Waves

WAVE

Particle mattan → Energy and momentum transfer from one Paint to ather by a particle motion.

Wave → Disturbance that transfer for energy momentum from one to ather pasitian with the help of medium or without medium. energy transfer but medium particle daes nat transfer it Only oscillate at their position

medium →

Mechanical Wave → A wave which required medium is called mechanic Wave
Ex! Sound Wave.

Non mechanical Wave → A wave which does no required medium.
Ex! EM Wave
light Wave

On the basis of propagation

longitudinal wave → Particle Oscillate in the direction of motion of wave - Ex - sound wave

Transverse wave → Particle oscillate in the perpendicular direction of mation of wave
Ex! Em Wave
Wave on String.

→ In gas or liquid only longitudinal wave can exist.

→ In solid, longitudinal & transverse both Can Exist

On the surface of water

Both longitudinal and transverse can exist.

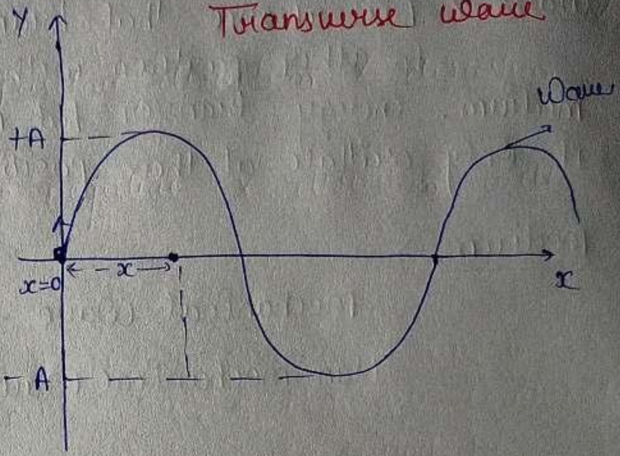
Qu A transwerse wave travels along x-axis. the particle of medium move

(1) Along x-axis

(2) Along y-axis ✓

Either along y-axis or z axis

Transwerse wave



Equation of S.H.M

Equation of S.H.M of a particle which is at $(x=0)$

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

Position of a Particle at time (t) which is at $x=0$.

Position of a particle at time 't' which is at x.

$$\boxed{Y = A \sin(\omega t + Kx + \phi)}$$

Eqⁿ wave

[∵ Wave no → no of wave on a unit length $= \frac{1}{\lambda}$]

$K = $ (Angular wave no.) $= \frac{2\pi}{\lambda}$

$\omega = $ Angular frequency $= \frac{2\pi}{T} = 2\pi f$ rad/sec

frequency $= \frac{1}{T} = $ Hz

$K = \frac{2\pi}{\lambda} = $ Angular wave no.

$\lambda = $ Wavelength

$$\boxed{Y = A \sin(\omega t + Kx + \phi)}$$ Transwerse

$$Y = A \sin\left(\frac{2\pi}{T}t + \frac{2\pi}{\lambda}x + \phi\right)$$

$$\boxed{Y = A \sin(\omega t \pm Ky + \phi)}$$ Longitudinal

Que

(1) $x = A\sin(\omega t - Ky)$

(2) $x = A\sin(\omega t + Ky)$

(3)

Que

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

(2) $y = A\sin(\omega t - Kx)$ ✓

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

(4) $y = A[\sin\omega t]Kx$

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

diff^m w.r.t time

Speed of wave $= \frac{\lambda}{T} = \lambda f$

$$\frac{dy}{dt} = A\cos(\omega t - Kx)\,\omega\frac{dt}{dt}$$

$$\boxed{V_{wave} = \frac{\lambda}{T} = \lambda f = \frac{\omega}{K}}$$

$$V = A\omega\cos(\omega t - Kx)$$

$$\boxed{V_{particle} = A\omega\cos(\omega t - Kx)}$$

Relation b/w speed of wave & max^m speed of particle

$V_w = \frac{\omega}{K}$ $\quad V_{max} = A\left[\frac{\omega}{K}\right] \times K$

$$\boxed{V_{max} = AK\,V_{wave}}$$

Que The equation of progressive wave, where t is the time in sec x is the distance in meters is $y = A\cos 24\left(t - \frac{x}{12}\right)$ then speed of wave.

$y = A\cos\left(24t - \frac{24x}{12}\right)$

$y = A\cos(24t - 2x)$

$V_{wave} = \frac{\omega}{K} = \frac{24}{2} = 12\text{ m/s}.$

Que A wave is represented by the equation $y = A \sin(10\pi x + 15\pi t + \frac{\pi}{3})$ where x is in metre and t is sec. The expression represent

(1) A wave travelling in negative X-direction with a velocity of 1.5 m/s

(2) A wave travelling in positive X-direction with a velocity of 1.5 m/s.

(3) A wave travelling in positive direction X-direction with wavelength 0.2 m.

(4) A wave travelling in negative X-direction with a velocity of 150 m/s.

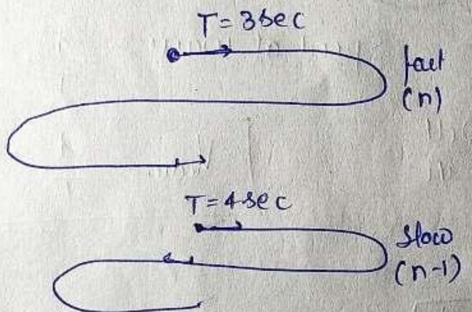
Que A SHM whose period is 4 s while another wave which also passes SHM has its period 3 s. If both are combined then the resultant wave will have the period to.

(1) 4 s

(2) 5 s

(3) 12 s

(4) 8 s



$$\boxed{t = 3sec + 3sec + 3sec + 3sec = 12\,sec}$$

$(3n = 4(n-1))$

$(3n = 4n - 4)$

$4 = 4x - 3x = n$

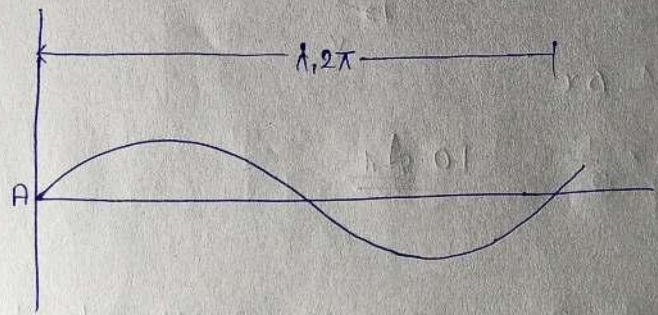
$$\boxed{\frac{1}{T} = \frac{1}{T_1} - \frac{1}{T_2}}$$ MR Ratta

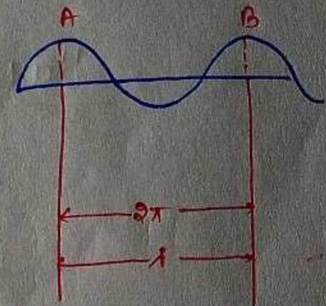
$v_{12} = v_1 - v_2$

$t = \frac{2\pi}{v} = \frac{2\pi}{v_1 - v_2} = \frac{2\pi}{t} = \frac{2\pi}{T} = \frac{2\pi}{T_2}$

Wave → Mode of energy transfer in which

Relation B/w phase diff and time difference and path difference





\# Phase difference b/w two particle which is at λ diff^n = 2π

\# Phase diff at unit 1m = $\frac{2\pi}{\lambda}$

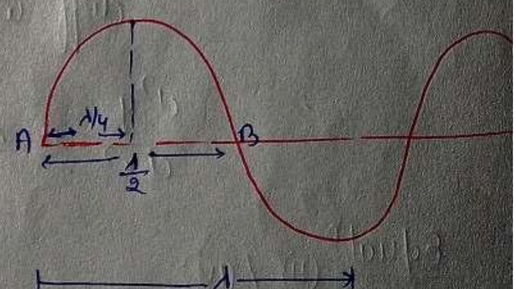
Phase diff $\Delta\phi$ in path diff^n = $\frac{2\pi}{\lambda}\Delta x$

Phase diff ← $\boxed{\Delta\phi = \frac{2\pi}{\lambda}\Delta x}$ → Path diff

MR. Ratta

$$\boxed{\frac{\Delta\phi}{2\pi} = \frac{\Delta x}{\lambda} = \frac{\Delta t}{T}}$$

$$\boxed{\frac{2\pi}{\Delta\phi} = \frac{\lambda}{\Delta x} = \frac{T}{\Delta t}}$$



$$\frac{\Delta\phi}{\cancel{2}\pi} = \frac{\cancel{\lambda}}{\frac{\cancel{4}\cancel{\lambda}}{2}}$$

$$\boxed{\Delta\phi = \frac{\pi}{2}}$$

Que The equation of the progressive wave, where t is the time in second. x is the distance in metre is $y = A\cos 240\left(t - \frac{x}{12}\right)$. The phase difference (in SI unit) b/w two position 0.5 m apart is.

(1) 40
(2) 20
(3) 10 ✓
(4) 5

$$y = A\cos 240\left(t - \frac{x}{12}\right) \qquad \Delta x = 0.5$$

$$y = A\cos\left(240t - \frac{\cancel{240}^{20}x}{\cancel{12}}\right)$$

$$\Delta\phi = \frac{2\pi}{\lambda}\Delta x$$

$$= 20 \times \frac{1}{2} = 10 \text{ Ans}$$

Harmonic Progressive wave equation

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

diff w.r.t 'x'

$$\frac{dy}{dx} = A\cos(kx - \omega t)\,k$$

$$\frac{dy}{dx} = Ak\cos(kx - \omega t) \quad \text{— (I)}$$

diff w.r.t x

$$\frac{d^2y}{dx^2} = -Ak^2\sin(kx - \omega t) \quad \text{— (II)}$$

diff w.r.t time — (3)

$$\frac{dy}{dt} = A\cos(kx - \omega t)\,\omega$$

diff w.r.t time

$$\frac{d^2y}{dx^2} = -A\omega\left[+\sin(kx - \omega t)\,\omega\right]$$

$$-A\omega^2\sin(kx - \omega t) \quad \text{— (IV)}$$

Equat^n (II) / (IV)

$$\frac{\frac{d^2y}{dx^2}}{\frac{d^2y}{dt^2}} = \frac{-Ak^2\sin(kx - \omega t)}{-A\omega^2\sin(kx - \omega t)}$$

$$\boxed{\frac{d^2y}{dx^2} = \frac{1}{v^2}\frac{d^2y}{dt^2}} \text{ — Wave equation}$$

$y = \sin(kx + \omega t)$ ✓

$y = \sin(kx + \omega t)^2$ ✓

$y = \sin(kx^2 + \omega t^2)$ ×

$y = (4x + 3t)^2 + 5$ ✓

$y = \left(\frac{1}{4x + 3t + 4}\right)$

y must be finite at all values

$$\frac{d^2y}{dt^2} = u^2\frac{d^2y}{dx^2}$$ ✓

$$\frac{d^2y}{dx^2} = \frac{1}{u^2}\frac{d^2y}{dt^2}$$ ✓

$$\frac{d^2y}{dt^2} = \frac{1}{u^2}\frac{d^2y}{dx^2}$$ ×

Equ^n I / III

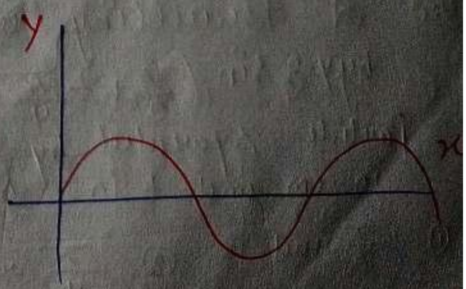
$$\frac{dy}{dx} = +Ak\cos(kx - \omega t)$$

$$\frac{dy}{dt} = -A\omega\cos(kx - \omega t)$$

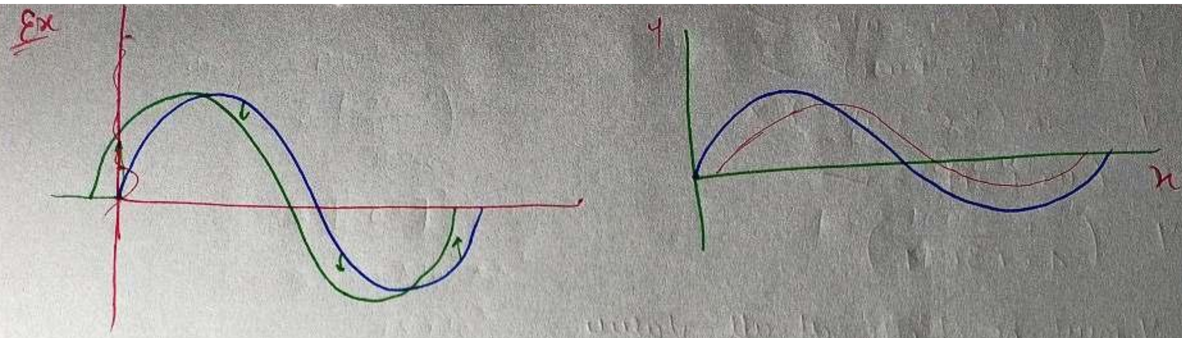
$$\frac{dy}{dx} = -\frac{k}{\omega}\frac{dy}{dt}$$

$$\frac{dy}{dt} = -\frac{\omega}{k}\frac{dy}{dx}$$

$$\vec{V}_{particle} = -\vec{V}_{wave}\left(\frac{dy}{dx}\right)$$



Ex



Que The wave function of a pulse is given by $y = \frac{5}{(4x+6t)^2}$ where x and y are in metre and t is in second. The velocity of pulse is in sec. The velocity of Pulse is.

(1) 2m/s
(2) 6 m/s
(3) 1.5 m/s ✓
(4) 3m/s

$Y = \frac{5}{\;}$

$V = \frac{\omega}{k} = \frac{6}{4} = \boxed{1.5 \text{ m/s}}$

Que A wave is represented by $x = 4\cos\left(8t - \frac{y}{2}\right)$. where x and y are in meter and t in second. The frequency of the wave

(1) $4/\pi$ ✓
(2) $8/\pi$
(3) $2/\pi$
(4) $\pi/4$

$\omega = 8$

$\cancel{2}\pi f = \cancel{8}\,4$

$f = \frac{4}{\pi}$ Hz

Que A travelling wave in a String is represented by $y = 3\sin\left(\frac{\pi}{2}t - \frac{\pi}{4}x\right)$. The phase difference b/w two Particle separated by a distance 4cm is (Take x and y in cm and t in seconds)

(1) $\frac{\pi}{2}$ rad (2) $\frac{\pi}{4}$ rad. (3) π rad ✓ (4) 0

$$y = 3\sin\left(\frac{\pi}{2}t - \frac{\pi}{4}x\right)$$

$$\Delta x = 4\text{ cm}$$

$$\Delta\phi = \left[\frac{2\pi}{\lambda}\right] \times \Delta x$$

$$\frac{\pi}{4} \times 4 = \pi \quad \underline{\text{Ans}}$$

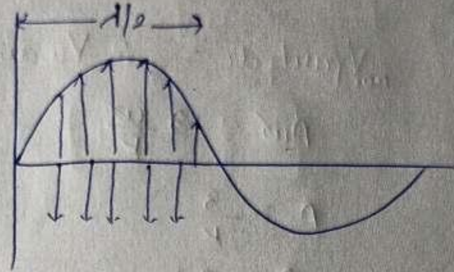
Qu In sin wave, minimum distance b/w 2 particles which always have same speed is

(1) $\lambda/2$ ✓

(2) $\lambda/4$

(3) $\lambda/3$

(4) λ



Qu The equation of a simple harmonic progressive wave is given by $y = A\sin(100\pi t - 3x)$. Find the distance b/w 2 particles having a phase difference of $\frac{\pi}{3}$.

(1) $\pi/9$ ✓

(2) $\pi/16$

(3) $\pi/6$

(4) $\pi/3$

$$y = A\sin(100\pi t - 3x)$$

$$\Delta\phi = \frac{2\pi}{\lambda}\Delta x$$

$$\frac{\pi}{3} = 3\,\Delta x$$

$$\boxed{\Delta x = \frac{\pi}{9}}$$

Qu A wave represented by $y = 3\sin 2\pi\left(\frac{t}{0.04} - \frac{x}{0.01}\right)$ cm. The frequency of the wave and the maximum acceleration under this frequency are

(1) 25 Hz, 7.5×10^4 cm/s^2 ✓ (2) 100 Hz, 4.5×10^3 cm/s^2

(3) 50 Hz, 7.5×10^3 cm/s^2 (4) 25 Hz, 4.5×10^4 cm/s^2

$a_{max} = A\omega^2$

$3\left(\frac{2\pi}{\frac{4}{100}}\right)^2$

$3[50\pi]^2$

$3 \times 25 \times 10^2 \times \pi^2$

75×10^3

$y = 3\sin\left(\frac{2\pi t}{0.04} - \frac{2\pi}{0.01}x\right)$

$\cancel{2\pi}f = \frac{\cancel{2\pi}}{0.04}$

$f = \frac{100}{4}$ 25 Hz

Que A travelling wave is described by the equation $y = A\sin 2\pi(nt - x/\lambda_0)$. the maximum particle velocity is equal to 3 times the wave velocity if.

$y = A\sin\left(2\pi(nt - \frac{2\pi k}{\lambda}\right)$

(1) $\lambda_0 = \frac{\pi A}{3}$

(2) $\lambda_0 = \frac{2\pi A}{3}$ ✓

(3) $\lambda_0 = \pi A$

(4) $\lambda_0 = 3\pi A$

$V_{particle\,max} = 3V_{wave}$

$A\cancel{\omega} = 3\frac{\cancel{\omega}}{k}$

$A = \frac{3}{k}$

$A = \frac{3\lambda_0}{2\pi}$

$\lambda_0 = \frac{2\pi A}{3}$

Que If v is instantaneous velocity of particle and $\vec{V}$ is velocity of wave then

(1) $\vec{a}$ is perpendicular to $\vec{V}$

(2) $\vec{v}$ is parallel to $\{\vec{v}\}$

(3) $|\vec{v}|$ is equal to $|\vec{v}|$

(4) $|\vec{v}| = $ (slope of wave form) $|\vec{V}|$

Que Which one of the following represent a wave?

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

(2) $y = A\cos^2(at - bx + c) + A\sin^2(at - bx + c)$

(3) $y = A\sin kx$

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

Que which of the following [illegible] represent a travelling wave?

(1) $(x^2 - vt)^2$ (2) $\log\left[\frac{(x+vt)}{x_0}\right]$ (3) $e\left[\frac{(x+vt)}{x_0}\right]^2$

(4) $\frac{1}{x+vt}$

(1) only (1) (2) 2 & 3 (3) 3 & 4 (4) only 3

Que A sinusoidal wave of frequency 500 Hz has a speed of 350 m/s. The phase difference too displacement at a certain

(1) $\frac{\pi}{4}$

(2) $\frac{\pi}{2}$

(3) π

(4) $\frac{3\pi}{4}$

$\Delta t = 1\,ms$

$f = 500\,Hz$

$v = 350\,m/s$

$\Delta\phi = \frac{2\pi}{T}\Delta t$

$\Delta\phi = 2\pi f\,\Delta t$

$2\pi(500)\,1\times10^{-3}$

$= \pi$

Que The equation of travelling wave is $y = a\sin 2\pi\left(pt - \frac{x}{5}\right)$ then the ratio of maximum particle velocity to wave velocity

(1) $\frac{\pi a}{5}$

(2) $2\sqrt{5}\pi a$

(3) $\frac{2\pi a}{5}$

(4) $\frac{2\pi a}{\sqrt{5}}$

$\frac{V_{p\,max}}{V_{wave}} = \frac{A\cancel{\omega}}{\frac{\cancel{\omega}}{k}}$

$= Ak$

$= a\frac{2\pi}{5}$

$= \frac{2\pi a}{5}$

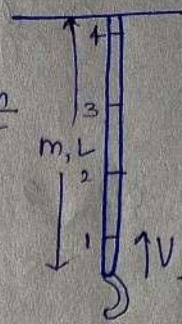
Que The ratio of maximum particle velocity to wave velocity is (where symbol have their usual meaning)

(1) KA (2) $A\omega$ (3) $k\omega$ (4) $\frac{\omega}{k}$

Velocity of transverse wave in a string

MR Ratta $\boxed{V = \sqrt{\frac{T}{\mu}}}$

A = Area of cross section.
T = Tension
μ = mass per unit length $= \frac{m}{L}$



$T_4 > T_3 > T_2 > T_1$

$V_4 > V_3 > V_2 > V_1$

$V = \sqrt{\frac{T}{\rho A}} = \sqrt{\frac{\text{Stress}}{\rho}}$

$\rho = \frac{\text{mass}}{\text{Volume}} = \frac{m}{AL} = \frac{\mu}{A}$

Hooks = Stress = Y Strain

$\boxed{\mu = \rho A}$

$V = \sqrt{\frac{Y \text{strain}}{\rho}} = \sqrt{\frac{Y}{\rho}\left(\frac{\Delta l}{l}\right)}$

$= \sqrt{\frac{Y \alpha \Delta\theta}{\rho}}$

$V_x = \sqrt{gx}$

$\boxed{a = \frac{g}{2} = \text{const}}$ $t = \sqrt{\frac{4L}{g}}$ $\boxed{t \propto \sqrt{L}}$

$$\boxed{V = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{T}{\rho A}} = \sqrt{\frac{\text{Stress}}{\rho}} = \sqrt{\frac{Y \text{strain}}{\rho}} = \sqrt{\frac{Y \Delta l}{\rho\, l}} = \sqrt{\frac{Y \alpha \Delta\theta}{\rho}}}$$

Que A metallic wire of 1 m length has a mass of 10×10^{-3} kg if a tension of 100 N is applied to a wire. What is the speed of transverse wave?

(1) 100 m/s ✓
(2) 10 m/s
(3) 200 m/s
(4) 0.1 m/s

$v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{10\cancel{0}}{\cancel{10} \times 10^{-3}}}$

$\sqrt{10 \times 10^{3}}$

$\sqrt{10^4} = 10^2$

Que Calculate the velocity of the transverse wave in a string which is stretched by a load of 15 kg. The mass of the string is 3×10^{-2} kg and its length is 2m.

$$l = 2m$$

$$\mu = \frac{3\times10^{-2}}{2}$$

$$mg = 15\times10 = 150\,N$$

$$u = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{150\times2}{3\times10^{-2}}}$$

$$\sqrt{\frac{\cancel{300}\,100}{\cancel{3}\times10^{-2}}}$$

$$= \boxed{100\ m/s}$$

as wave moves up then its velocity Increases

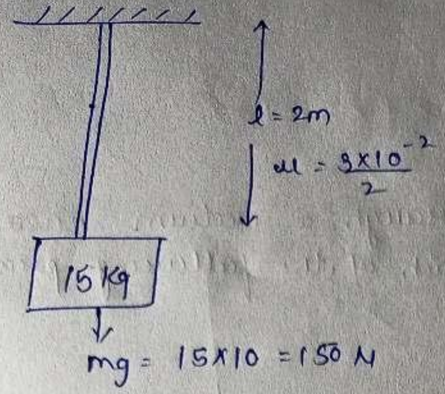
accl^n = ??

Velocity of wave at dist x from bottom

$$V_x = \sqrt{\frac{T_x}{\mu}} = \sqrt{\frac{\mu x g}{\mu}} = \sqrt{gx}$$

$$V_x = \sqrt{gx}$$

$$V_{mid} = \sqrt{\frac{gL}{2}}$$



Speed of transverse wave on string

$$\boxed{v = \sqrt{\frac{T}{\mu}}}$$

Qy when a wave propagating through a medium encounter a change in medium. then which of the following property remains same ?

① Speed
② Amplitude
③ frequency
④ wavelength

Qy The wave which cannot travel without medium are

① X-ray
② Radio waves
③ light waves
④ Sound waves

Qy which of the following phenomenon cannot take place with sound wave

① polarisation [only transverse wave not occur longitudinal wave]
② Refraction
③ Diffraction
④ Reflaction

Qy The speed of sound in air is Independent from its

① aplitude ② frequency ③ phase ④ All of these

$$V_{wave} = \frac{\omega}{K} = \lambda f$$

Qu The frequency of a mechanical wave is 256 Hz. Calculate the wavelength when its speed is 512 m/s.

$$v = \lambda f$$

$$\lambda = \frac{v}{f} = \frac{\cancel{512}^{2}}{\cancel{256}} = 2m$$

Qu A Transverse pulse generated at the bottom of a uniform rope of length travel in upward direction the time taken by it to travel the full length of rope will be.

(1) $\sqrt{\frac{L}{2g}}$

(2) $\sqrt{\frac{2L}{g}}$

(3) $\sqrt{\frac{L}{g}}$

(4) $\sqrt{\frac{4L}{g}}$ ✓

$$S = \left(\frac{u_1 + v_1}{2}\right)T$$

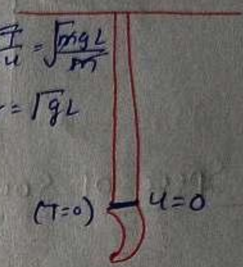
$$2L = \left(0 + \sqrt{gL}\right)T$$

$$T = \frac{2L}{\sqrt{gL}}$$

$$T = \sqrt{\frac{4L}{g}}$$

$$V = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{mgL}{m}}$$

$$V = \sqrt{gL}$$



Qu A rope of length L and mass M hang freely from the ceiling. If the time taken by a transverse wave to travel from the bottom to the top of the rope is T. then time to cover first half length is.

(a) T

(b) $T\left(\frac{\sqrt{2}-1}{\sqrt{2}}\right)$

(c) $\left(\frac{T}{\sqrt{2}}\right)$ ✓

(d) $\frac{T}{2}$

$$\frac{T \propto \sqrt{L}}{t \propto \sqrt{\frac{L}{2}}}$$

$$\frac{T}{t} = \sqrt{2}$$

$$\boxed{t = \frac{T}{\sqrt{2}}}$$

Qu Two string of same material are streched to the same tension the respective wave If their radii are in the ratio 1:2 velocities in them will be in ratio.

(1) 4:1

(2) 2:1 ✓

(3) 1:2

(4) 1:4

$$V = \sqrt{\frac{T}{\rho A}} \propto \frac{1}{\sqrt{\pi r^2}} \propto \frac{1}{r}$$

ρ = same $\quad \frac{r_1}{r_2} = \frac{1}{2}$

T = same

$$V = \sqrt{\frac{T}{\rho A}} \propto \frac{1}{\sqrt{\pi r^2}}$$

$$V \propto \frac{1}{\sqrt{r^2}} \propto \frac{1}{r}$$

$$\frac{V_1}{V_2} = \frac{2}{1}$$

Sound wave

1. Infrasonic sound — $f < 20 Hz$
2. Audible Sound — $20 Hz < f < 20 kHz$
3. ultrasonic sound — $f > 20 kHz$

Sound $\boxed{V_{solid} > V_{liquid} > V_{gas}}$

Speed of Sound wave ⇒

$V_{sound} \propto$ elastic Property

$V_{sound} \propto \frac{1}{\text{Inertial Property}}$

$$V_{\text{sound in solid}} = \sqrt{\frac{Y}{\rho}}$$

$Y \rightarrow$ Young modulus of solid
$\rho \rightarrow$ density of solid

$$V_{\text{gas \& liquid}} = \sqrt{\frac{B}{\rho}}$$

$B \rightarrow$ Bulk modulus of liquid & gas

Newtons formula for speed of sound ⇒

Propagation of sound assume to be Isothermal process

$\boxed{\text{Temp} = \text{Const}}$

$P_{air} = 1$ atm
$= 1.01 \times 10^5$
$\rho = 1.2 \ kg/m^3$

$$V_{sound} = \sqrt{\frac{P}{\rho}}$$

$$\boxed{V_{sound} = 280 \ m/s}$$

$V_{Experiment} = 332 \ m/s$

Laplace Correction of Velocity of Sound ⇒

Assume to be adiabatic process

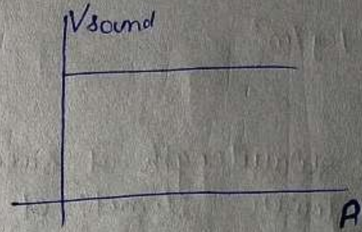
$$V_{sound} = \sqrt{\frac{B}{\rho}} = \sqrt{\frac{\gamma P}{\rho}}$$

$\Delta Q = 0$

$PV^{\gamma} = \text{const}$

$$\boxed{B = \gamma P}$$

$$\boxed{V_{sound} \approx V_{exp^m} / P}$$



Que at const temp if pressure becomes double then speed of sound will be

$$V = \sqrt{\frac{\gamma P}{\rho}} = \sqrt{\frac{\gamma \cancel{P} RT}{\cancel{P} M}}$$

$$V = \sqrt{\frac{\gamma RT}{M}} \propto \sqrt{Temp}$$

Ans :- Speed of sound does not change

Que If pressure becomes double at constant density.

$\rho = \text{const}$

$$V_{sound} = \sqrt{\frac{\gamma P}{\rho_{-\,const}}}$$

∴ Speed of sound becomes double

Que Calculate the speed of longitudinal wave in steel.

$$v = \sqrt{\frac{Y}{\rho}} = \sqrt{\frac{3\times10^{10}}{1.2\times10^{3}}} = \sqrt{\frac{30}{1.2}\times10^{6}} = 10^{3}\sqrt{\frac{300}{12}} = 5000$$

Que If the speed of longitudinal wave in water is 1400 then Calculate the Bulk modulus of elasticity of water. (given density of water is 1 g/cm^3)

$$V_{sound} = 1400 \text{ m/s}$$

$$1 \text{ gram/cm}^3 = \frac{10^{-3} \text{ kg}}{10^{-6} \text{ m}^3} = 10^3 \text{ kg/m}^3$$

$$\rho = 1 \text{ g/cm}^3 = \frac{10^3 \text{ kg}}{\cancel{\quad}} = 10^9 \text{ kg/m}^3$$

Que The wavelength of sound wave in hydrogen gas corresponding to the lower limit of audibility (Speed of sound in hydrogen gas is about 1350 m/s)

(1) 60 m (2) 67.5 m (c) 100 m (d) 500 m

$V = 1350$ m/s

$\lambda = ?$

$f = 20$ Hz $\quad V = \lambda f$

$$\lambda = \frac{V}{f} = \frac{135\cancel{0}}{2\cancel{0}} = \frac{135}{2} = \boxed{67.5 \text{ m}}$$

Que The Speed of longitudinal mechanical wave in a material is 4200 m/s. Youngs modulus of the material is 15×10^9 N/m^2 what is the density of the material?

$$V = \sqrt{\frac{Y}{\rho}}$$

$$4200 = \sqrt{\frac{15 \times 10^9}{\rho}}$$

Speed of Sound

$$\underset{\text{in solid}}{V_{\text{Sound}}} = \sqrt{\frac{Y}{\rho}} \rightarrow \text{Young modulus (for solid)}$$

$$\underset{\text{in gas}}{V_{\text{sound}}} = \sqrt{\frac{B}{\rho}}$$

Que Speed of sound wave in a gas v_1 and rms speed of molecules of the gas at the same temp. is v_2. then.

(a) $v_1 = v_2$

(b) $v_1 < v_2$ ✓

(c) $v_1 > v_2$

(d) $v_1 \leq v_2$

$$V_{sound} = V_1 = \sqrt{\frac{\gamma RT}{m}}$$

$$V_{rms\,g} = \sqrt{\frac{3RT}{m}} = V_2$$

Que The speed of sound in air at NTP is 332 m/s. Calculate the percentage error in speed of sound as calculated from newton formula. Given that the density of air is $1.293\ kg/m^3$.

$$V_{True} = 332\ m/s$$

$$V_{newton} = 280\ m/s$$

$$\%\ error = \frac{V_T - V_m}{V_T} \times 100 \quad \left(\frac{332 - 280}{332}\right) \times 100 \approx 1$$

Qu The speed of sound in hydrogen at NTP is 1270 m/s. Then the speed in a mixture of hydrogen and oxygen in the ratio 4 : 1 volume.

(1) 635

(2) 318

(3) 158

(4) 1270

Qus The speed of sound wave in air at 300 K is 332 m/s. At what temperature will the speed be 574 m/s.

$T = 300\,K$

$V_1 = 332\,m/s$

$V_f = 574$

$T = ??$

$V \propto \sqrt{Temp}$

$$\frac{332}{574} = \frac{\sqrt{300\,K}}{\sqrt{T}}$$

$$\sqrt{T} = \frac{\sqrt{300\,K} \times [574]}{332}$$

$$\sqrt{T} = \sqrt{300} \times 1.72$$

$T = 300 \times 2.95$

$= 887$

$= 900$ Ans

Qus The Velocity of sound in air at 20°C is 340 ms^{-1} keeping the temp. Const what will be the ~~capacity~~ Velocity of sound in air when the Pressure of the gas is doubled.

Remain Same

Qus Calculate the speed of sound in hydrogen at NTP. If density of hydrogen at NTP is 1/16th of air. Given that the speed of sound in air is 332 m/s

Ans

$V_{air} = 332\,m/s$

$$V \propto \frac{1}{\sqrt{\rho}}$$

$$\frac{V_{air}}{V_H} = \frac{\sqrt{\rho_H}}{\sqrt{\rho_{air}}} = \sqrt{\frac{\rho_{air}}{1.6 \times \rho_a}} = \frac{1}{4}$$

$V_H = 4 \times V_{air}$

$4 \times 332\,m/s$

$\boxed{1328\,m/s}$ Ans

If Speed of Sound wave is V_0 at $0^\circ C$ then find speed at $t^\circ C$

$$V_{sound} = \sqrt{\frac{\gamma P}{\rho}} = \sqrt{\frac{\gamma RT}{M}} \propto \sqrt{Temp.}$$

$V_0 \propto \sqrt{Temp.}$

$V_0 \propto \sqrt{273\,K}$ — (i)

$V_t \propto \sqrt{(273 + t^\circ)}$ — (ii)

(ii) / (i)

$$\frac{V_t}{V_0} = \sqrt{\frac{273+t}{273}}$$

$$V_t = V_0 \left(\frac{273+t}{273}\right)^{1/2}$$

$$V_t = V_0 \left(1 + \frac{t}{273}\right)^{1/2}$$

$$V_t = V_0 \left(1 + \frac{t}{273 \times 2}\right) = V_0 \left[1 + \frac{t}{546}\right]$$

$$V_t = V_0 \left(1 + \frac{t}{546}\right)$$

$$V_t = V_0 + \frac{V_0 t}{546}$$

$$V_t - V_0 = \frac{332\,t}{546}$$

$$[V_t - V_0] = [0.61\,t^\circ C]$$

If temp Increase by $3^\circ C$ then Speed of Sound Increase by

$V_{0^\circ C} \propto \sqrt{273}$ — (i)

$V_{t^\circ C} \propto \sqrt{273 + t}$ — (ii)

(ii) / (i)

$$\frac{V_t}{V_0} = \left(\frac{273+t}{273}\right)^{1/2}$$

$$V_t = V_0 \left(1 + \frac{t}{273}\right)^{1/2} = V_0 \left(1 + \frac{t}{546}\right)$$

$$(V_t - V_0) = 0.61 \times 3$$

$$1.83\ m/s$$

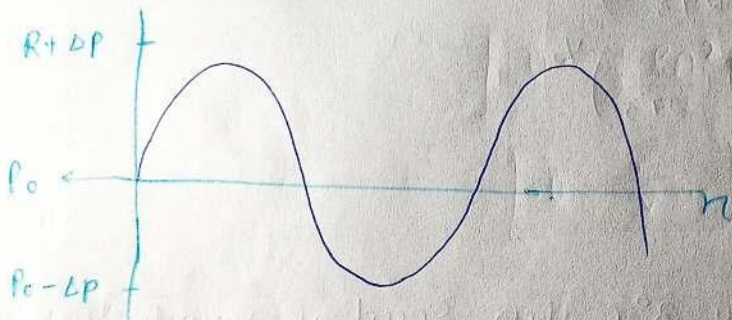
Speed of Sound

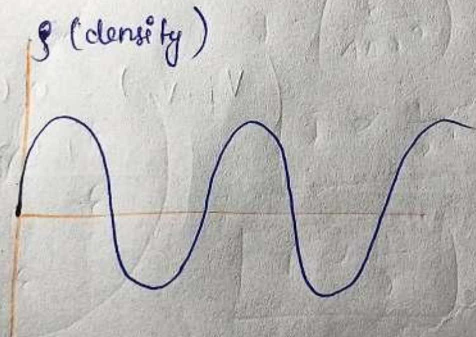
$\boxed{V_{dry\ air} < V_{moist\ air}}$

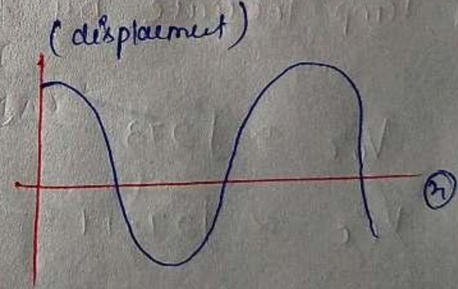
$\boxed{\rho_{dry} > \rho_{moist\ air}}$

$V \propto \frac{1}{\sqrt{\rho}}$

Sound wave travel due to density & pressure Variation.







What is the phase difference b/w the displacement wave and pressure wave in sound wave?

(1) zero (2) $\frac{\pi}{2}$ (3) π (4) $\frac{\pi}{4}$

Intensity of wave

$$I = \frac{\text{Energy}}{\text{Area sec}} = \left(\frac{J}{m^2\text{-sec}}\right) = \left(\frac{\text{watt}}{m^2}\right)$$

$$I = \frac{1}{2}\rho v A^2 \omega^2$$

$I \propto \rho$ (density of medium)

$I \propto A^2$ (Amplitude)

$I \propto \omega^2$ (Angular wave no.)

$I \propto v$ (speed of wave in medium)

$$I = \frac{1}{2}\rho v A^2 \omega^2$$

$$I = \frac{1}{2}\rho v A^2 (2\pi f)^2$$

$$\boxed{I = 2\pi^2 \rho v A^2 f^2}$$

Que If amplitude becomes half and frequency becomes one fourth then Intensity of wave becomes.

$$I \propto A^2 f^2$$

$$I' \propto \left(\frac{A}{2}\right)^2 \left(\frac{f}{4}\right)^2$$

$$I' = \frac{1}{64} I$$

Loudness of Sound Wave

measure of Intensity of sound wave

$$L = \log_{10}\left(\frac{I}{I_0}\right) \text{ Bell}$$

$$\boxed{L = 10\log_{10}\left(\frac{I}{I_0}\right) \text{ dB}}$$

$$\boxed{1 \text{ Bell} = 10 \text{ dB}}$$

$$\boxed{I_0 = 10^{-12} \text{ watt}/m^2}$$

Que What is the Intensity of sound of 70 decibel (Given the reference Intensity $I_0 = 10^{-12}$ Watt / m^2)

$$L = 10 \log_{10}\left(\frac{I}{I_0}\right) dB$$

$$70 \cancel{dB} = 10 \log_{10}\left(\frac{I}{I_0}\right) \cancel{dB}$$

$$7 = \log_{10}\left(\frac{I}{I_0}\right)$$

$$10^7 = \frac{I}{I_0}$$

$$I = I_0 \times 10^7$$

$$10^{-12} \times 10^7$$

$$\boxed{I = 10^{-5}.}$$

Energy density →

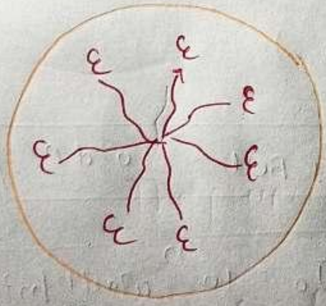
$$u = \frac{\text{Energy}}{\text{Volume}} = \frac{E}{Al}\frac{t}{t} = I \times \frac{t}{l}$$

$$= \frac{1}{2}\rho \cancel{v}^2 A^2 \omega^2 \times \frac{1}{\cancel{v}}$$

$$\boxed{U = \frac{1}{2}\rho A^2 \omega^2}$$

$$\boxed{U = \frac{I}{V}}$$

Point Source



$$I = \left(\frac{E}{4\pi r^2}\right) = \frac{E}{4\pi r^2}$$

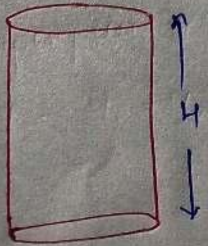
$$\boxed{I \propto \frac{1}{r^2}}$$

$$\boxed{A \propto \frac{1}{r}}$$

Planar Source

$$\boxed{\begin{matrix} I \propto r^0 \\ A \propto r^0 \end{matrix}}$$

Line Source



$$I = \frac{E}{2\pi r H}$$

$$\boxed{I \propto \frac{1}{r}}$$

$$I \propto \frac{1}{r} \propto A^2 \quad \boxed{A \propto \frac{1}{\sqrt{r}}}$$

Loudness is measure of Intensity

The Sound Intensity level at a point 14 m from the Point Source is 10 dB, then the Sound level at a distance 7m from the Same

$(I_2 = 4I_1)$

7m, $L_2 = ?$

$r = 14m$, $L_1 = 10 dB$ $\left(I_1 \propto \frac{1}{r^2}\right)$

$L_1 = 10 \log_{10}\left(\frac{I_1}{I_0}\right) dB$

$L_2 = 10 \log_{10}\left(\frac{4I_1}{I_0}\right) dB$

$L_2 - L_1 = 10\left(\log_{10}\left(\frac{4I_1}{I_0}\right) - \log\left(\frac{I_1}{I_0}\right)\right) dB$

$L_2 - 10 dB = 10\left[\log_{10}\frac{4\cancel{I_1}}{\cancel{I_0}} \times \left(\frac{\cancel{I_0}}{\cancel{I_1}}\right)\right]$

$L_2 - 10 = 10 \times 2\left[\log_{10} 2\right]$

$L_2 - 10 = 20 \times 0.301$

$L_2 - 10 = 6$

$\boxed{L_2 = 16 dB}$

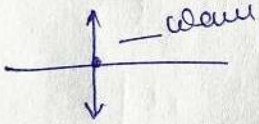
Que If the Intensity

① 12 dB
② 14.77 dB
③ 10 dB
④ 13 dB

Wave

mechanical wave

Non mechemical wave



The principal of superposition of wave

$y_1 = A_1 \sin(\omega t + kx)$

$y_2 = A_2 \sin(\omega t + kx + \phi)$

Superposition of linear these two way

$y = y_1 + y_2 = A_{net} \sin(\omega t + kx + \beta)$

$$\boxed{A_{net} = \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos\theta}}$$

$$\boxed{I_{net} = I_1 + I_2 + 2\sqrt{I_1}\sqrt{I_2}\cos\phi}$$

Intensity of resultant wave

Qu If $y_1 = 6\sin(kx - \omega t)$ then find intensity resultant amplitude
$y_2 = 4\sin(kx - \omega t)$

$\phi = 0$

$A_{net} = \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos 0^\circ}$

$\sqrt{(A_1 + A_2)^2}$

$= A_1 + A_2 = 6 + 4 = 10$

$I_{net} = (10)^2 = 100$ Ans

$A_{net} = \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos\phi}$

$\phi = 0$	$\phi = 90^\circ$	$\phi = 180^\circ$
$A_{net} = A_1 + A_2$	$A_{net} = \sqrt{A_1^2 + A_2^2}$	$(A_{net}) = A_1 - A_2$

Constructive Interference

$\phi = 0 = 2\pi = 4\pi = 6\pi$
$\phi = n(2\pi)$

$A_{max} = A_1 + A_2$

$I_{max} = (A_1 + A_2)^2 = (\sqrt{I_1} + \sqrt{I_2})^2$

$A_1 = A_2$
$A_{net} = 2A$

$\boxed{I_{net} = 4A^2 = 4I}$

Destructive Interference

$\phi = \pi / 180^\circ$

$A_{min} = A_1 - A_2$

$I_{min} = (A_1 - A_2)^2 = (\sqrt{I_1} - \sqrt{I_2})^2$

$(A_1 = A_2)$

$\boxed{A_{min} = 0 = I_{min}}$

Q3 If $\frac{I_1}{I_2} = \frac{9}{4}$ then find $\frac{I_{max}}{I_{min}} = ?$

$$\frac{I_1}{I_2} = \frac{9}{4} \qquad \frac{I_{max}}{I_{min}} = \frac{(\sqrt{I_1} + \sqrt{I_2})^2}{(\sqrt{I_1} - \sqrt{I_2})^2} = \left(\frac{\sqrt{9} + \sqrt{4}}{\sqrt{9} - \sqrt{4}}\right)^2$$

$$\left(\frac{3+2}{3-2}\right)^2 = \left(\frac{5}{1}\right)^2 = \frac{25}{1}$$

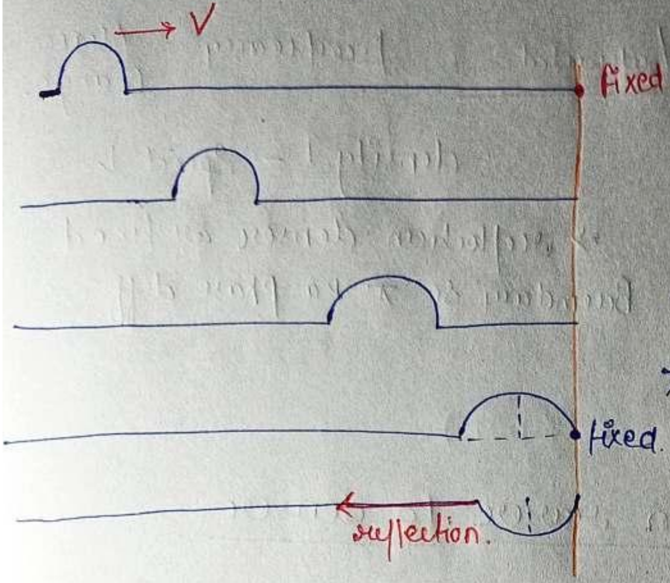
Q4 $\frac{I_{max}}{I_{min}} = \frac{25}{16}$ then find $\frac{I_1}{I_2} = ?$

$$\left(\frac{\sqrt{I_1} + \sqrt{I_2}}{\sqrt{I_1} - \sqrt{I_2}}\right)^2 = \frac{25}{16}$$

$$= \frac{\sqrt{I_1} + \sqrt{I_2}}{\sqrt{I_1} - \sqrt{I_2}} = \frac{5}{4} \quad \Rightarrow \quad \frac{I_1}{I_2} = \left(\frac{9}{1}\right)^2$$

$$= \frac{\sqrt{I_1}}{\sqrt{I_2}} = \frac{5+4}{5-4} \qquad = \frac{81}{1}$$

Reflection of transverse wave in a string from rigid boundary



$$\boxed{y = A \sin [kx - \omega t]}$$

frequency = same

Speed of wave = same

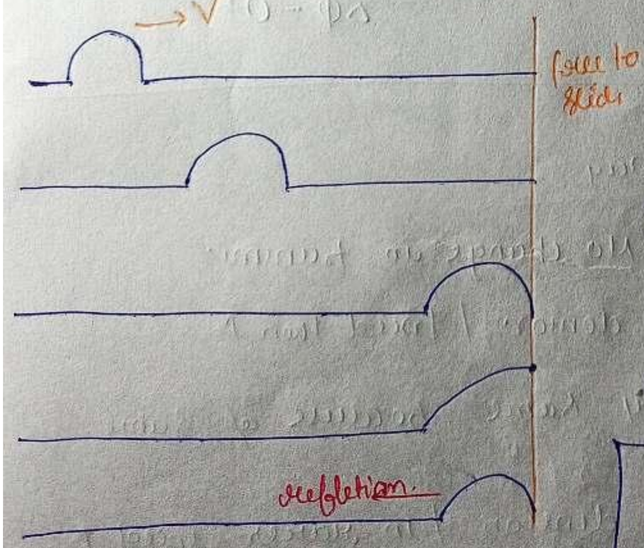
π Phase diff /

$$y_{ref} = A \sin (kx + \omega t + \pi)$$

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

$\boxed{\text{Rigid boundary/ reflection mai } \pi \text{ ka difference}}$
denser

Reflection of transverse wave in a string from free boundary



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

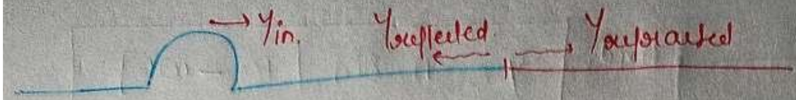
Velocity, Angular frequency, Amplitude, Wavelength, phase = same

Only dirn of motion will change

$$\boxed{y_{ref} = A \sin (kx + \omega t)}$$

Transmission of wave

$y_{in} = A \sin(\omega t - kx)$



frequency = Never Change

density ↑ = Speed ↓

$y_{reflect^n} = A_{reflec} \sin(kx + \omega t + \pi)$

$y_{reflected} = A_{reflec^n} \sin(kx + \omega t)$

⇒ reflection denser or fixed Boundary se π ka Phase diff

Wave moving from rarer to denser

Properties	Reflected wave	Refracted transmitted wave
Velocity	Same	Speed ↓
frequency	same	same
wavelength	same	$v = \lambda f$
Phase difference	π	$\Delta\phi = 0$

frequency = Same alway

Phase transmission → No change in transmi
Phase change in ref^n from denser / fixed then π

Reflection me speed alway same because of same medium
Transmission me speed in denser ↓ in rarer speed ↑

Wave moving from densor to rare

Property	Reflected wave	Refracted transmitted wave
Velocity	Same	Speed ↑
Frequency	Same	Same
Wavelength	Same	$\lambda \uparrow$
Phase difference	Same $\Delta\phi = 0$	$\Delta\phi = 0$

Stationary wave

Superposition of two wave having same velocity, amplitude, frequency, wavelength but moving in opposite direction.

$$y_1 = A \sin(kx - \omega t)$$
$$y_2 = A \sin(kx + \omega t)$$

$$y = y_1 + y_2 = A\left[\sin(\underbrace{kx - \omega t}_{C}) + \sin(\underbrace{kx + \omega t}_{D})\right]$$

$$y = A2 \sin\left(\frac{\cancel{2}kx}{\cancel{2}}\right) \cdot \cos\left(\frac{-\cancel{2}\omega t}{\cancel{2}}\right)$$

$$\boxed{y = 2A \sin(kx) \cdot \cos(\omega t)}$$

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

y is a position of a Particle at time 't' which is at x

at $x = 0$

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

eqⁿ of S.H.M of Particle which is at $x = 0$

$Y = 2A \sin(kx) \cdot \cos(\omega t)$

If $x = 0$

$Y = 2A \sin(0) \cdot \cos(\omega t)$

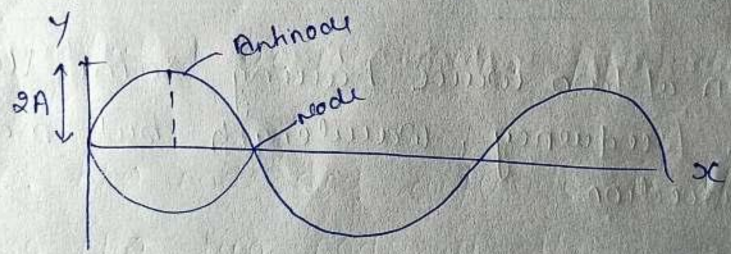
$\boxed{y = 0}$

does not depend on time.

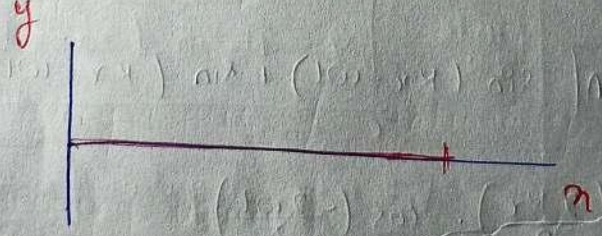
$y = 2A \sin(kx) \cdot \cos(\omega t)$

Case-1 at $t = 0$

$Y = 2A \sin(kx)$



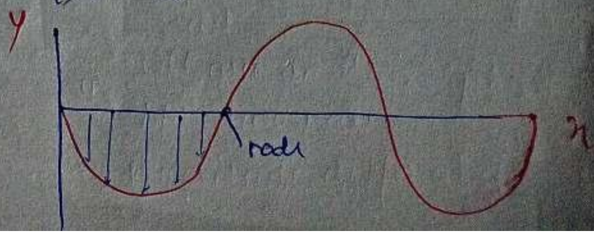
Case-2 at $= T/4$ $Y = 2A \sin(kx) \cos\left(\frac{2\pi}{\cancel{T}} \times \frac{\cancel{T}}{4}\right)$



Case-3 $t = T/2$

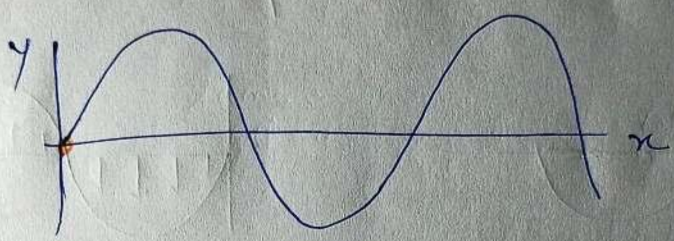
$Y = 2A \sin(kx) \cdot \cos\left(\frac{2\pi}{\cancel{T}} \cdot \frac{\cancel{T}}{2}\right)$

$Y = -2A \sin(kx)$



Case - $3T/4$

Case $t = T$



$$\boxed{y = 2A\sin(kx)\cdot\cos(\omega t)}$$

$y = A'\cos(\omega t)$

$A' = 2A\sin(kx)$

$$\boxed{x = 0,\ \frac{\lambda}{2},\ \frac{3\lambda}{2},\ 2\lambda,\ \frac{3\lambda}{2}}$$

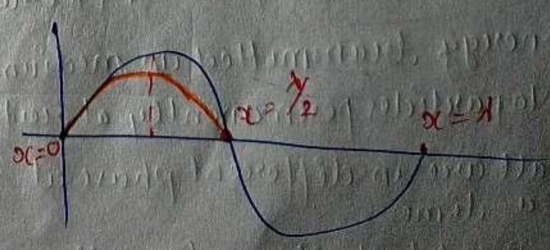
$A' = 2A\sin(kx)$

$x = \lambda/4$

$A' = 2A\sin\left(\frac{2\pi}{\cancel{\lambda}} \times \frac{\cancel{\lambda}}{\cancel{4}_{2}}\right)$

$A' = 2A\sin(\pi/2)$

$A' = 2A$ (Antinode)



Important point for stationary wave

1. formed by identical wave moving in opposite direction
2. All the particle are in same phase b/w two node. But π is a phase different b/w particle which is in adjacent node.
3. All the particle is oscillating with same frequency
4. All the particle have different amplitude
5. particle which have zero amplitude is called node

6. particle which have maximum amplitude is called anti-node
7. Distance b/w node and antinode is $\lambda/4$.
8. Distance b/w two node is $\lambda/2$
9. All particle will cross the mean position at same but different speed.

Moving wave / Stationary wave

Moving wave

1. wave equation $y = A\sin(kx - \omega t)$
2. Energy transmitted in medium
3. No particles permanently at rest
4. all are in different phase at a time
5. Amplitude same for all

Stationary wave

1. $y = 2A\sin(kx)\cos(\omega t)$
2. There is no transmission of energy.
3. Particle at node always at rest
4. All are in same phase b/w two node
5. Amplitude different for all

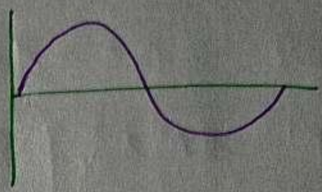
diff^n form of Stationary wave

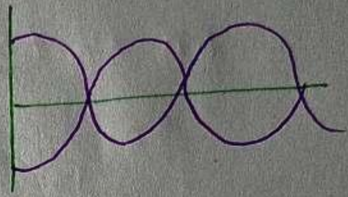
$y = 2A\sin(Kx)\cdot\cos(\omega t)$

$y = 2A\sin(Kx)\cdot\sin(\omega t)$

$y = 2A\cos(Kx)\cdot\sin(\omega t)$

$y = 2A\cos(Kx)\cdot\cos(\omega t)$





Que A stationary wave is represented by $y = A\sin(100t)\cos(0.01x)$ where y and A are in millimetre. t is in second and x is in metre. the velocity of the constituent wave is.

(1) 10^4 m/s ✓
(2) not derivative
(3) 1 m/s
(4) 10^2 m/s

$v = \frac{\omega}{K} = \frac{100}{0.01} = 10^4$ m/s

Que The equation given below represent a stationary wave set up in a medium $y = 12\sin(4\pi x)\sin(40\pi t)$. Where y and x are in cm and t is in second. Calculate the amplitude wavelength and velocity of the component wave.

$v = \frac{\omega}{K} = \frac{40\cancel{\pi}}{4\cancel{\pi}} = \boxed{10\ m/s}$

$K = 4\pi$

$\frac{2\cancel{\pi}}{\lambda} = 4\cancel{\pi}^{2}$

$\lambda = \frac{1}{2} = 0.5m$

Que In stationary wave find amplitude of oscillation of a particle which is b/w node and anti-node and frequency of oscillation that particle ??

$$y = 2A\sin(kx)\cos(\omega t)$$

$$A' = 2A\sin\left(\frac{\cancel{2}\pi}{\cancel{\lambda}}\cdot\frac{\cancel{\lambda}}{\cancel{8}_{4}}\right)$$

$$= 2A\sin\left(\frac{\pi}{4}\right)$$

$$= 2A\frac{1}{\sqrt{2}} = \sqrt{2}A$$

Que The constituent waves of a stationary wave have amplitude, frequency and velocity as 8 cm, 25 Hz and 150 cm s^{-1} respectively. What is the amplitude of the stationary wave at $x = 2$ cm.

$A = 8$ cm

$f = 25$ Hz

$V = 150$ cm

$$V = \frac{\omega}{k} = k = \frac{\omega}{V} = \frac{\cancel{2}\pi \times \cancel{25}}{\cancel{150}_{\cancel{3}3}}$$

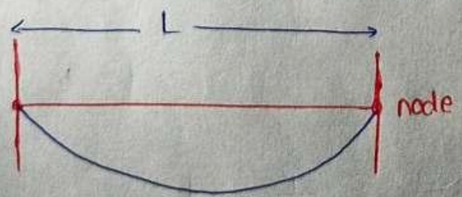
$$y = 2A\sin(kx).\cos(\omega t)$$

$$y = 2\times 8\sin\left(\frac{\pi}{3}\times 2\right)$$

$$\cancel{2}\times 8\times\frac{\sqrt{3}}{\cancel{2}}$$

$$\boxed{8\sqrt{3}\text{ cm}}$$

Formation of Stationary wave string

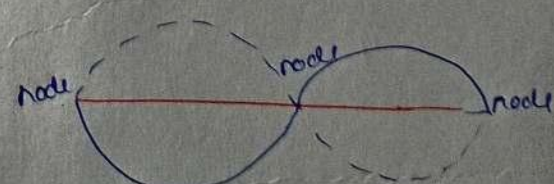


$\longleftarrow \frac{\lambda}{2} = L \longrightarrow$

$\lambda = 2L$

$$f = \frac{V}{\lambda} = \frac{1V}{2L}$$

fundament
1st harmonic



$\longleftarrow \lambda = L \longrightarrow$

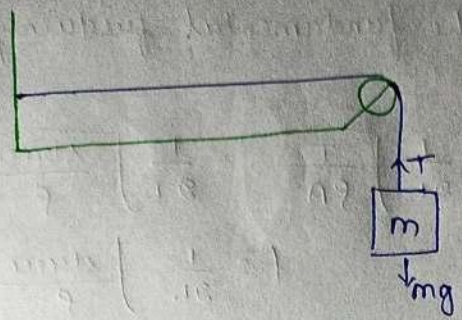
$$f = \frac{V}{\lambda} = \frac{2V}{2L}$$

2nd harmonic
1st overtone.

$$\boxed{f_{n^{th}\text{ harm}} = \frac{nV}{2L}\quad (n-1)\text{overtone}}$$

V = Speed of transverse wave $= \sqrt{\frac{T}{\mu}} = \sqrt{\frac{T}{\rho A}}$

Sonometere wire $\Rightarrow$



$$f_{n^{th}\ \text{Harmonic}} = \frac{nv}{2L} = \frac{n}{2L}\sqrt{\frac{T}{\mu}}$$

$$\frac{n}{2L}\sqrt{\frac{mg}{\mu}}$$

Que A String 50 cm long is under a tension of 20 N force. Calculate the frequency of fundamental mode given that mass of the string is 1 g.

$$f = \frac{v}{2L} = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$$

$$= \frac{1}{2\times\frac{1}{2}}\sqrt{\frac{20}{\frac{10^{-3}}{\frac{1}{2}}}}$$

$$= 1\sqrt{\frac{\cancel{20}}{\cancel{2}\times10^{-3}}} = \sqrt{10\times10^{-3}} = \sqrt{10^{4}} = 10^{2}\ \text{Ans}$$

Que A Sonometer wire is under a tension of 10 N and the length b/w the bridge is 2m. A metre long wire of sonometre has mass of 1.0 gm. Reduce the speed of transverse wave and frequency of 1st harmonic

$$V = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{10}{10^{-3}}}$$

$$\sqrt{10^{4}} = 100\ m$$

$T = 10$

$L = 2m$

$$f = \frac{v}{2L}$$

$$\frac{100}{2\times2} = \boxed{25\ Hz}\ \text{Ans}$$

Que The tension in a wire is decreased by 19% (19% kam hua) the percentage decrease in frequency will be

$$f = \frac{nv}{2L} = \frac{v}{2L} \propto v \propto \sqrt{\text{Tension}}$$

$$T_f = 81\%\ T_i$$

$$\boxed{T_f = \frac{81}{100}T_i}$$

(1)

$$f_i = \sqrt{T_i}$$

$$f_f = \sqrt{T_f} = \sqrt{\frac{81}{100}T_i}$$

$$f_f = \frac{9}{10}f_i$$

$$f_f = 0.9 f_i, \quad f_f = 90\%\ f_i$$

Que The length of a sonometer wire is 0.75 m and density 9×10^3 kg/m^3. It can bear a stress of 8.1×10^8 N/m^2 without exceeding the elastic limit. The fundamental frequency that can be produced in the wire is.

1. 200 Hz
2. 150 Hz
3. 600 Hz
4. 450 Hz

$$f = \frac{v}{2L} = \frac{1}{2L}\sqrt{\frac{T}{\mu}} = \frac{1}{2L}\sqrt{\frac{T}{\rho A}} = \frac{1}{2L}\sqrt{\frac{\text{stress}}{\rho}}$$

$$f = \frac{1}{2L}\sqrt{\frac{\text{stress}}{\rho}}$$

$$\boxed{200\text{ Hz}} \Leftarrow \frac{2 \times \cancel{3} \times 10^2}{\cancel{3}} \Leftarrow \frac{1}{\cancel{2} \times \frac{75}{\cancel{100}_{50}}}\sqrt{\frac{\cancel{81} \times 10^{\cancel{8}\,4}}{9 \times 10^{\cancel{3}}}}$$

Que The string of a violin has a frequency of 440 cps. If the violin string is shortened by one fifth. Its frequency will be changed to.

1. 440 cps
2. 880 cps
3. 550 cps
4. 2200 cps

$$l_f = l_i - \frac{l_i}{5}$$

$$l_f = \frac{4l_i}{5}$$

$$f_i \propto \frac{1}{l_i}$$

$$f_f = \frac{1}{l_f}$$

$$\frac{f_f}{f_i} = \frac{l_i}{l_f} = \frac{5\cancel{l_i}}{4\cancel{l_i}}$$

$$f_f = \frac{5}{\cancel{4}} \times \cancel{440}^{110} = \boxed{550\text{ Hz}}$$

Que The string of a violin has a frequency of 440 cps. If the violin string is shortened to one fifth. Its frequency will be changed to.

1. 440
2. 880
3. 550
4. 2200 cps

$$f = \frac{1}{l}$$

$$440 \times 5 =$$

2200 Hz

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Que A 12 m long vibrating string has the speed of wave 48 m/s. To what frequency it will resonate.

① 2 cps
② 4 cps
③ 6 cps
④ All of these

$L = 12m$
$v = 48 m/s$
$f = \frac{v}{2L} = \frac{48}{2\times12} = \frac{48}{24} = \boxed{2\ cps}$

Que A certain string will resonate to several frequencies. The lowest of which is 200 cps what are the next three higher frequencies to which it resonates?

① 400, 600, 800
② 300, 400, 500
③ 100, 150, 200
④ 200, 250, 300

$f_{2nd} = 2\left(\frac{v}{2L}\right)$

2×200
$= 400 Hz$

Que A wire of length one metre under a certain initial tension emits a sound of fundamental frequency 256 Hz. When the Tension ~~emits a sound of fundamental~~ is increased by 1 kg wt. The frequency of the fundamental node increase to 320 Hz. The initial tension is.

① 3/4 kg wt
② 4/3 kg wt
③ 16/9 kg wt
④ 20/9 kg wt

$f = 256 Hz$
$l = 1m$
T (let)

$\boxed{1\ kg\ wt = 10N}$
$T_f = T+10$
$f = 320 Hz$

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

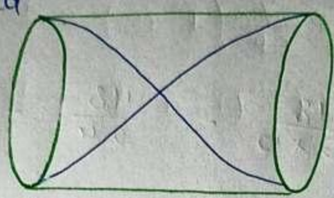
$\frac{256}{320} = \frac{\sqrt{T}}{\sqrt{T+10}} \Rightarrow \frac{4}{5} = \sqrt{\frac{T}{T+10}}$

$\frac{16}{25} = \frac{T}{T+10}$

$16T + 160 = 25T$
$160 = 9T$
$T = \frac{160}{9} N$
$= \frac{16}{9}$

Standing waves and Normal mode in open organ pipe

open end



open end.

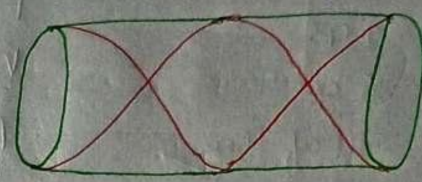
$\longleftarrow \frac{\lambda}{2} = L \longrightarrow$

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

$$f = \frac{v}{\lambda} = \frac{v}{2L}$$ Speed of sound wave.

Fundamental frequency and 1st harmonic

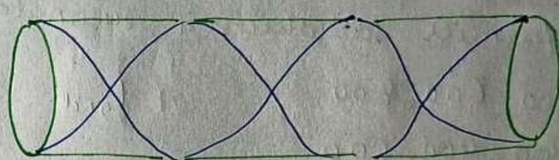
Antinode - 3
Node - 2



$\longleftarrow \lambda = L \longrightarrow$

$$f = \frac{v}{L} = \frac{2v}{2L}$$

2nd Harmonic ; 1st overtone



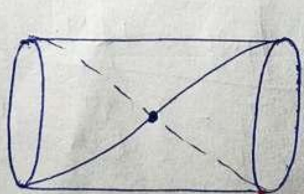
$\longleftarrow \frac{3\lambda}{2} = L \longrightarrow$

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

$$f = \frac{3v}{2L}$$

3rd harmonic and 2nd overtone

Open organ pipe



Displacement → Anti node at open end node at close end.

Pressure → Node at open end.

n^{th} harmonic →

$$f = n\left(\frac{v}{2L}\right)$$

$(n-1)$ overtone

node $= n$

Antinode $= n+1$

$$\boxed{f_1 : f_2 : f_3 : f_4 = 1 : 2 : 3 : 4}$$

$$f_n - f_{(n-1)} = n\left(\frac{v}{2L}\right) - \frac{(n-1)v}{2L}$$

$$= \frac{v}{2L}$$

$$f_n - f. =$$

* If 7^{th} overtone is 120 Hz then find fundamental frequency.

7^{th} Overtone

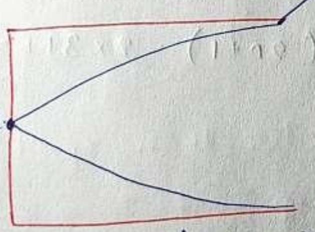
$$f_{8^{th}\text{ Harmonic}} = 120\text{ Hz} = 8\left(\frac{v}{2L}\right)$$

$$15\text{ Hz} = \frac{v}{2L}$$

* Normal modes of Oscillation of an Air Column with One end closed and other open (closed Organ pipe)

Antinode.

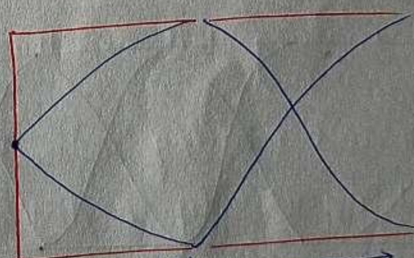
Node



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

$$f = \frac{v}{\lambda} = \frac{v}{4L}$$

fundamental frequency - 1st harmonic.

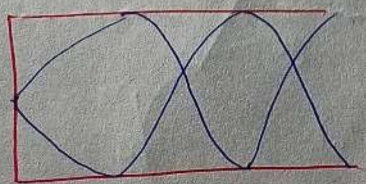


$$\frac{3\lambda}{4} = L$$

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

$$f = \frac{v}{\lambda} = \frac{3v}{4L}$$

3rd harmonic
1st Overtone



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

$$f = 5\left(\frac{v}{4L}\right)$$

only odd harmonic formed

$$f_1 : f_2 : f_3 = 1 : 3 : 5$$

$$f = (2n+1)\frac{v}{4L}$$

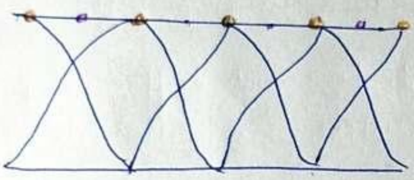
$$f = (2n+1)^{th} \text{ harmonic}$$

$\boxed{n = 0 \rightarrow 1^{st} \text{ harmonic}}$

$n = 1$ — 3^{rd} harmonic
1^{st} overtone

$n = 2 \rightarrow 2^{nd}$ overtone / 5^{th} harm.

Find no. of Antinode in 3^{rd} overtone in open organ pipe

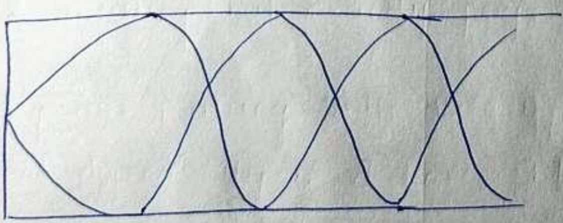


4^{th} harmonic

Antinode = 5 Ans
node = 4

Find no. of Antinode in 3^{rd} Overtone in close organ pipe

$(2n+1) = 2 \times 3 + 1 = 7^{th}$ harmoni



4 Antinode

Close organ pipe

$$\boxed{f_1 : f_3 : f_5 : f_7 = 1 : 3 : 5 : 7}$$

$$f_{n^{th}} - f_{(n-2)} = 2 \text{ fundamental}$$

$$\frac{\Delta f}{2} = \text{fundamental}$$

Que A cylindrical tube, open at both ends, has a fundamental frequency f in air. The tube is dipped vertically in water so that half of it is in water. The fundamental frequency of the air column is now.

(1) $\frac{f}{2}$

$f = \frac{v}{2L}$

(2) $\frac{3f}{4}$

$f' = \frac{v}{4l} = \frac{v}{4\frac{L}{2}} = \frac{v}{2L}$

(3) f ✓

(4) $2f$

Que In case of closed pipe which harmonic the p^{th} overtone will be

(1) $2p+1$ ✓

(2) $2p-1$

(3) $p+1$

(4) $p-1$

Que The Pitch of an Organ pipe is highest when the pipe is filled with

(1) Air

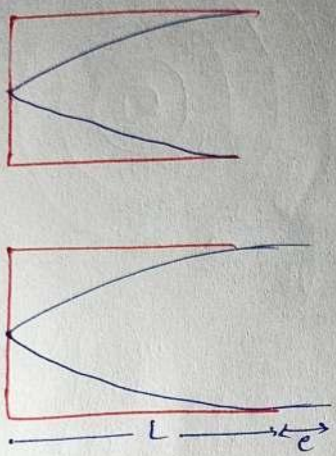
(2) Hydrogen ✓

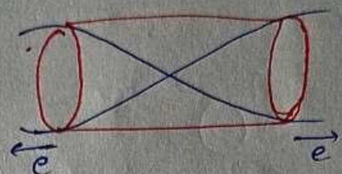
(3) Oxygen

(4) Carbon dioxide

$f = \frac{v}{2L} = \frac{1}{2L}\sqrt{\frac{\gamma RT}{M}}$

end correction



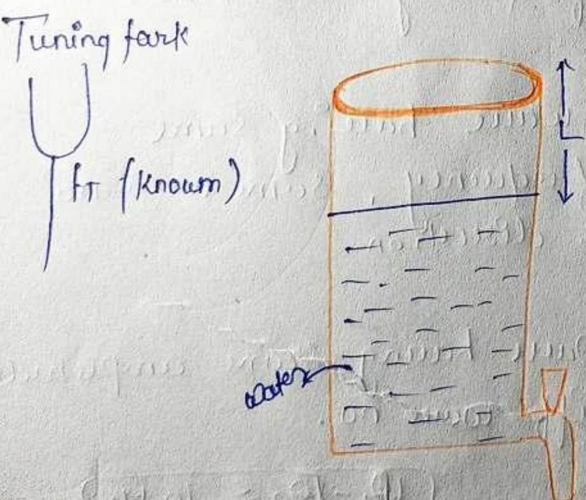


$$\boxed{f = \frac{nV}{2(L+2e)}}$$

$\boxed{e = 0.6r}$ Radius of organ pipe

$$f_{fund} = \frac{V}{4(L+e)}$$

Resonance Tube ⇒ Instrument use to find speed of sound.



$$f_{fundament} = \frac{V}{4L}$$

at resonance conditions

$$f_{organ\ pipe} = f_T$$

$$\frac{V}{4L} = f_T \text{ (known)}$$

$$V = \boxed{4 f_T L}$$

Speed of sound

3rd harmonics

$$3\left[\frac{\cancel{V}}{\cancel{4}L'}\right] = f_T = \frac{\cancel{V}}{\cancel{4}L}$$

$$\boxed{3L = L'}$$

Finding of end Correction using Resonance tube

Interference → Superposition of wave having difference amplitude but same frequency, wave no.

Stationary wave → Superposition of wave having same amplitude, same frequency, same wave no moving in opposite direction

Beat force → Superposition of two wave having same amplitude but diff frequency diff wave no.

$\boxed{f_1 - f_2 \leq 10\text{ Hz}}$

$y_1 = A\sin(\omega_1 t + k_1 x)$

$y_2 = A\sin(\omega_2 t + k_2 x)$

Beat freq. $\boxed{\beta = f_1 - f_2}$

$y = y_1 + y_2$ at $x = 0$

$y = A\sin(\omega_1 t) + A\sin(\omega_2 t)$

$A[\sin\omega_1 t + \sin(\omega_2 t)]$

Wave moving from denser to rarer

Property	Reflected wave	Refracted transmitted wave
Velocity	Same	Speed ↑
Frequency	Same	Same
Wavelength	Same	$\lambda \uparrow$
Phase difference	Same $\Delta\phi = 0$	$\Delta\phi = 0$

Stationary wave

Superposition of two wave having same velocity, amplitude, frequency, wavelength but moving in opposite direction.

$$y_1 = A \sin(kx - \omega t)$$
$$y_2 = A \sin(kx + \omega t)$$

$$y = y_1 + y_2 = A\left[\sin(\underbrace{kx - \omega t}_{C}) + \sin(\underbrace{kx + \omega t}_{D})\right]$$

$$y = A2 \sin\left(\frac{\cancel{2}kx}{\cancel{2}}\right) \cdot \cos\left(\frac{-\cancel{2}\omega t}{\cancel{2}}\right)$$

$$\boxed{y = 2A \sin(kx) \cdot \cos(\omega t)}$$

Doppler effect

Wherever there is a relative motion b/w the source of sound and an observer. The frequency of sound received are heard by the observer is different from the frequency of sound produced by the source. This is called doppler effect. Doppler effect is also valid for electromagnetic waves.

Doppler effect can be observed when

(i) The source is moving but the observer when

(ii) The observer is moving but the source is stationary.

(iii) Both the source and observer are moving

(iv) dopplar effect does not depend on dist^n b/w source and observer it depend on relative velocity.

Condition when dopplar effect will not occur

when both are at rest

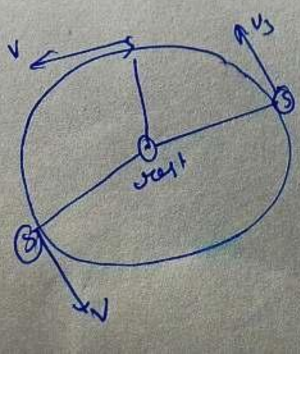
- when source and observer both are moving but with same velocity
- Both are moving but exactly perpendicular to each other
- when they are moving with velocity greater than speed of sound
- Does not depend upon distance b/w them.

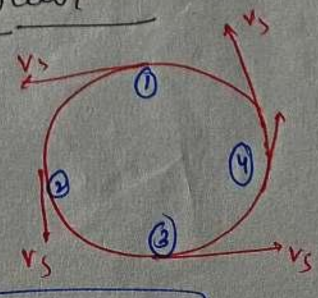
(S) $\rightarrow V_s = 10\,m/s$

(O) $\rightarrow V_o = 10\,m/s$

$$f' = f_0\left(\frac{v - v_0}{v - v_s}\right) = f_0$$

doppler effect will not occur

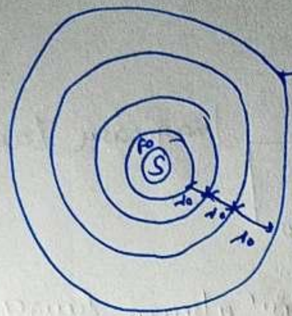




$$\boxed{f_1 > f_2 = f_4 > f_3}$$

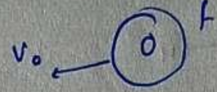
relat^n b/w freq heard by observer for diff position of source

Source is at rest and observer is moving



$\boxed{V = \lambda f}$

V = Speed of sound
f_0 = real frequency
V_s = speed of source
V_0 = Speed of observer



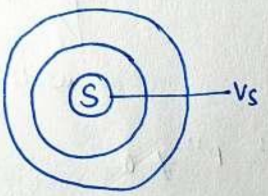
$\boxed{\lambda' = \lambda_0}$

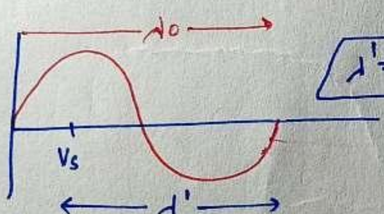
$V' = \lambda' f'$

$f' = \frac{V'}{\lambda'} = \frac{V+V_0}{\lambda_0}$

$$\boxed{f' = f_0\left(\frac{V+V_0}{V}\right)}$$

Observer is at rest & source is moving





$\boxed{\lambda' = \lambda_0 - V_s T}$

O f' = app^t

$\lambda' \neq \lambda_0$

$f' = \frac{V'}{\lambda'} = \frac{V}{\lambda_0 - V_s T}$

$F' = \frac{V}{\frac{V}{f_0} - \frac{V_s}{f_0}}$

$$\boxed{f' = \left(\frac{V}{V - V_s}\right) f_0}$$

Que An observer is approaching with a speed V, towards a stationary source emitting sound wave of wavelength λ_0. The wavelength shift detected by the Observer is

① $\lambda_0 V / c$

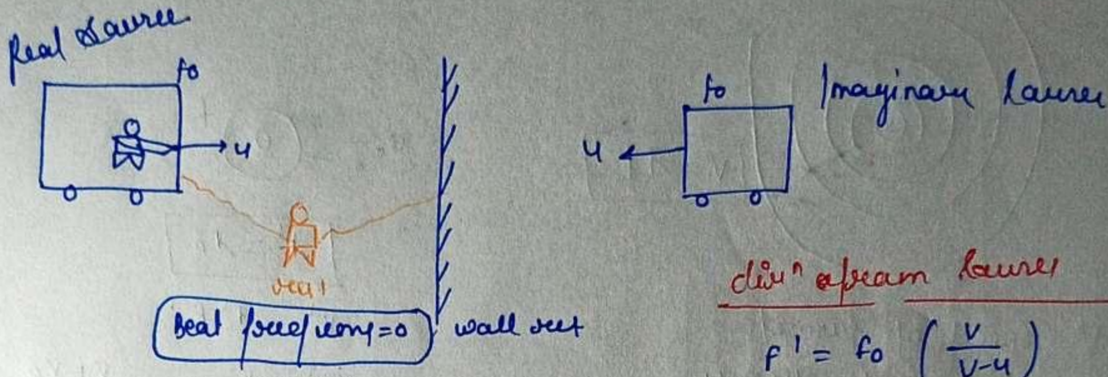
② $\frac{\lambda_0 c}{V}$

③ $\frac{\lambda_0 V^2}{c^2}$

④ zero. ✓

Source is moving toward Stationary source

Case-1



dirn of beam source

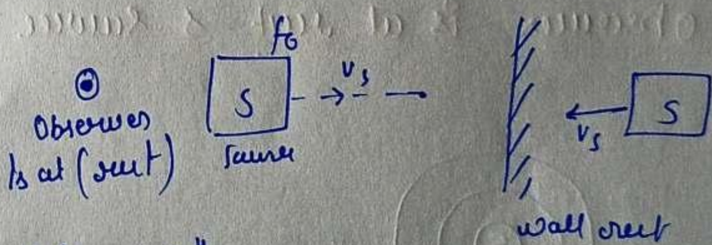
$$f' = f_0 \left(\frac{v}{v-u}\right)$$

from surface = $f'' = f_0\left(\frac{v}{v-u}\right)$

Case-2

$$f' = \left(\frac{v}{v+v_s}\right) \text{ real source}$$

$$f'' = f_0 \left(\frac{v}{v-v_s}\right)$$



$f' \uparrow$ & f''

Beat freq = $f' - f'' \neq 0$