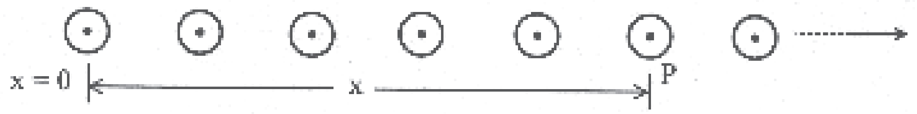
2. $v = \pm\omega\sqrt{A^2 - y^2}$

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

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

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

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.

$y = y_1 + y_2$

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

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

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.

Beats : 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 $d\vec{p} = -2mvSin30\,\hat{i}$

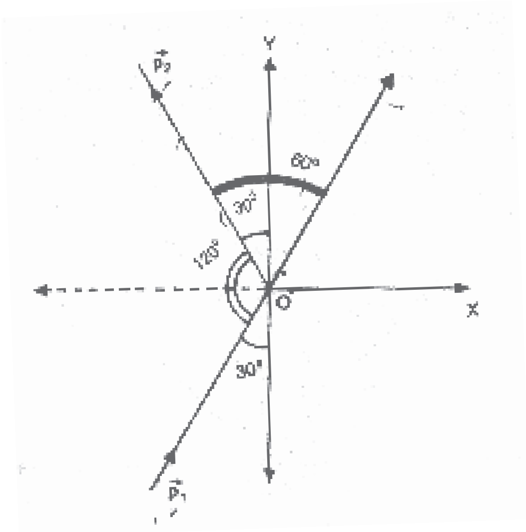
= -2 (4) (1) (1/2) $\hat{i}$

= -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 %

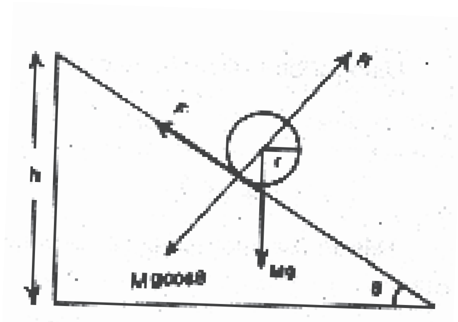
2. Joule - Second

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).

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

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

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

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.

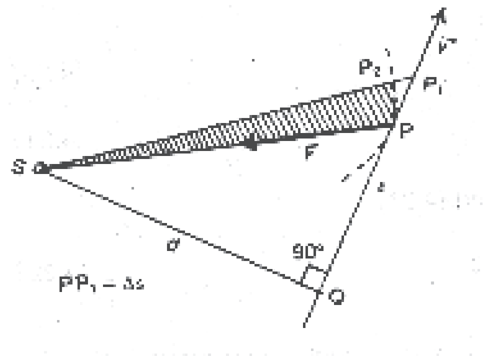


Figure shows, by a broken line, a part of the orbit of a planet going around the sun S. Let the linear velocity of the planet be $\vec{v}$ when it is at a position P. The perpendicular distance between the sun S and the direction of $\vec{v}$ is d. Let m be the mass of the planet. Angular momentum of 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.

$\therefore \frac{dA}{dt} = \text{constant}$ .... (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

$\theta = \left(\frac{w + wo}{2}\right)t$

$\theta = 75 rad$

$\alpha = \frac{\omega - \omega_0}{t} = \frac{25-5}{5}$

$\alpha = 4 rad / s^2$

$I = Mr^2 = 25 \times 10^{-2} \times 25 \times 10^{-2} \times 40 = 2.5 Kg\, m^2$

$\theta = \left(\frac{\omega + \omega_0}{2}\right)t$

$= \left(\frac{25+5}{2}\right)5$

= 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. $n_1 = 1 - \frac{T_2}{T_1}$

$\frac{1}{6} = 1 - \frac{T_2}{T_1}$ .... (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. $P_1V_1 = P_2V_2 \Rightarrow \frac{V_2}{V_1} = \frac{P_1}{P_2}$

$W = 2.303nRT \log\left(\frac{P_1}{P_2}\right)$

$= 2.303 \text{ x } 1 \text{ x } 83 \text{ x } 300 \text{ x } \log(1/5)$

$= -4008$ Joule

Q.3. (A) 1. 5 x 6.25 x 10^{15}

= 31.25 x 10^{15}

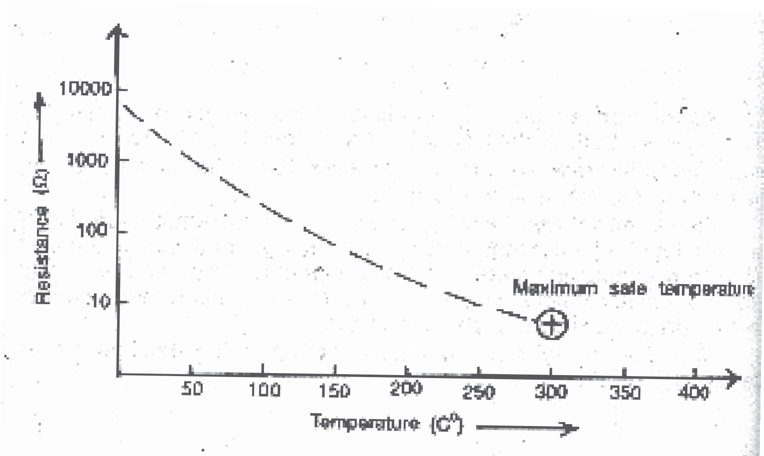
2. Kirchoofs Second Rule

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

$$\frac{m_1}{m_2} = \frac{e_1}{e_2} \qquad \text{............. (1)}$$

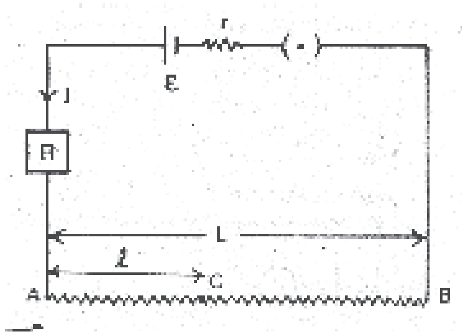
$$\frac{m_1}{m_2} = \frac{e_1}{e_2} = \frac{It\,Z_1}{It\,Z_2}$$

$$\therefore \frac{e_1}{e_2} = \frac{z_1}{z_2} \qquad \text{........... (2)}$$

$$\therefore \frac{e_1}{z_1} = \frac{e_2}{z_2} \qquad \text{............ (3)}$$

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)

$$V_l = \left[\frac{\varepsilon\rho}{R + L\rho + r}\right] l \qquad \text{............. (3)}$$

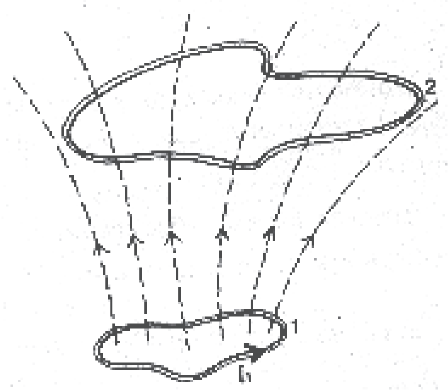
The potential difference per unit length of the wire $\frac{V_l}{l}$ is called its potential gradient and is represented by σ.

$$\therefore V_l = \sigma\ell$$

$\therefore V_l \alpha \ell$

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.

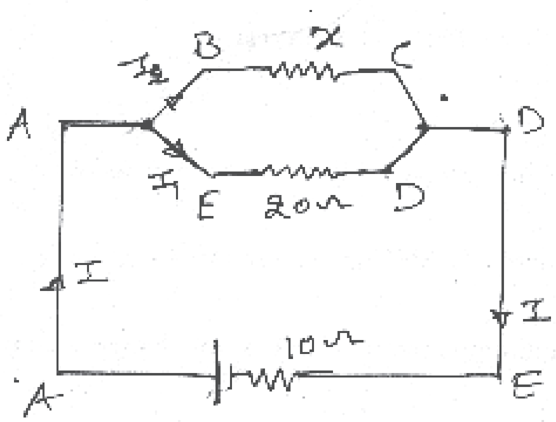
$\therefore \Phi_2 \alpha I_1$

$\therefore \Phi_2 = M_{21} I_1$ .... (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 $-20I_1 - 10I = -2$

$20(I - 0.05) + 10I = 2$ $(\because I_1 = 1 - 0.05)$

$20I - 1 + 10I = 2$

$30I = 2 + 1 = 3$

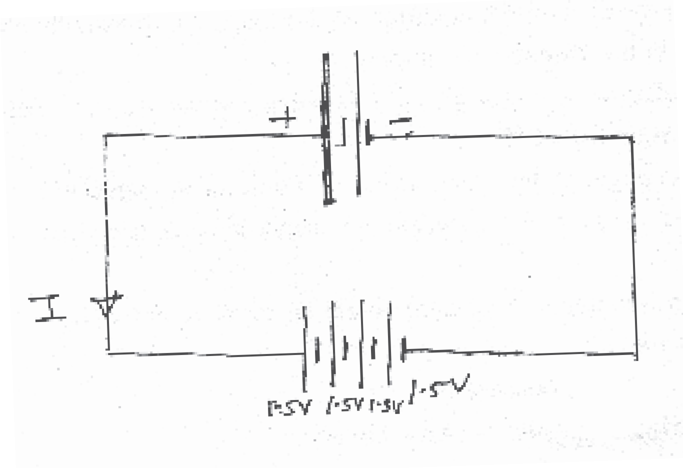
$I = 0.1$ Amp.

In BCDEB $-20 I1 + 0.05x = 0$

$x = \frac{20I}{0.05} = \frac{20 \times 0.05}{0.05}$

$x = 20\Omega$

2.



$V = 4\varepsilon + 4Ir + 1R$

$\therefore\ I = \frac{V - 4\varepsilon}{4r + R} I_1$

$\therefore \quad I = \frac{110-(4\times1.5)}{4\times0.5+49} = \frac{104}{51}$

$\therefore$ 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

$I_g = \frac{10I}{100}$

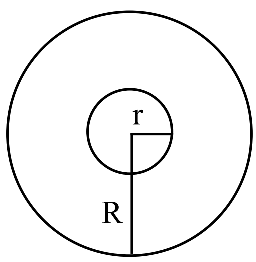
$\therefore I_g = 0.1I$

$\therefore \; S = G\frac{I_g}{I - I_g}$

$\therefore \; S = 18\frac{0.1I}{I - 0.1I}$

$= 18\times\frac{0.1}{0.9} \qquad = 2\ \Omega$

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

$$P = \frac{V_m I_m}{2} \left[\frac{1}{T} \int_0^T Cos\delta dt + \frac{1}{T} \int_0^T Cos(2\omega t - \delta) dt \right]$$

$$P = \frac{V_m I_m}{2} Cos\delta \qquad \left[\because \int_0^T Cos(2\omega t - \delta) dt = 0 \right]$$

$$P = \frac{V_m}{\sqrt{2}} \frac{I_m}{\sqrt{2}} Cos\delta$$

$P = V_{rms} I_{rms} \cos\delta$

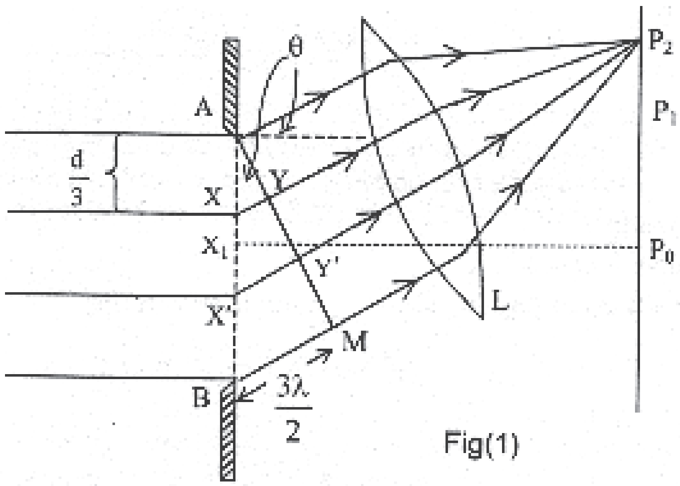
Where $\cos\delta$ = power factor.

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. $\delta = 45 \qquad \therefore\ \tan\delta = 1$

$$\therefore\ tan\,\delta = \frac{\omega L - \frac{1}{\omega C}}{R} = 1$$

$$\therefore\ R = \omega L - {}^{1}\!/_{\omega C}$$

$$\therefore\ |z| = \sqrt{R^2 + (\omega L - \frac{1}{\omega C})^2}$$

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

$$\therefore\ |z| = \frac{Vm}{Im} = \frac{20}{1} = 20\Omega$$

$$\therefore\ R\sqrt{2} = 20\Omega$$

$$\therefore\ R = 14.14\Omega$$

2. $C = \lambda f$

$$\therefore\ f = {}^{C}\!/_{\lambda}$$

$$= \frac{3\times10^{8}}{5600\times10^{-10}}$$

$\therefore\ f = 5.357 \times 10^{14}\ H_z$

3. $\frac{I_1}{I_2} = \alpha$ *and* $\therefore\ I \alpha A^2$

$\therefore\ \frac{I_1}{I_2} = \frac{A_1^2}{A_2^2} = \alpha \qquad \Rightarrow \frac{A_1}{A_2} = \frac{\sqrt{\alpha}}{1}$

For Constructive Intorfarance $A_1 + A_2 = \sqrt{\alpha} + 1$

$\therefore\ A_1 - A_2 = \sqrt{\alpha} - 1$ *(For destructive Interference)*

$\therefore I_{max}\ \alpha\ \ (A_1 + A_2)^2 \alpha (\sqrt{\alpha} - 1)^2$

$\therefore I_{min}\ \alpha\ (A1 - A2)^2 \alpha (\sqrt{\alpha} - 1)^2$

$$\therefore \frac{I_{max}}{I_{min}} = \frac{(\sqrt{\alpha}+1)^2}{(\sqrt{\alpha}-1)^2} = \frac{\alpha + 2\sqrt{\alpha} + 1}{\alpha - 2\sqrt{\alpha} + 1}$$

$$\therefore \frac{I_{max} + I_{min}}{I_{max} - I_{min}} = \frac{2\alpha + 2}{4\sqrt{\alpha}} = \frac{2(\alpha + 1)}{4\sqrt{\alpha}} = \frac{1 + \alpha}{2\sqrt{\alpha}}$$ *by taking Comp. and dividen.*

4. $x_3 = \frac{3\lambda D}{d} \qquad x_9 = \frac{9\lambda D}{d}$

$x_9 - x_3 = \frac{\lambda D}{d}(9 - 3)$

$0.6 = \frac{\lambda \times 100}{0.05} \times 6$

$\lambda = \frac{0.6 \times 0.05}{100 \times 6}$

$\lambda = 5000 A^o$

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.

$$\therefore \frac{1}{2}mv_{max}^2 = hf - W_0 \qquad \text{..........} (1)$$

$$\therefore eV_0 = hf - hf_0 \qquad \text{..........} (2)$$

$$\therefore V_0 = \left(\frac{h}{e}\right)f - \frac{hf_0}{e} = \left(\frac{h}{e}\right)(f - f_0) \qquad \text{............} (3)$$

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 $t = 0 \Rightarrow N = No$

$\therefore \ln N_0 = C$

$\therefore \ln N = -\lambda t + \ell n N_0$

$\therefore \ell n \dfrac{N}{N_0} = -\lambda t$

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

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

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.

$_1H^1 + _1H^2 \rightarrow _2He^3 + 5 Mev.$

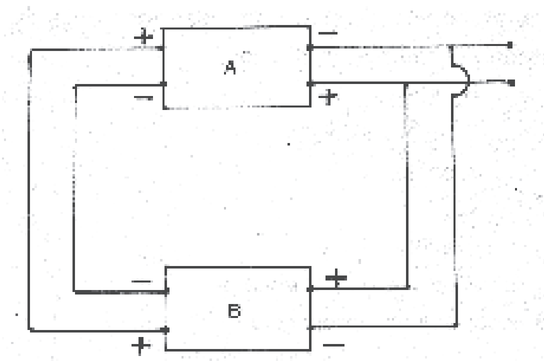
Two of such reactions are then followed by

$_2He^3 + _2He^3 \rightarrow _2He^4 + 2(_1H^1) + 12.9\, Mev.$

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

$$q = \frac{g}{E}(m - mo)$$

$$q = \frac{g}{\frac{V}{d}}\left[\frac{4}{3}\pi r^3\rho - \frac{4}{3}\pi r^3\rho_0\right]$$

$$q = \frac{9.8\times6\times10^{-3}}{10^3}\times\frac{4}{3}\times3.14\times(7.25\times10^{-7})^3\times(880 - I - 29)$$

$$q = 8.003\times10^{-19}\,C$$

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

$$10 = \frac{\delta V_{CE}}{\delta V_{BE}} \times 0.98$$

$$\therefore 10 = \frac{R_L \delta I_C}{r_i \delta I_B} \times 0.98$$

$$\therefore \frac{r_i}{R_L} = \frac{0.98 \times 0.98}{10}$$

$$\therefore \quad \frac{r_i}{R_L} = 0.096$$

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