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 0.5x 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 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.

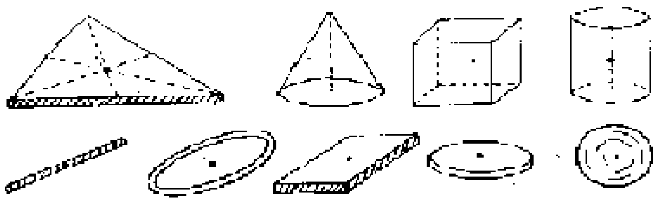
1. (A)

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 $\vec{F} = 0$ $\quad M\,\vec{a}_{cm} = \frac{d\vec{p}}{dt} = \vec{F} = 0$ 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

$\sin kx = \pm 1 \Rightarrow kx = (2n-1)\pi/2,$

$\Rightarrow x = (2n-1)\pi/2\kappa = (2n-1)\lambda/4.$

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.

$$\therefore \frac{d^2y}{dt^2} + \frac{b}{m}\text{v} + \omega^2 y = \frac{F_0}{m}\sin \omega t = a_0 \sin \omega t$$ ……………………………(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.

$$A = \frac{a_0}{[(\omega_0^2 - \omega^2)^2 + r^2\omega^2]}$$ …………………………………………………(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 $\vec{v}_1 = \hat{i} + 2\hat{j} + 3\hat{k}$;

$\vec{v}_2 = 3\hat{i} + 4\hat{j} + 5\hat{k}$ 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 $y = -2A\sin(kx)\cos(\omega t)$

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 = <u>9.8</u> 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

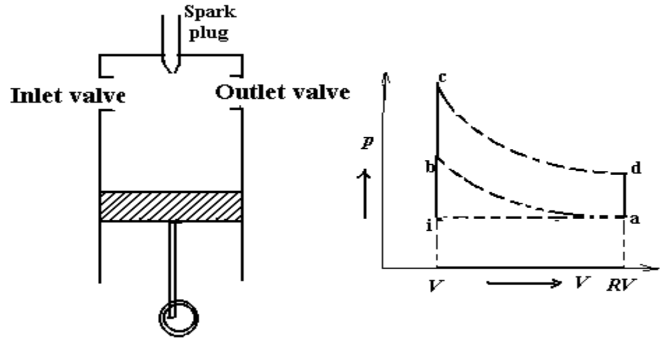
$$W = \int_{V_1}^{V_2} p\,dV = \int_{V_1}^{V_2} \frac{nRT}{V} dV$$

$$\therefore W = nRT[\ln V]_{V_1}^{V_2}$$

$$\therefore W = nRT[\ln V_2 - \ln V_1]$$

$$\therefore W = nRT \ln\left(\frac{V_2}{V_1}\right) \text{.........} \qquad (2)$$

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***.

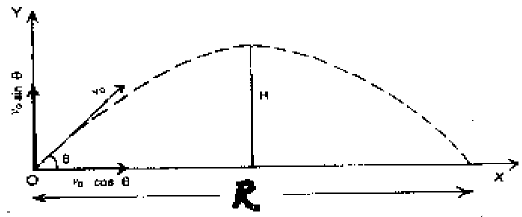
1.*Intake Stroke*: In this process, the inlet valve is open and the outlet valve is close. The mixture of air and the vapor of the petrol enter form the inlet valve into the cylinder and the piston moves downwards. The pressure of the air and the petrol vapor is maintained constant. This process is shown 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.

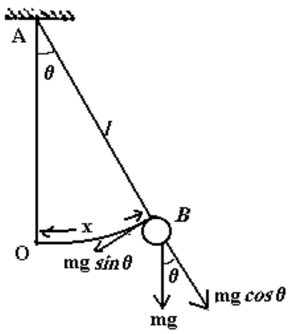
4. Suppose the length of pendulum is l and the mass of its bob is m.

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.)

$\vec{\tau} = \vec{l} \times \vec{mg}$ ......(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

$$\tau = I\alpha = I \frac{d\omega}{dt} = I \frac{d^2\theta}{dt^2} \quad \text{.......... (3)}$$

$$\therefore I \frac{d^2\theta}{dt^2} = -\, l\; mg \sin\theta$$

Moreover, $I = ml^2$

$$\therefore ml^2 \frac{d^2\theta}{dt^2} = -\, l\; mg\; \sin\,\theta \text{ ....(4)}$$

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)

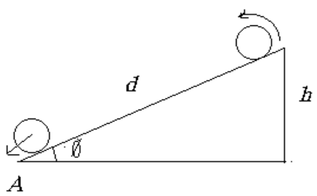
$$\frac{d^2\theta}{dt^2} + \omega^2\theta = 0 \text{ .... (5)}$$

(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 $\eta_1 = 1 - \frac{T_2}{T_1}$

$\therefore \frac{1}{4} = 1 - \frac{300}{T_1}$

$\therefore \frac{300}{T_1} = \frac{3}{4}$

$\therefore T_1 = 400^0 K;$

Now, $\eta_2 = 1 - \frac{T_2}{T_1^{'}} = 1 - \frac{300}{T_1^{'}}$

$\therefore \frac{300}{T_1^{'}} = \frac{3}{5}$

$\therefore T_1 = 500^0 \ K$

so increase in temperature required is $T_1^{`} - T_1 = 100\,K$

4. Here, Re = 6400 km

$= 6400 \times 10^3 \ Meter$

$\rho = 19.3 \ \times 10^3 \frac{Kg}{m^3}$

$G = 6.67 \ \times 10^{-11} \ MKS$

Acceleration due to gravity on the surface of the earth is given by

$g = \frac{G\ Me}{\mathrm{Re}^2}$

But mass of the earth = volume x density.

$\therefore M_e = \frac{4}{3} \pi \mathrm{Re}^3 \rho$

Now $g = \frac{G\ M_e}{R_e^{\ 2}}$

$\therefore g = \frac{G \frac{4}{3} \pi R_e^{\ 3} \rho}{R_e^{\ 2}}$

$= \frac{4}{3} \pi R_e \rho\ G$

$$\therefore g = \frac{4 \times 3.14 \times 64 \times 10^{5} \times 19.3 \times 10^{3} \times 6.67 \times 10^{-11}}{3} = \frac{103.48}{3}$$

$$\therefore g = 34.49 \frac{m}{S^2}$$

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 $P' = P/4 = 100/4 = 25W$.

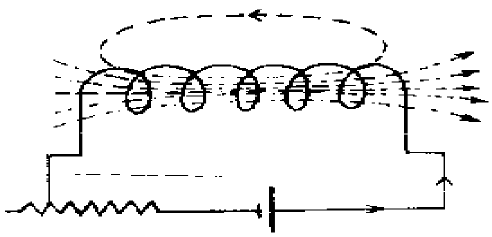
4. To produce arial magnetic field so even after some deflection magnetic flux passing through coil remains same and deflection directly proportional to current passing through it.

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.

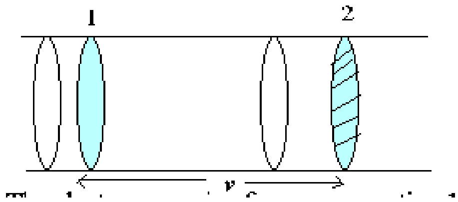
Its value of self induction depends upon the size and shape of the coil as well as the number of turns. If also depends upon the magnetic property of the medium of the space within the coil.

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

$$E = \frac{V}{l} = \frac{IR}{l} \qquad (1)$$

$$\therefore E = \frac{I\rho l}{Al} \quad ....(2) \qquad (\because R = \rho\frac{l}{A})$$

$$\therefore E = \frac{I\rho}{A} \quad ....(3)$$



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*.

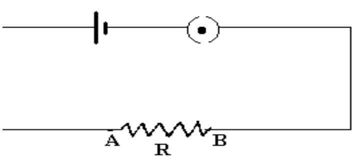
Total electric charge of these electrons is *nAve* .... (4)

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)

$$\therefore E = \frac{I\rho}{A} = \frac{nAve\rho}{A} = nev\rho \quad ....(6)$$

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.

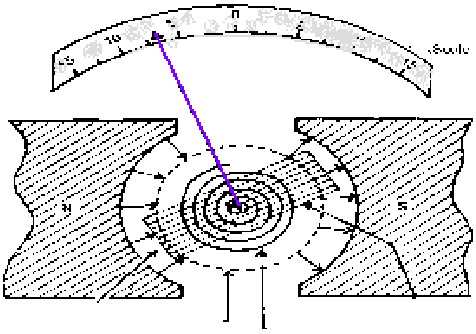
Now if the electric current is considered to form due to the motion of the electrons then unit negative electric charge at point B is said to have V joule electrical energy.

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 $R_1 = \frac{V_1^2}{P_1}$

$\therefore R_1 = \frac{110 \times 110}{40} = 302.5$ Ohm

Current $I_1 = \frac{P_1}{V_1} = \frac{40}{110} = 0.3636A$

Resistance of bulb B $R_2 = \frac{V_2^2}{P_2} = \frac{110 \times 110}{100} = 121$ Ohm

Current $I_2 = \frac{P_2}{V_2} = \frac{100}{110} = .909A$

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 $I = \frac{V}{R_1 + R_2} = \frac{220}{423.5} = 0.5195A$

$\therefore I > I_1$ 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 $\varepsilon = N\dfrac{\Delta\phi}{\Delta t}$

$$\therefore \quad \varepsilon = \frac{NAB}{\Delta t} = \frac{100 \times 15 \times 10^{-2} \times 0.5}{0.05}$$

= 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 $\frac{3\lambda'}{2} = d\sin\theta.$

$$\therefore \frac{3\lambda'}{2} = 6000$$

$$\therefore \quad \lambda = 4000\ A^0$$

4. Unit of $\mu_o = \frac{Tesla\ meter}{ampere} = \frac{Newton\ .\ second\ .\ meter}{coulomb\ .\ meter\ .\ ampere} = \frac{Newton}{Ampere^2}$

Unit of $\varepsilon_0 = \frac{coulomb^2}{newton\,(meter)^2}$

$$\therefore \frac{1}{\sqrt{\mu_0\,\varepsilon_0}} = \frac{1}{\sqrt{\frac{newton}{ampere^2} \cdot \frac{coulomb^2}{newton\,(meter)^2}}}.$$

$$= \frac{1}{\sqrt{\frac{ampere^2\,(second)^2}{ampere^2\,(meter)^2}}}$$

$$= \frac{meter}{second}$$

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.

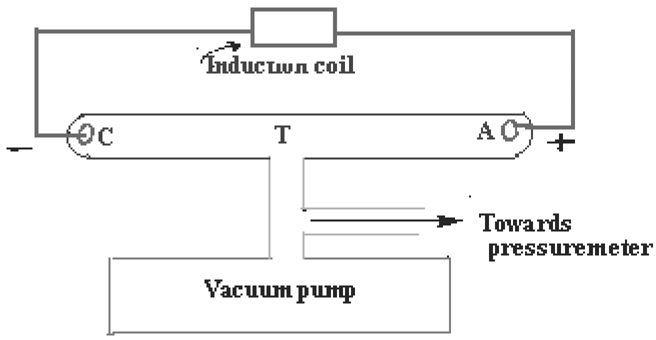
5. The unit of trans-conductance is mho.

(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,

$$\frac{1}{\lambda_2} = R\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = R\left(\frac{1}{4} - \frac{1}{9}\right) = \frac{5R}{36} \quad \ldots\ldots\ldots(1)$$

If wavelength is λ for first line in Lymen series

$$\frac{1}{\lambda} = R\left(\frac{1}{1^2} - \frac{1}{2^2}\right) = R\left(\frac{1}{1} - \frac{1}{4}\right) = \frac{3R}{4} \quad \ldots\ldots\ldots(2)$$

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.

• • •