LAQ'S (8 MARKS)

WAVES

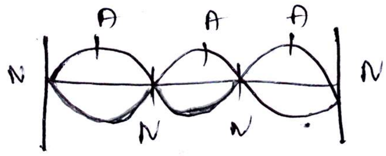
1. Explain the formation fo stationary waves in stretched strings and hence deduce the laws of transverse waves in stretched strings.

A. **Stationary wave:** The interference of two idnetical waves moving in opposite directions produces stationary waves.

It forms nodes when the displacement is O and antinodes when the displacement is maximum

$y_1 = A \sin (wt - kx)$

$y_2 = A \sin (wt + kx)$



$y = y_1 + y_2$

$y = A \sin (wt + kx) + A \sin (wt + kx)$

$y = 2A \sin kx \quad \cos wt$

$y = a_m \cos wt, \quad a_m = 2a \sin kx$

→ It forms alternate nodes and antinodes.

→ If amplitude is zero, it gives node.

→ If amoplitudes is maximum if gives antinode.

→ The distance between N-N (or) A -A = $\lambda/2$.

→ The distance between A-N (or) N-A = $\lambda/4$.

→ The position of nodes kx $n\pi$ (n = 0, 1, 2, ...)

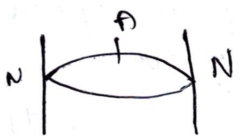
→ The position of antinode $kx = \left(n + \frac{1}{2}\right)\pi$ (n = 0, 1, 2, ...)

Modes of Vibrationin a stretched string:

→ We know that velocity of transverse wave is a stretchede string is $\sqrt{\frac{7}{\mu}}$

Fundametnal Frequency:

→ It is the lowest possible natural frequency of stationary wave is called fundamental frequency or first harmonic.



$n_1 = \sqrt{\frac{T}{\mu}}$

$= v/\lambda$

$n_1 = \frac{V}{\lambda}$ $\qquad \ell = \lambda/2$

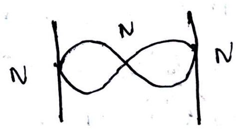
$n_1 = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$ $\qquad \lambda = 2\ell$

$n_1 = \frac{1}{2\ell}\sqrt{\frac{T}{\mu}}$.

First overtone:

→ If the frequency is more than fundamental frequency are called overtone.

$n_2 = \frac{\frac{1}{2l}\sqrt{\frac{T}{\mu}}}{2}$

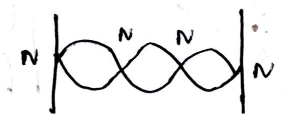


$n_2 = 2\frac{1}{2\ell}\sqrt{\frac{7}{\mu}}$ $\qquad \ell = 2\lambda / 2$

$n_2 = 2n_1$ $\qquad \lambda = 2\ell / 2$

Second Overtone:

$n_3 = 3\left[\frac{1}{2\ell}\sqrt{\frac{7}{\mu}}\right]$



$n_1 : n_2 : n_3 = 1 : 2 : 3$ $\qquad \ell = 3\lambda/2$

Law of Transverse wave in a Stretched String:

$$n = \frac{1}{2\ell}\sqrt{\frac{T}{\mu}}$$

I Law : $n \propto \frac{1}{\ell}$ [7 & μ are constant]

$n_1\ell_1 = n_2\ell_2$

II Law : $n \propto \sqrt{T}$

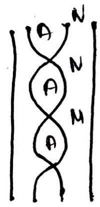
$\frac{n_1}{n_2} = \sqrt{\frac{T_1}{T_2}}$ [ℓ & μ are constant]

III Law : $n \propto \frac{1}{\sqrt{\mu}}$

$n_1\sqrt{\mu_1} = n_2\sqrt{\mu_2}$ [ℓ & T are constant]

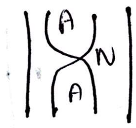
2. Explain the formation of stationary waves in an air column unclosed in open pipe. Derive the equation for the frequencies of the harmonics produced.

A. If the pipe is open at both the ends is called open pipe.
$n = V/\lambda$



Fundamental Frequency :

$$n_1 = \frac{V}{2\ell}$$

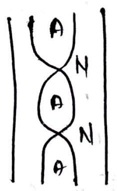


$\ell = \lambda / 2$

$\lambda = 2\ell$

First overtone :

$$n_2 = \frac{V}{\frac{2\ell}{2}}$$



$\ell = 2\lambda / 2$

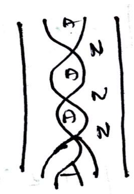
$$n_2 = \frac{2V}{2\ell}$$

$\lambda = 2\ell / 2$

$\therefore n_2 = 2n_1$

Second overtone:

$$n_3 = \frac{V}{\frac{2\ell}{3}}$$



$\ell = \frac{3\lambda}{2}$

$$n_3 = \frac{3V}{2\ell}$$

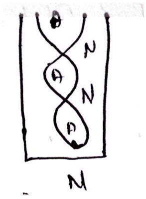
$\lambda = \frac{2\ell}{3}$

$n_3 = 3n_1$

$n_1 : n_2 : n_3 \;\; 1 : 2 : 3.$

3. How are stationary waves formed in closed pipes? Expalin the various modes of vibrations and obtain relations for thier frequencies?

A. If the pipe is closed at one end is called closed pipe.



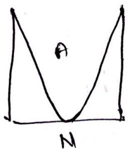
$$v = n\lambda$$

$$n = \frac{V}{\lambda}$$

Fundamental frequency:

It consists of one antinode and one node

$$n_1 = \frac{V}{4\ell}$$



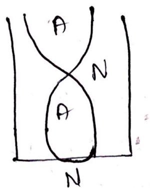
$$\ell = \frac{\lambda}{4}$$

$$\lambda = 4\ell$$

First overtone:

It consists of two nodes and two antinode

$$n_2 = \frac{V}{\frac{4\ell}{3}}$$



$$\ell = \frac{3\lambda}{4}$$

$$n_2 = \frac{3V}{4\ell}$$

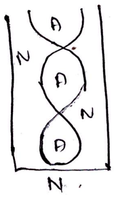
$$\lambda = \frac{4\ell}{3}$$

$$n_2 = 3n_1$$

Second overtone:

It consists of three antinode and three nodes

$$n_3 = \frac{V}{\frac{4\ell}{5}}$$



$$\ell = \frac{5\lambda}{4}$$

$$n_3 = 5n_1$$

$$\lambda = \frac{4\ell}{5}$$

$n_1 : n_2 : n_3 = 1 : 3 : 5.$

4. What is Doppler effect? Obtain an expression for the apparent frqeucny of sound heard when the source is in motion with respect to an observer at rest.

A. Doppler Effect : The apparent change in the frequency due to relative motion between the source nad observes is called Doppler effect.

Expression : When the source 's' is moving away from stationary observer.

Let the source produce at crust and it reaches the observer in t_1' sec.

$$t_1 = \frac{L}{V} \text{ -------- (1)}$$

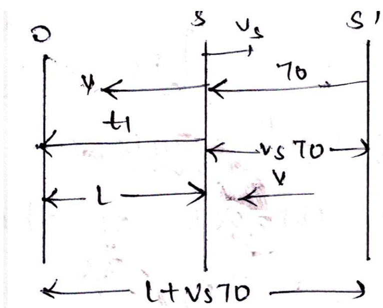
→ Now the source moved from 's' to 's'' in to sec with a velocity Vs and the second crest reaches the observer

$$t_2 = T_0 + \frac{L + VsT_0}{V}$$

Similarly

$$t_{n+1} = nT_0 + \frac{L + nVsT_0}{V} \text{ ----------(2)}$$

2 (-) 1



$$t_n = t_{n+1} - t_1 = n\,T_0 + \cancel{\frac{\ell}{V}} + \frac{n\,VsT_0}{V} - \cancel{\frac{\ell}{V}}$$

$$t_n = nT_0\left[1+\frac{Vs}{V}\right]$$

$$T^{l} = \text{time period} = \frac{t_n}{n} = \frac{\cancel{n}\,T_0\left[1+\frac{Vs}{V}\right]}{\cancel{n}}$$

$$\text{Apparent fue } n^{l} = \frac{1}{T'}$$

$$n^{l} = \frac{1}{T_0\left[1+\frac{Vs}{V}\right]} = n_0\left[1+\frac{Vs}{V}\right]^{-1} = n_0\left[1-\frac{Vs}{V}\right]$$

$$n^{l} = n_0\left[\frac{V-Vs}{V}\right] \qquad n^{l} < n_0$$

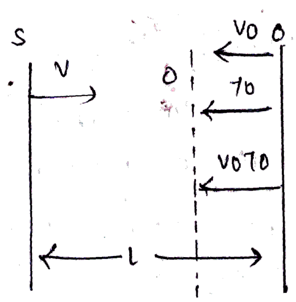
simlarly of 's' moves towards stationary observer.

$$n^{l} = n_0\,\frac{\mu_0 i_1 i_2 \ell}{2\pi r} \qquad n^{l} > n_0$$

5. What is Doppler Shift? Obtain an expression for the apparent frequency of sound heard when the observer is in motion with respect ot a source at rest.

A. **<u>Doppler Shift:</u>** The change in the frequency of sound produced and apparent frequency of sound heard by teh listenes is called Dopller shift.

Expression : Observer is moving towards statonary source



$$t_1 = \frac{L}{V+V_0}$$

$$t_2 = T_0 + \frac{L-V_0T_0}{V+V_0}$$

$$t_{n+1} = n\,T_0 + \frac{L-nV_0T_0}{V+V_0}$$

$$T_n = t_{n+1} - t_1 = nT_0 + \cancel{\frac{L}{V+V_0}} - \frac{nV_0T_0}{V+V_0} - \cancel{\frac{L}{V+V_0}}$$

$$T_n = nT_0\left[1+\frac{V_0}{V+V_0}\right]$$

$$T = \frac{T_n}{n} = T_0\left[1-\frac{V_0}{V+V_0}\right]$$

$$n^{l} = \frac{1}{T} = \frac{1}{T_0\left[\frac{V_0}{V-V_0}\right]}$$

$$n^{l} = n_0\left[\frac{V+V_0}{V}\right]^{-1} \qquad n^{l} > n_0$$

y (2) If '0' is moving away from the source $n^{l} = n_0\left[\frac{V-V_0}{V}\right]$ $n^{l} < n_0$.

CURRENT ELECTRICITY

6. State Kirchhoff's Law for an electrical network using these laws deduce the condtion for balance in a wheat stone bridge.

A. **Kirchhoff's 1st Law:** The sum of the currents flowing towards a junction is equal to the sum of the current flowing away from the junction (or) the algebuia sum of current meeting at a junction is zero i.e., $\sum I = 0$.

Kirchhoff's 2nd Law: It is states that is any closed mesh of a circuit, the algebriun sum of the products of the current and resistance in each part of the loop is equal to the algebuia sum of the emf's in that loop $\sum IR = 0$.

Wheatston Bridge : Wheat stone buidge is used to compare the resistances to determine unknown resistance and to measure small strains in hard materials. This works on the principle of Kirchhoff's laws.

Description: Wheatstone Bridge consists of four resistors R_1, R_2, R_3 and R_4 connected in the four arms of a square to form four junctions A, B, C, D as shown in the figure. A galvanometer G is connected between the junction B and D. A battery of emf and no internal resistance is connected across the junction A and C . Let G be the resistance of the galvanometer.

Principle: The current in the resistances are shown and let 1g be the current passing through the galvanometer. Consider the case when the current throughthe galvanometer is zero i.e., I g=0. This is called bridge balancing condition.

By applying Kirchhoff's law to the junction B & D at junction 'B' $I_2 = I_4 + I_g \Rightarrow I_2 = I_4$ at junction. 'D' $I_1 + I_g = I_3 \Rightarrow I_1 = I_3$

By applying Kirchhoff's 2nd law to the closed loop ADBA

$- I_1R_1 + 0 + I_2R_2 = 0$

$$\Rightarrow I_1R_1 = I_2R_2 \Rightarrow \frac{I_1}{I_2} = \frac{R_2}{R_1} \quad \text{-----------(1)}$$

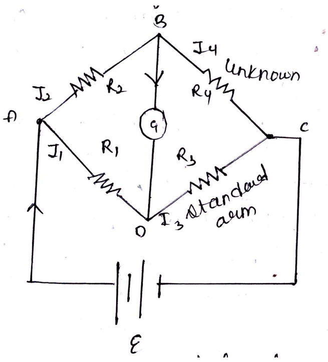
By applying Kirchhoff's 2nd law to the closed loop CBDC

$I_2R_4 + 0 - I_1R_3 = 0$

$$\Rightarrow I_2R_4 = I_1R_3 \ \frac{I_1}{I_2} = \frac{R_4}{R_3} \quad \text{-------------------- (2)}$$

From equation (1) and (2) $\frac{R_2}{R_1} = \frac{R_4}{R_3}$

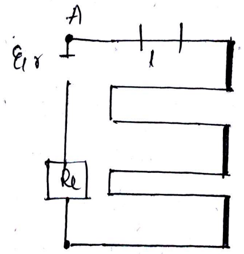
This is called bridge balancing condition.



7. State the working principle of potentiometer explain with the help of a circuit diagram how the emf of two primary cells are compared by using the potentiometer.

A. **Description:** A potentiometer consists of uniform wire of length 10m arranged between A and C as 10 wires each of length 1m on a wooden board.

The balancing length is measured from the end which is connected to the positive terminal of the battery by moving the Jockey J on the wire.



Principle :

L - Length of wire

R - Resistance of wire

Resistance of 'ℓ' is = $\left(R/L\right)\ell$

$$I = \frac{\varepsilon}{r + Rs + R}$$

Potential across 'ℓ '

V = I x resistance

$$V = \frac{\varepsilon}{r + Rs + R}\left[\frac{R}{L}\right]\ell$$

$$V = \phi\ell$$

$$\phi = \frac{V}{\ell} = \text{Potential}$$

$$V \propto \ell$$

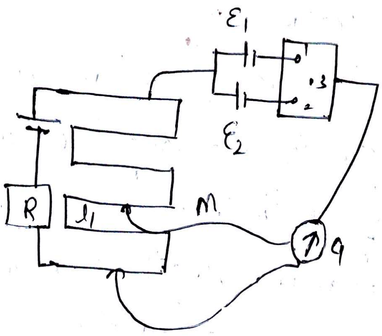
To compare e.m.f of cells :

$$\varepsilon = \phi\,\ell_1$$

$$\varepsilon_1 \propto \ell_1$$

$$\varepsilon_2 \propto \ell_2$$

$$\frac{\varepsilon_1}{\varepsilon_2} = \frac{\ell_1}{\ell_2}$$



Precautions :

1. Jockey schould not be damagged.
2. Current value should be small.
3. Current should be passed only white taking the reading.

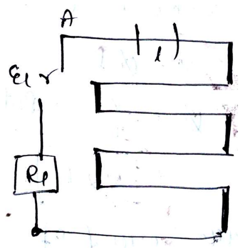
8. State the working principle of potential explain with the help of a circuit diagram how the potentiometer is used to determine the internal resistance of the given primary cell.

A. **Description :** A potential consists of uniform wire of length 10m arraged between A and C as 10 wires each of length 1m on a wooden board since the wire is uniform the p.d between A and any point at a distance ℓ from A is $\varepsilon(\ell) = \phi d$ where ϕ is the potential drop per unit length of the potentiometer wire.

Principle:

I = Length of the wire

R = Resistance of wire



Resistance of '' is $\left(R/L\right)\ell$

$$I = \frac{\varepsilon}{r + Rs + R}$$

Potential across 'ℓ'

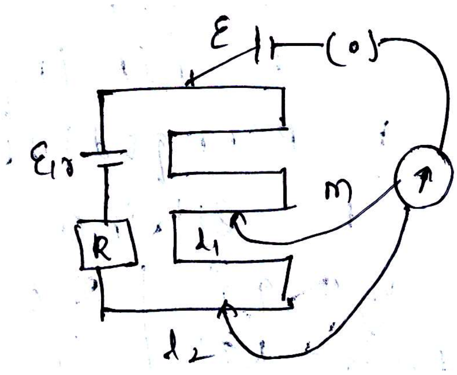
V = I x resistance

$$V = \frac{\varepsilon}{r + Rs + R}\left[\frac{R}{L}\right]\ell$$

$$V = \phi\ell$$

$$\phi = \frac{V}{\ell} = \text{Potential}$$

$$V \propto \ell$$



Inter resistance (r) :

$$\varepsilon_1 \propto \ell_1$$
$$V \propto \ell_2$$

$$\frac{\varepsilon}{V} = \frac{\ell_1}{\ell_2}$$

$$\frac{\ell_1}{\ell_2} - 1 = \frac{r}{R} \Rightarrow \frac{r}{R} = \frac{\ell_1 - \ell_2}{\ell_2}$$

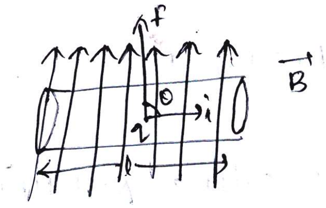
$$r = R\left[\frac{\ell_1 - \ell_2}{\ell_2}\right]$$

Precautions:
1) Jockey should not beduagged along the wire.
2) Current value should be small.
3) Current should be passed while taking readings.

MOVING CHANGES AND MAGNETISM

9. Deduce an expression for the force on a current carrying conductor placed in a magnetic field. Derive an expression for the force per unit length between two parallel current conductors.

A. Let us consider a conductor of length 'ℓ' area of cross section 'A' placed in unforum magnetic field of induction $\bar{B}$ as shown in the figure.



Force acting on the charge

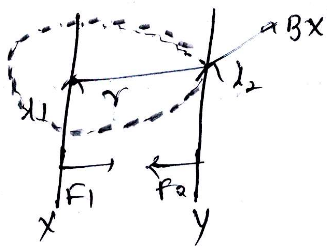
$$F = -q\left(\bar{V} \times \bar{B}\right)$$
$$= -B_2 V \sin\theta$$

Area of conductor = A
Vel of change = Vd
Falling acting on the conductor

$$F = n\ell Af$$
$$F = n\ell A\,(Bqv \sin\theta)$$
$$F = B(nAqvd)\,\ell\sin\theta$$
$$F = Bil\sin\theta$$

If $\theta = 90^0$ — f max = Bil
If $\theta = 0^0$ — f min = 0

Let us consider two parallel conductors x and y seperated by a distance 'r' as shown in the figure Let i_1 and i_2 be the currents passing through the conductors.



$$B_x = \frac{\mu_0 i_1}{2\pi r}$$

Force acting on 'y' due to Bx is

$$F_y = B \times i_2\ell \quad (\therefore\ \theta = 90^0)$$

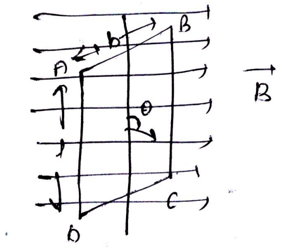
$$F_y = \frac{\mu_0 i_1 i_2 \ell}{2\pi r}$$

similarly By = $\frac{\mu_0 i_2}{2\pi r}$ and F x = $\frac{\mu_0 i_1 i_2 \ell}{2\pi r}$ $\quad\therefore F_1 = F_2 = F_3 = \frac{\mu_0 i_1 i_2 \ell}{2\pi r}$

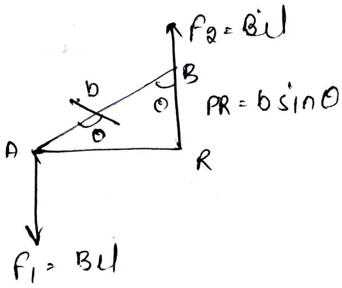
Force acting per unit length $\frac{F}{\ell} = \frac{\mu_0 i_1 i_2}{2\pi r}$

10. Obtain an expression for the torque on a current carrying loop placed in a uniform magnetic field. Describe the construction and working of a moving coil galvanometer.

A. Let us consider a rectangular coil of length 'ℓ' breadth 'b' placed in uniform magnetic field as shown in the figure.



Along the length side
(AD and BC)
$F_1 = F_2 = Bil$ [$\because \theta = 90^0$]
Along AB and CD $F_3 = F_4 = Bib$
Resultant force along
AB & CD = 0
Torque T = one of the force
X perpendicular distance (PR)
T = Bil b sinθ
T = Bi A sinθ



For 'N' no. of turns

If θ = 90^0 | If θ = 0^0
Tmax = Bi AN | Tmin = 0

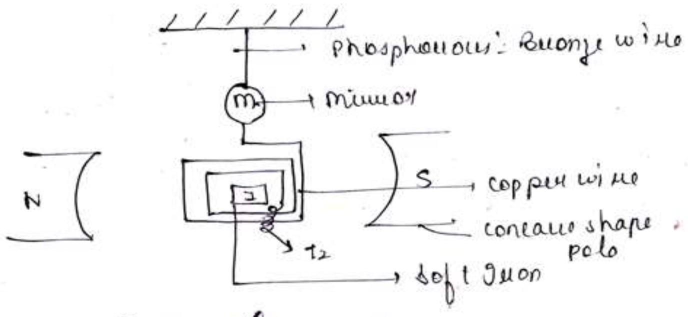
Moving coil Galvanometer:

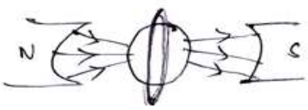
Let us consider a copper wire wound on a non-metallic frame and placed in between concave shaped poles as shown in the figures.

→ Let 'm' be the merror is used to measure the number of deflections.

→ It is used to detect and measure small electric current of the order 10^{-9} amper's.

Principle: When a current carrying coil placed in a uniform magnetic field it experences a torque.





In equilibrium position
Torque = Resoring couple
Bi AN = Cθ

$$i = \frac{c}{BAN}\theta$$

i = kθ

i ∝ θ

11. Explain the principle and working of a nuclear reactor with the help of a labelled diagram.

A. **Principle of Nuclear Reactor:** Nuclear reactor is used to produce a large amount of nuclear energy through a controlled nuclear fission process.

The essential part of a nuclear reactor are

i) Nuclear fuel ii) Moderator iii) Control rods iv) Protective shielding v) Coolant

i. **Nuclear Fuel :** The fissionable material used in the reactor is called nuclear fuel. The uranium isotopes $_{92}U^{235}$ and $_{92}U^{238}$. Platenium Pu and thorium $_{99}Th^{232}$ are commonly used fuels in the rectors.

ii. **Moderators:** Core contain moderators. These are used to slow down the fast moving neutrons produce in the fission process. The material used as moderators are heavy water carbon in the form of pure graphite hydrocarbon plastics etc. The core is surrounded by reflectors to reudce leakage.

iii. **Control rods:** These are the materials that can absorb the neutrons and control the nuclear chain reaction cadmium or Boron or Beryllium rods are generally used for htis purpose.

iv. **Protective Shielding:** It is used to prevet the spreading of radioactive effect to the space around the nuclear reactor. For this purpose lead block, concrete walls of thickness 10m is used.

v. **Coalant :** The material used to absorb heat generated in the reactor is called coolant. The coolants are water moltten sodiuom etc.

Working:

i. Uranium fuels are placed in the aluminium cylinders which are sepracted by some distance. The graphite moderators in the form of pure carbon blocks is placed in between the fuel cylinder.

ii. To control the number of neutrons a number of control rods of codium or beryllium or boron are placed in the holes of graphite block.

iii. When thermal neutron collides with U^{235} nuclei it undergoes fission then produces fast neutrons are liberated. These neutrons pass through the surronding graphite moderator and lose their kinetic energy to become thermal reaction.

iv. These thermal neutrons are captured by U^{235} which carries out the fission reaction.

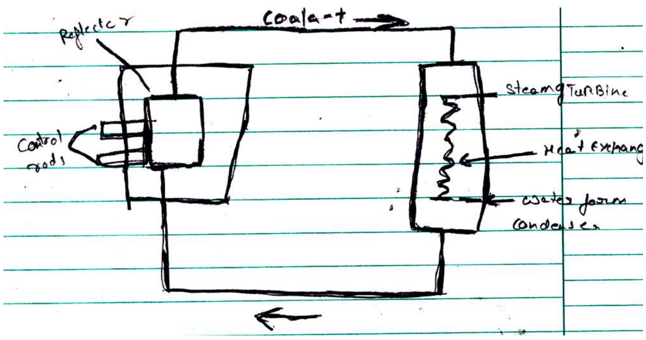
v. By using control rods the fission process can be controlled by obsorbing neutrons.

vi. The steam used to rotate a turbine for the production of electric power.

Used of nuclear reactors:

To generate electric power.

To produce radioactive materials like plutonium -239 used in the filed of medicine, industry etc.



**********The End*********