Date: 27-11-25 Classwork Day: Thursday

Topic: SLO # 08 Waves

~~Disturbance~~ in a medium

Wave :- Wave transfer energy from one place to another.

There are two types of waves.

i) Mechanical Waves :- These are the waves which required medium for their propagation.

Examples :- Sound waves, Water waves.

ii) Electromagnetic Waves :-

These are the waves which donot required medum for their propagation.

Examples :- Light waves, Gamma rays, X- rays.

* Progressive Waves :- The wave which transfer energy from the source of disturbance.

* Transverse Waves :- These are the waves in which particle of the medium are displaced in a direction perpendicular to the direction of propagation of wave.

* Longitudinal Waves :-

These are the waves in which particle of the medium are displaced in a direction parallel to the direction of propagation of wave.

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* Periodic waves:-

These are the waves which repeat itself in equal interval of time.

* Wavelength:-

Distance between any two Consecutive crest or trough is called wavelength.

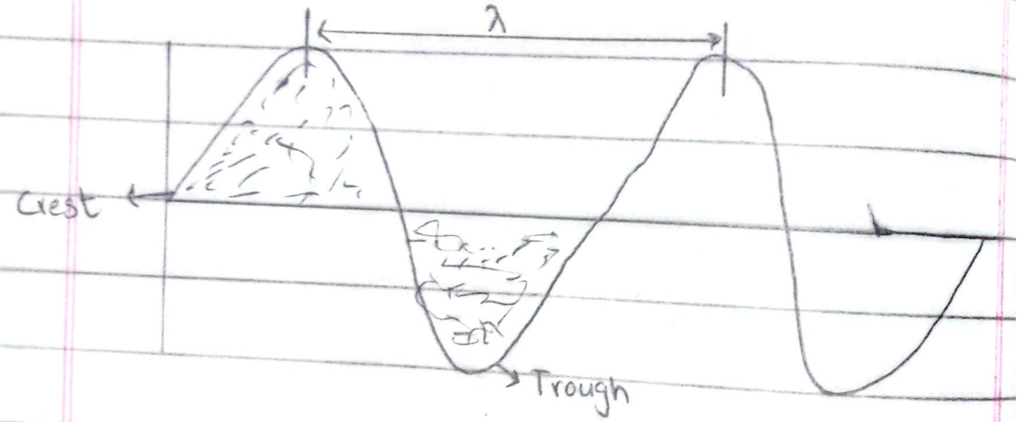
It is denoted by λ.

* Crest:-

The above Portion of wave from mean position

* Trough:-

The below portion of wave from mean position.



* Wave equation:-

$$\text{Velocity} = \frac{\text{Displacement}}{\text{time}}$$

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

$$V = \lambda \times \frac{1}{t} \qquad \because f = \frac{1}{t}$$

$\boxed{V = f\lambda}$ This is called wave equation

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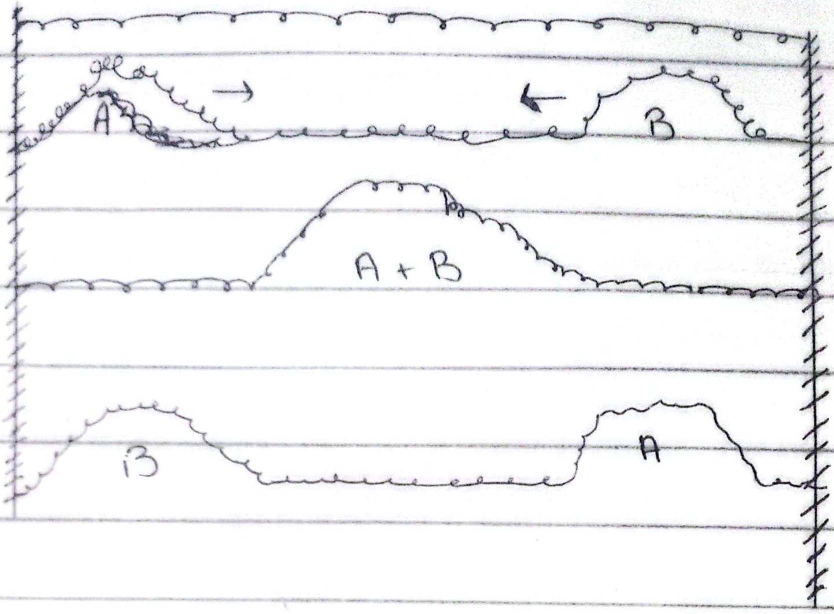
Topic: Physics.

* **Principle of superposition:-**

When two waves meet in a medium their resultant amplitude is equal to the sum of their individual amplitudes of two waves.



Interference of waves:-

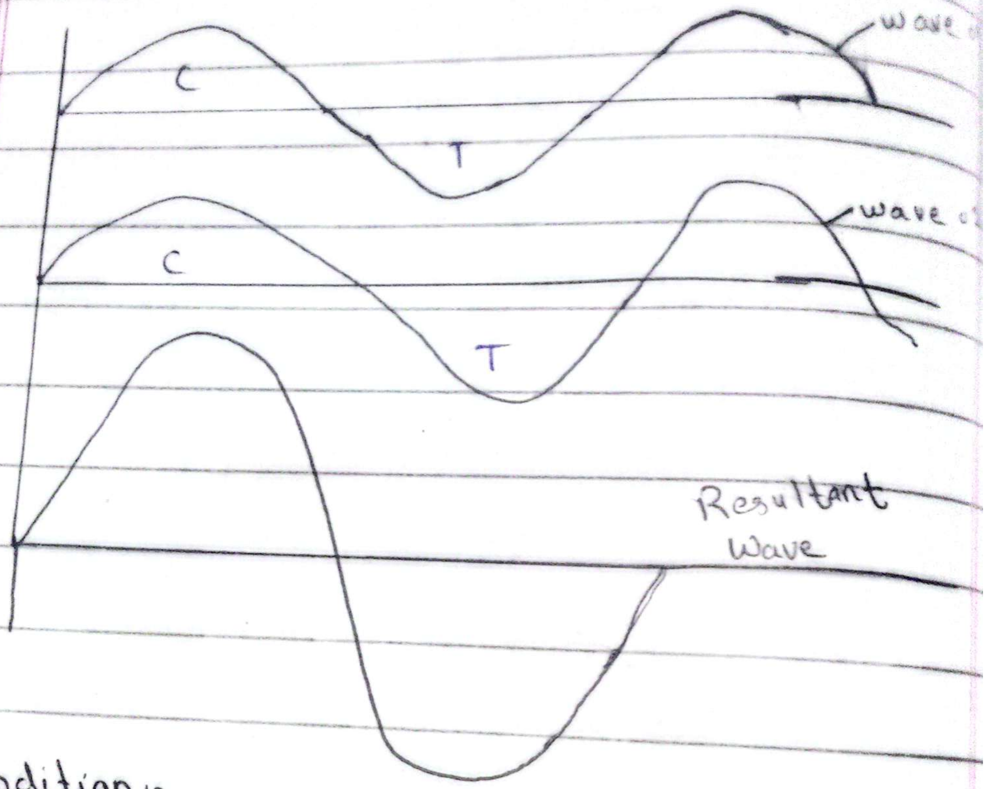
When two waves having same frequency same speed and travelling in same direction meet in a same medium then at some points they rise the effect of each others and at some other points they cancel the effects of each others. This is called interference of two waves.

There are two types of interference of waves:-

a) **Contructive Interference:-**

When two waves meet in a medium in such

a way that crest of one wave fall on crest of other waves and ~~through~~ trough of one wave falls on trough of other wave they rise the effects of each other and this type of Interference is called constructive Interference.



Condition:-

Path of difference $= \Delta S = n\lambda$

where $n = 0, 1, 2, 3, \ldots$

b) Destructive Interference:-

When two waves meet in a medium is such a way that crest of one wave falls on trough of other wave and trough of one wave falls on crest of other wave. In this case

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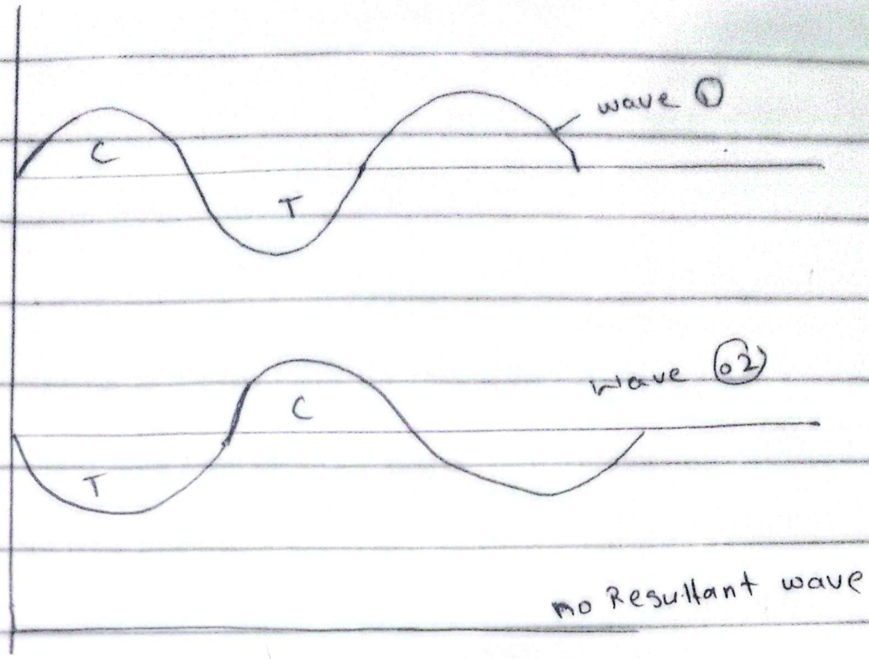
they will cancel the effect of each other and this type of Interference is called destructive Interference.



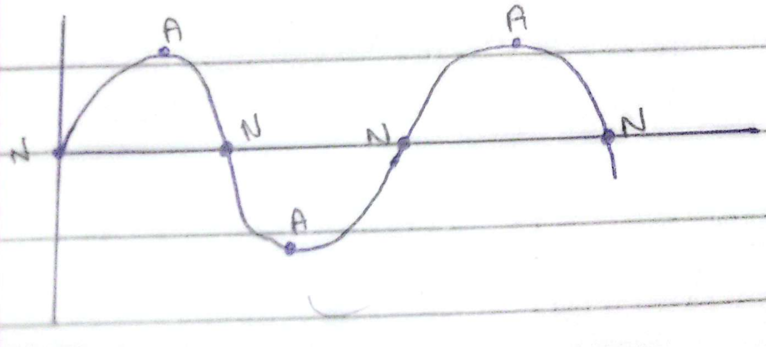
Condition

Path difference $= \Delta S = (2n+1)\frac{\lambda}{2}$

* **Beats**:- Fluction of sound wave is called Beats. Pg # 175 fig 8.9 Refrence.

* **Node**:- it is a point when amplitude is zero.

* **Anti-node**:- It is a point where amplitude is max.



Date: 1-12-25 Classwork

Topic: Physics

* **Stationary Waves:**

Stationary waves do not transfer energy from one place to another

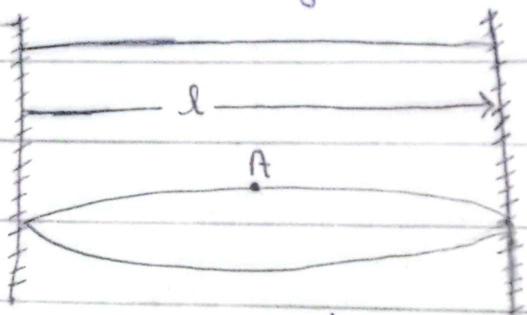
* Energy oscillates b/w nodes and antinodes

* **Stationary Waves in stretched string**

Case ①:

Consider a string of length l fixed at both ends.

If the string is plucked at the center.



$$l = \frac{\lambda_1}{2}$$

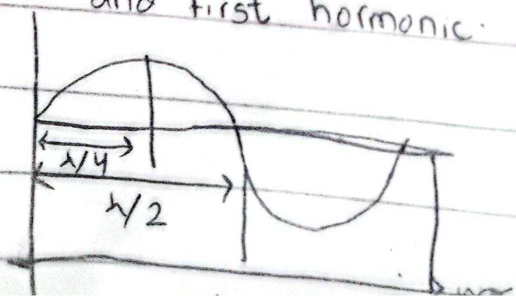
$$\lambda_1 = 2l$$

As $v = f\lambda$

$$f_1 = \frac{v}{\lambda_1}$$

$$\boxed{f_1 = \frac{v}{2l}}$$

This is called fundamental frequncy and first hormonic.



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Case 2:-

If the string is pluged at 1/4.

$v = f\lambda$

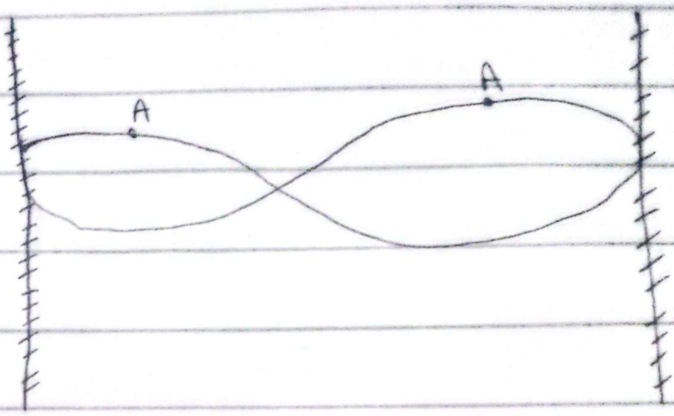
$f_2 = \dfrac{v}{\lambda_2}$

$f_2 = v/l$

$f_2 = 2\left(\dfrac{v}{2l}\right)$

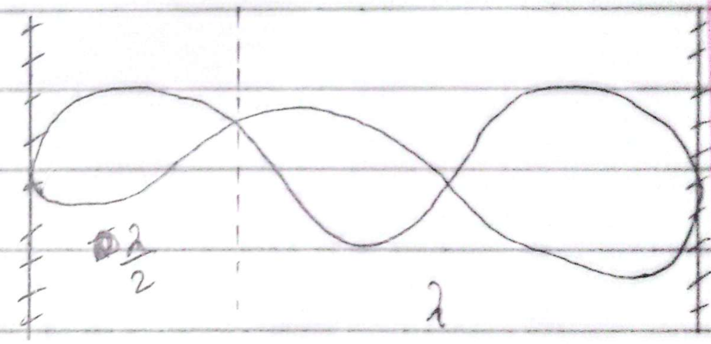
$\because l = \lambda^{2}$

$\because f_2 = 2f_1$



Case 3:-

$l = \lambda + \dfrac{\lambda}{2}$



$\dfrac{2\lambda + \lambda}{2}$

$l = \dfrac{3\lambda}{2}$

$2l = 3\lambda$

$\boxed{\lambda_3 = \dfrac{2l}{3}}$

As $v = f\lambda$

$f_3 = v/\lambda_3$

$f_3 = \dfrac{v}{2l/3}$

$f_3 = 3\left(\dfrac{v}{2l}\right)$

$f_3 = 3f_1$

This is called third hormonic & second overtone.

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$f_2 = 2f_1$

$f_3 = 3f_1$

$f_4 = 4f_1$

The general relation

$f_n = nf_1$

where $n = 1, 2, 3, 4 \ldots$

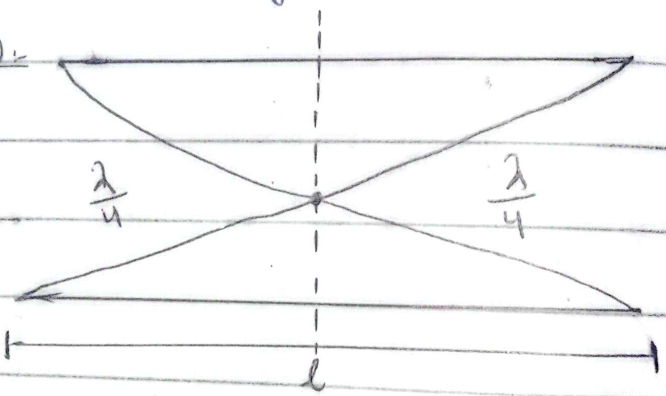
$\lambda_n = \frac{2l}{n}$

* <u>Stationary Waves in air column.</u>

a) <u>Open pipe.</u> open pipe is a pipe which is open from both ends. At open end always anti-node is formed.

At closed end always node is formed.

* <u>Case (1).</u>



$l = \frac{\lambda}{4} + \frac{\lambda}{4}$

$l = \frac{2\lambda}{4}$

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

$\lambda_1 = 2l$

$v = f\lambda$

$f_1 = \frac{v}{\lambda_1}$

$\boxed{f_1 = v/2l}$

This is called fundmental frequency and first harmonic.

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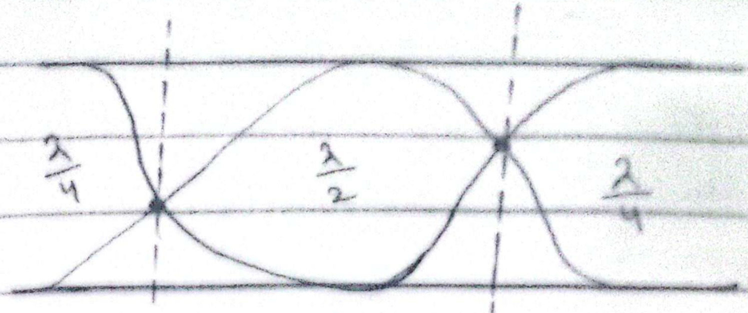
Case ② :-



$l = \frac{\lambda}{4} + \frac{\lambda}{2} + \frac{\lambda}{4}$

$\frac{\lambda + 2\lambda + \lambda}{4}$

$l = \frac{\cancel{4}\lambda}{\cancel{4}}$

$\boxed{l = \lambda_2}$

As $v = f\lambda$

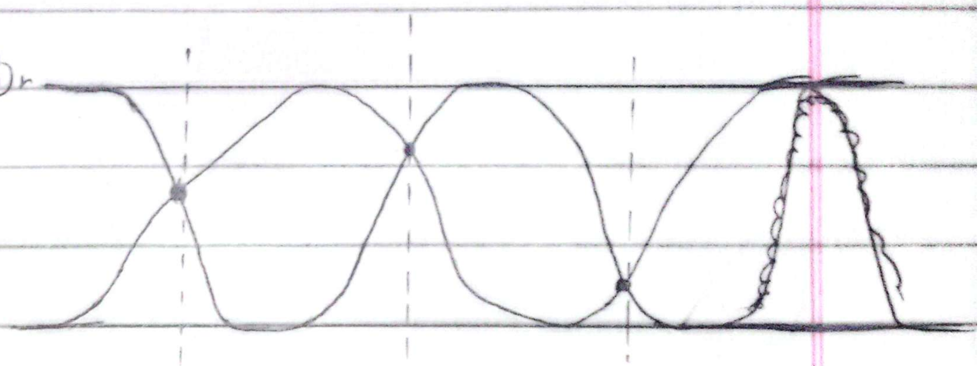
$f_2 = v/\lambda_2$ $\because l_2 = 2l_1$

$f_2 = v/l$

$2\left(\frac{v}{2l}\right)$ $f_2 = 2(f_1)$

This is called second harmonic & first over tone.

* Case ③ :-



$l = \frac{6\lambda}{4}$

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

$\frac{2l}{3} = \lambda_3$

As $v = f\lambda$

$f_3 = v/\lambda_3$

$f_3 = \frac{v}{2l/3}$ $v \div \frac{2l}{3}$

$v \times \frac{3}{2l}$

$f_3 = 3\left(\frac{v}{2l}\right)$ $\left(\frac{v}{2l}\right) \times 3$

$f_3 = 3f_1$

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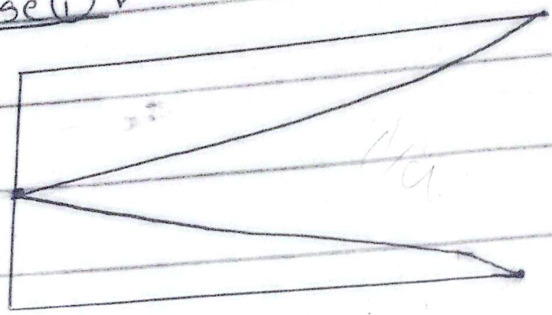
b) Close pipe: Close pipe is a pipe which is open from one end and other end is closed.

Case ①:



$l = \lambda/4$

$\lambda = 4l$

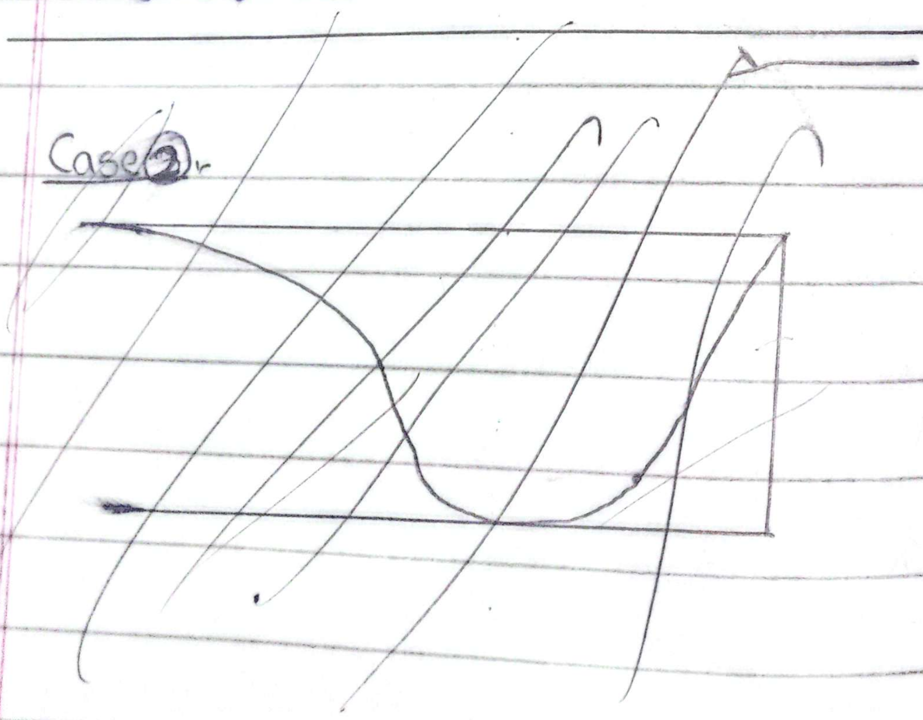
As $V = f\lambda$

$f_1 = V/\lambda_1$

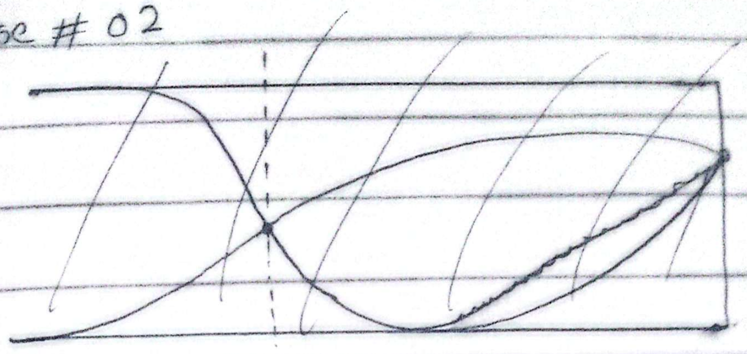
$f_1 = \frac{v}{4l}$

This is called fundamental and first Harmonic.

Case ②:



Case # 02



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

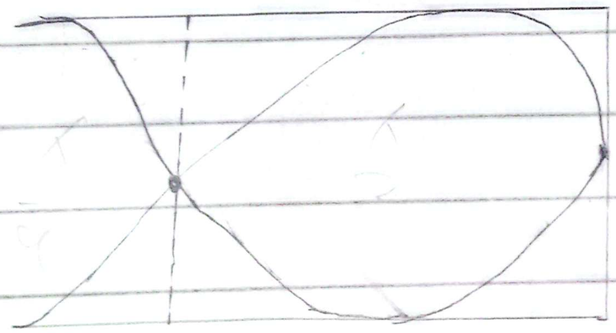
$\frac{4l}{3} = \lambda_2$

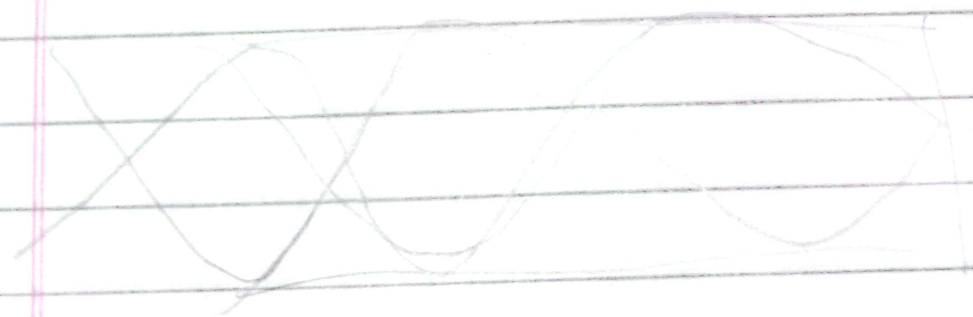
As $v = f\lambda$

$f_2 = v/\lambda_2$

$f_2 = \frac{v}{\frac{4l}{3}} = f_2 = 3\left(\frac{v}{4l}\right)$

$f_2 = 3f_1$

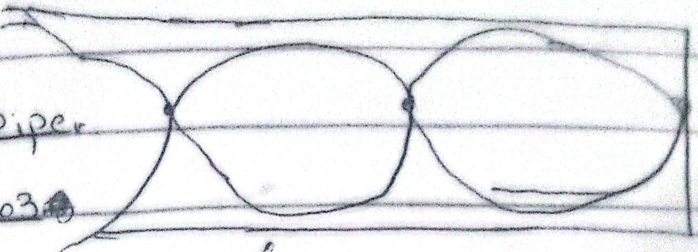


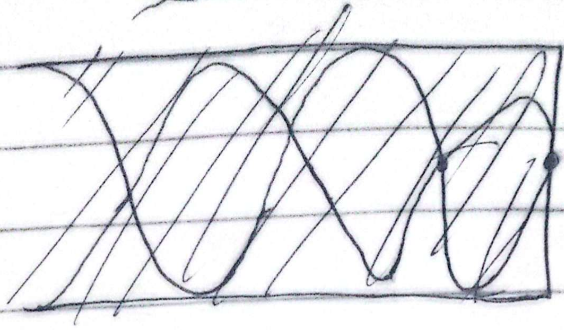


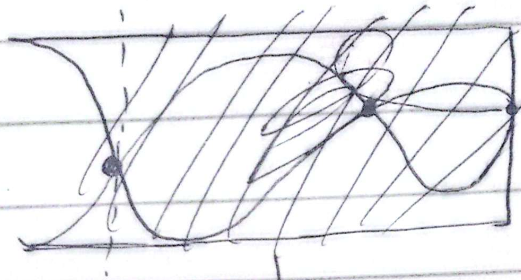
Topic: Physics

* Close Pipe.

Case 03







$l = \lambda + \frac{\lambda}{4}$

$\frac{4\lambda + \lambda}{4}$

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

$4l = 5\lambda$

$\lambda_3 = 4l/5$

$v = f\lambda$

$f_3 = v/\lambda_3$ $\therefore f_3 = 5f_1$

$f_3 = \frac{v}{4l/5}$

$f_3 = 5\left(\frac{v}{4l}\right)$

$f_2 = 3f_1$

$f_3 = 5f_1$

$f_4 = 7f_1$

The general relation $f_n = nf_1$

$\downarrow$

$n = 1, 3, 5, 7 \ldots.$

* [redacted]

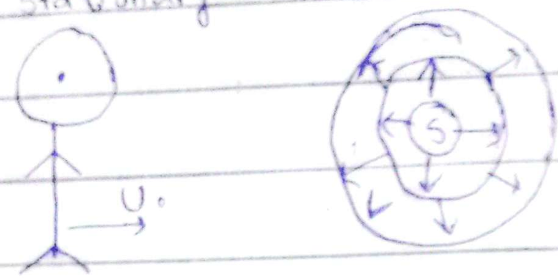
* **Doppler's Effect:-**

The apparent change in the frequency of Sound is called Doppler's effect.

* Doppler's effect is applicable to both Sound waves & electromagnetic waves.

Cases:-

a) **Case # 01:-** When an observer is moving towards the stationary source



from wave equ.

$$v = f\lambda$$

$$f = v/\lambda$$

$$f_A = \frac{v + v_o}{\lambda} \quad \text{--- (1)}$$

Again

$$v = f\lambda$$

$$\lambda = v/f$$

Put in equ (1)

$$f_A = \frac{v + v_o}{v/f}$$

$$f_A = \left(\frac{v + v_o}{v}\right) f$$

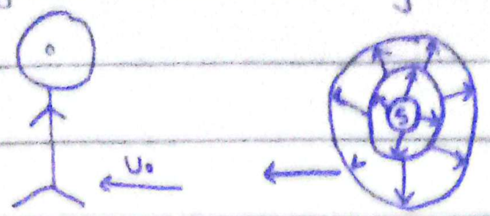
Then

$$f_A > f$$

Result:

The apparent frequency of sound increases.

* **Case ②:-** When an observer is moving away from the stationary source.



from wave equ

$$v = f\lambda$$

$$f = v/\lambda$$

$$f_B = \frac{v - v_o}{\lambda} \quad \text{— ①}$$

Again:-

$$v = f\lambda$$

$$\lambda = v/f$$

Put in equ -①

$$f_B = \frac{v - v_o}{v/f}$$

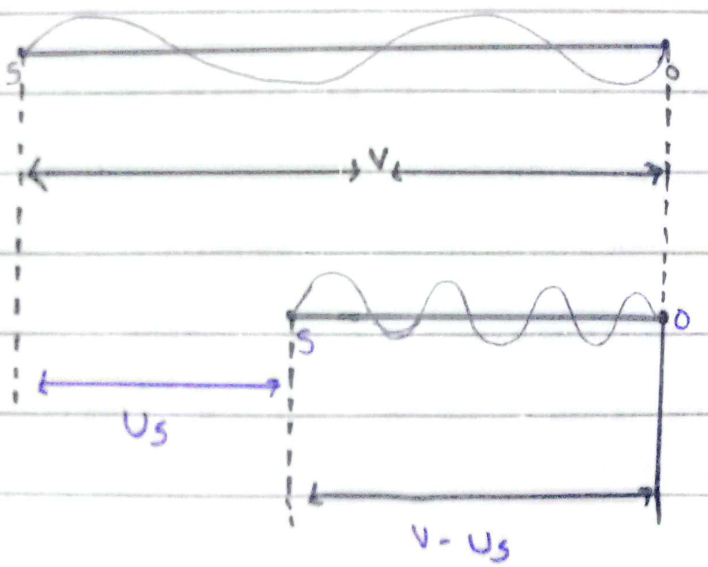
$$f_B = \left(\frac{v - v_o}{v}\right) f$$

$$\frac{v - v_o}{v} < 1$$

Then $f_B < f$

Result: The apparent frequency of sound decreases.

* **Case # 03:-** When a source is moving towards the stationary observer.



Date:

from wave equ :-

$V = f\lambda$

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

$\lambda = \frac{V - U_s}{f}$ — ①

$f_c = \frac{V}{\frac{V - U_s}{f}}$

$f_c = \left(\frac{V}{V - U_s}\right) f$

As $\frac{V}{V - U_s} > 1$

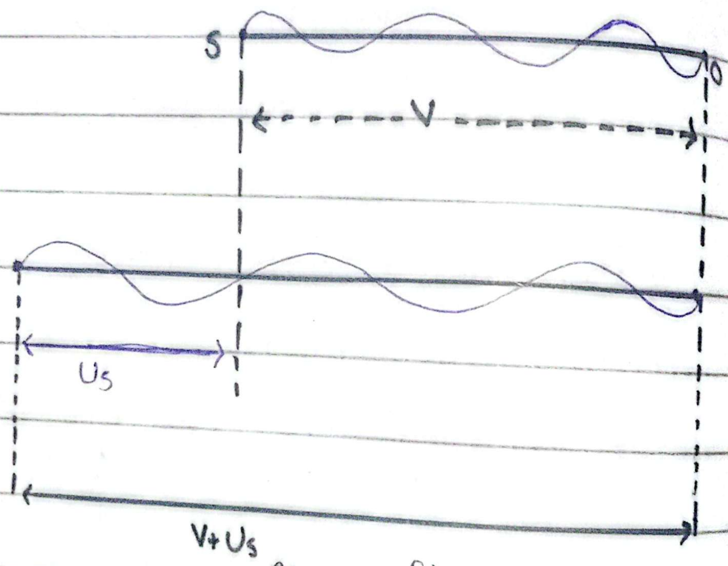
$\boxed{f_c > f}$

Again :-

$V = f\lambda$

$f_c = V/\lambda$

* **Case # 04 :-** When a source is moving away from stationary observer.



From wave equ

$V = f\lambda$

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

$\lambda = \frac{V + U_s}{f}$ — ①

Again $V = f\lambda$

$f_o = \frac{V}{\frac{V + U_s}{f}}$

$f_o = \left(\frac{V}{V + U_s}\right) f$

As $\frac{V}{V + U_s} < 1$ $\boxed{f_o < f}$

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Topic: Physics.

* Doppler's effect.

Case # 05:- When both observer and source are moving Towards eachothers.

$$f_E = \left(\frac{V + U_o}{V - U_s}\right) f$$

Case # 06:- When both observer and Source are moving Away from eachothers.

$$f_F = \left(\frac{V - U_o}{V + U_s}\right) f$$

* Applications:-

a) Radar system:- It is a device which trasmit radio waves to determine the elevation and speed of Air plane. If an air plane appraoches towards toward the radar, then the wavelength of the wave reflected from air plane would be ~~sotter~~ shorter. If an air planes moving away from the radar then the wavelength would be longer.

b) Sonar (sound navigation and Ranging):

c) Bat.