Chapter

17

Waves and Sound

Waves

Ripple on a pond

Musical sound

Seismic waves

(Earth quake)

Tsunami

on.

stem is disturbed from equilibrium and wh r propagate from one region of the system to another. Wave can carry energy and momentum. The energy in light waves from the sun warms the surface of our planet; the energy in seismic waves can crack our planet's crust.

Characteristics of Wave Motion

(1) When a wave motion passes through a medium, particles of the medium only vibrate simple harmonically about their mean position. They do leave their position and move with the disturbance.

(2) In wave motion, the phase of particles of medium keeps on changing.

(3) The velocity of the particle during their vibration is different at different position.

(4) The velocity of wave motion through a particular medium is constant. It depends only on the nature of medium not on the frequency, wavelength or intensity.

(5) Energy is propagated along with the wave motion without any net transport of the medium.

(6) For the propagation of wave, a medium should have following characteristics.

(i) Elasticity : So that particles can return to their mean position, after having been.

(ii) Inertia : So that particles can store energy and overshoot their mean position.

(iii) Minimum friction amongst the particles of the medium.

(iv) Uniform density of the medium.

Types of Waves

Waves can be classified in a number of ways based on the following characteristics

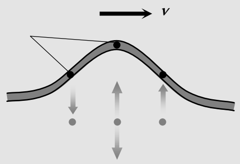
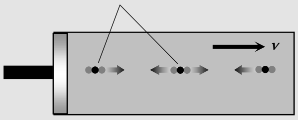
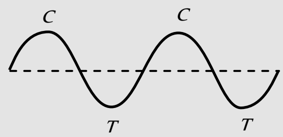
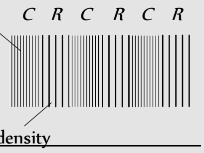
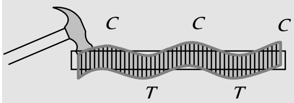
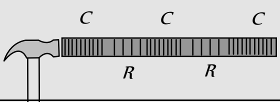
(1) **On the basis necessity of medium**

(i) **Mechanical waves :** Require medium for their propagation *e.g.* Waves on string and spring, waves on water surface, sound waves, seismic waves.

(ii) **Non-mechanical waves :** Do not require medium for their propagation are called *e.g,* Light, heat (Infrared), radio waves, γ- rays, X-rays *etc.*

(2) **On the basis of vibration of particle :** On the basis of vibration of particle of medium waves can be classified as transverse waves and longitudinal waves.

Table 17.1 : Transverse and longitudinal waves

Transverse waves	Longitudinal waves
Particles of the medium vibrates in a direction perpendicular to the direction of propagation of wave.	Particles of a medium vibrate in the direction of wave motion.
 Transverse wave on a string	 Longitudinal wave in a fluid
It travels in the form of crests (C) and troughs (T).	It travels in the form of compression (C) and rarefaction (R).
	
Transverse waves can be transmitted through solids, they can be setup on the surface of liquids. But they can not be transmitted into liquids and gases.	These waves can be transmitted through solids, liquids and gases because for these waves propagation, volume elasticity is necessary.
 Transverse wave in a rod	 Longitudinal wave in a rod
Medium should posses the property of rigidity	Medium should posses the property of elasticity
Transverse waves can be polarised.	Longitudinal waves can not be polarised.
Movement of string of a sitar or violin, movement of the membrane of a Tabla or Dholak, movement of kink on a rope, waves set-up on the surface of water.	Sound waves travel through air, Vibration of air column in organ pipes Vibration of air column above the surface of water in the tube of resonance apparatus

(3) **On the basis of energy propagation**

(i) **Progressive wave :** These waves advances in a medium with definite velocity. These waves propagate energy in the medium *e.g.* Sound wave and light waves.

(ii) **Stationary wave :** These waves remains stationary between two boundaries in medium. Energy is not propagated by these waves but it is confined in segments (or loops) *e.g.*. Wave in a string, waves in organ pipes.

(4) **On the basis of dimension**

(i) **One dimensional wave :** Energy is transferred in a single direction only *e.g.* Wave propagating in a stretched string.

(ii) **Two dimensional wave :** Energy is transferred in a plane in two mutually perpendicular directions *e.g.* Wave propagating on the surface of water.

(iii) **Three dimensional wave :** Energy in transferred in space in all direction *e.g.* Light and sound waves propagating in space.

(5) **Some other waves**

(i) **Matter waves :** The waves associated with the moving particles are called matter waves.

(ii) **Audible or sound waves :** Range 20 *Hz* to 20 *KHz.* These are generated by vibrating bodies such as vocal cords, stretched strings or membrane.

(iii) **Infrasonic waves :** Frequency lie below 20 *Hz* and wavelengths are greater than 16.6 *cm. Example* : waves produced during earth quake, ocean waves *etc.*

(iv) **Ultrasonic waves :** Frequency greater than 20 *KHz.* Human ear cannot detect these waves, certain creatures such as mosquito, dog and bat show response to these. As velocity of sound in air is 332 *m/sec* so the wavelength λ < 1.66 *cm.*

These waves are used for navigation under water (SONAR).

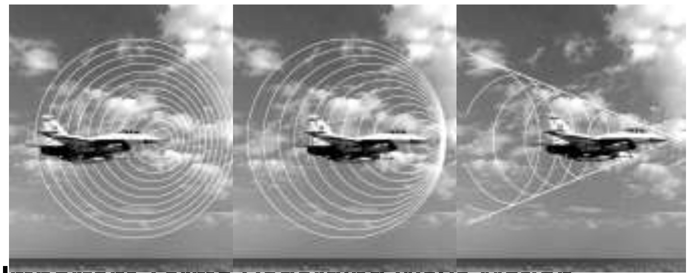
They are used in ultrasonography (in photography or scanning soft tissue of body).

Their used to repel mosquitoes or attract fishes

(v) **Shock waves :** When an object moves with a velocity greater than that of sound, it is termed as **Supersonic**. When such a supersonic body or plane travels in air, it produces energetic disturbance which moves in backward direction and diverges in the form of a cone. Such disturbance are called the shock waves.

The speed of supersonic is measured in Mach number. One mach number is the speed of sound.

Mach Number = $\dfrac{\text{Velocity of source}}{\text{Velocity of sound}}$.



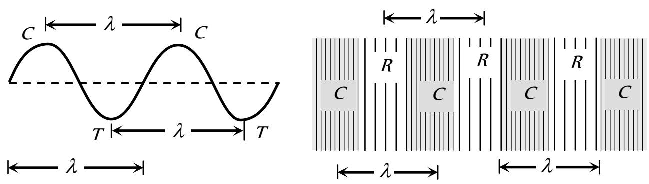
Important Terms Regarding Wave Motion

(1) **Amplitude** (a) **:** Maximum displacement of a vibrating particle of medium from it's mean position is called amplitude.

(2) **Wavelength** (λ) **:** It is equal to the distance travelled by the wave during the time in which any one particle of the medium completes one vibration about its mean position.

(i) Or distance travelled by the wave in one time period is known as wavelength.

(ii) Or is the distance between the two successive points with the same phase.



(A) Transverse wave **(B)** Longitudinal wave

Fig. 17.1

(3) **Frequency** (n) **:** Frequency of vibration of a particle is defined as the number of vibrations completed by particle in one second.

It is the number of complete wavelengths traversed by the wave in one second.

Units of frequency are hertz (*Hz*) and per second.

(4) **Time period** (T) **:** Time period of vibration of particle is defined as the time taken by the particle to complete one vibration about its mean position.

It is the time taken by the wave to travel a distance equal to one wavelength

Time period = 1/Frequency $\Rightarrow T = 1/n$

(5) **Wave pulse :** It is a short wave produced in a medium when the disturbance created for a short time.

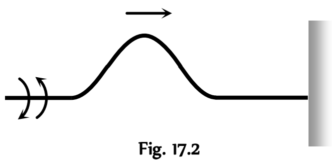


Fig. 17.2

(6) **Wave train :** A series of wave pulse is called wave train.

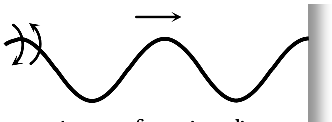
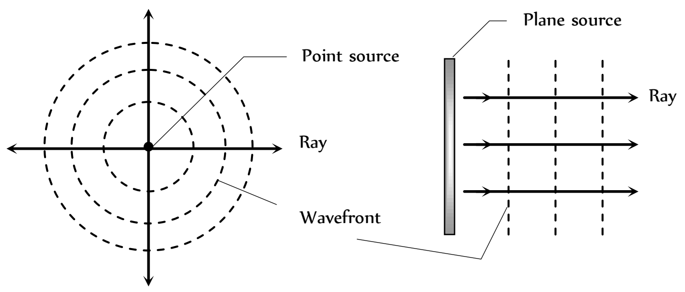


Fig. 17.3

(7) **Wave front :** A wave front is a line or surface on which the disturbance has **the** same phase at all points. If the source is periodic, it produces a succession of wave front, all of the same shape. Ripples on a pond are the example of wave fronts.



(A) Spherical wavefront (B) Plane wavefront

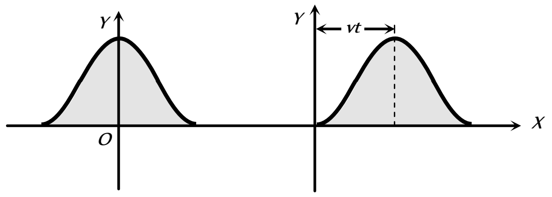
Fig. 17.4

(8) **Wave function ;** It is a mathematical description of the disturbance created by a wave. For a string, the wave function is a displacement for sound waves. It is a pressure or density fluctuation where as for light waves it is electric or magnetic field.

Now let us consider a one dimensional wave travelling along x-axis. During wave motion, a particle with equilibrium position x is displaced some distance y in the direction perpendicular to the x-axis. In this case y is a function of position (x) and time (t).

i.e. $y = f(x, t)$. This is called wave function .

Let the wave pulse is travelling with a speed v, after a time t, the pulse reaches a distance vt along the $+x$-axis as shown. The wave function now can be represented as $y = f(x - vt)$



(A) Pulse at time $t = 0$ (B) Pulse after time t

Fig. 17.5

If the wave pulse is travelling along $-x$-axis then $y = f(x + vt)$

If order of a wave function to represent a wave, the three quantities x, v, t must appear in combinations $(x + vt)$ or $(x - vt)$

Thus $y = (x - vt)$, $\sqrt{(x - vt)}$, $Ae^{-B(x-vt)^2}$ *etc.* represents travelling waves while $y = (x^2 - v^2t^2), (\sqrt{x} - \sqrt{vt})$, $A \sin (4x - 9t)$ *etc.* doesn't represents a wave.

(9) **Harmonic wave :** If a travelling wave is a sin or cos function of $(x \pm vt)$ the wave is said to be harmonic or plane progressive wave.

(10) **The wave equation :** All the travelling waves satisfy a differential equation which is called the wave equation. It is given by $\frac{\partial^2 y}{\partial t^2} = v^2 \frac{\partial^2 y}{\partial x^2}$; where $v = \frac{\omega}{k}$

It is satisfied by any equation of the form $y = f(x \pm vt)$

(11) **Angular wave number or propagation constant (k) :** Number of wavelengths in the distance 2π is called the wave number or propagation constant *i.e.* $k = \frac{2\pi}{\lambda}$.

It is unit is *rad/m.*

(12) **Wave velocity** (v) **:** It is the distance travelled by the disturbance in one time period. It only depends on the properties of the medium and it independent of time and position.

$$v = n\lambda = \frac{\lambda}{T} = \frac{\omega}{2\pi} = \frac{\omega}{k}$$

(13) **Group velocity** (v) **:** The velocity with which the group of waves travels is known as group velocity

or the velocity with which a wave packet travels is known as group velocity $v_g = \frac{d\omega}{dk}$.

(14) **Phase** (ϕ) **:** The quantity which express at any instant, the displacement of the particle and it's direction of motion is called the phase of the particle.

If two particles of the medium, at any instant are at the same distance in the same direction from their equilibrium positions and are moving in the same direction then they are said to be in same phase *e.g.* In the following figure particles 1, 3 and 5 are in same phase and point 6, 7 are also in same phase.

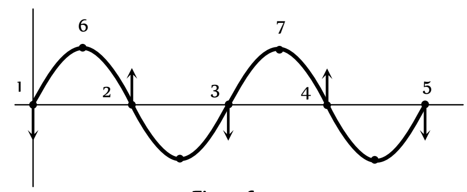


Fig. 17.6

(15) **Intensity of wave :** The wave intensity is defined as the average amount of energy flow in medium per unit time and per unit of it's cross-sectional area. It's unit is W/m^2

Hence intensity $(I) = \frac{\text{Energy}}{\text{Area} \times \text{Time}} = \frac{\text{Power}}{\text{Area}} = 2\pi na\rho v$

$\Rightarrow I \propto a^2$ (when v, ρ = constant)

where a = Amplitude, n =Frequency, v = Wave velocity,

ρ = Density of medium.

At a distance r from a point source of power P the intensity is given by $I = \frac{P}{4\pi r^2} \Rightarrow I \propto \frac{1}{r^2}$

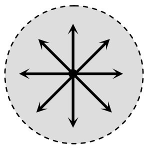


Fig. 17.7

The human ear can hear sound of intensity up to 10^{-12} W/m^2. This is called **threshold of intensity**. The upper limit of intensity of sound which can be tolerated by human ear is 1 W/m^2. This is called **threshold of pain**.

(16) **Energy density :** The energy associated with unit volume of the medium is defined as energy density

Energy density $= \frac{\text{Energy}}{\text{Volume}} = \frac{\text{Intensity}}{\text{Velocity}} = \frac{2\pi^2 n^2 a^2 \rho v}{v} = 2\pi^2 n^2 a^2 \rho$

Velocity of Transverse Wave

The velocity of a transverse wave in a stretched string is given by $v = \sqrt{\frac{T}{m}}$; where T = Tension in the string; m = Linear density of string (mass per unit length).

(1) If A is the area of cross-section of the wire then $m = \rho A$

$$\Rightarrow v = \sqrt{\frac{T}{\rho A}} = \sqrt{\frac{S}{\rho}} \text{ ; where } S = \text{Stress } = \frac{T}{A}$$

(2) If string is stretched by some weight then

$$T = Mg$$

$$\Rightarrow v = \sqrt{\frac{Mg}{m}}$$

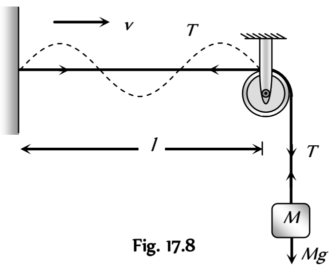


Fig. 17.8

(3) If suspended weight is immersed in a liquid of density σ and ρ = density of material of the suspended load then

$$T = Mg\left(1 - \frac{\sigma}{\rho}\right)$$

$$\Rightarrow v = \sqrt{\frac{Mg(1 - \sigma/\rho)}{m}}$$

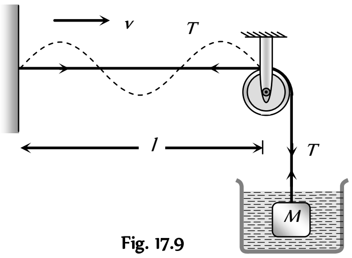


Fig. 17.9

(4) If two rigid supports of stretched string are maintained at temperature difference of $\Delta\theta$ then due to elasticity of string.

$T = YA\, \alpha\, \Delta\theta$

$$\Rightarrow v = \sqrt{\frac{YA\,\alpha\Delta\theta}{m}}$$

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

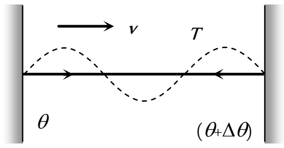


Fig. 17.10

where Y = Young's modulus of elasticity of string, A = Area of cross section of string, α = Temperature coefficient of thermal expansion, d = Density of wire $= \frac{m}{A}$

(5) In a solid body : $v = \sqrt{\frac{\eta}{\rho}}$

where η = Modulus of rigidity; ρ = Density of the material.

Velocity of Longitudinal Wave (Sound Wave)

(1) **Velocity of sound in any elastic medium :** It is given by $v = \sqrt{\frac{E}{\rho}} = \sqrt{\frac{\text{Elasticity of the medium}}{\text{Density of the medium}}}$

(i) In solids $v = \sqrt{\frac{Y}{\rho}}$; where Y = Young's modulus of elasticity

(ii) In a liquid and gaseous medium $v = \sqrt{\frac{B}{\rho}}$; where B = Bulk modulus of elasticity of liquid or gaseous medium.

(iii) As solids are most elastic while gases least *i.e.* $E_S > E_L > E_G$. So the velocity of sound is maximum in solids and minimum in gases, hence $v_{steel} > v_{water} > v_{air}$

5000 m/s > 1500 m/s > 330 m/s

(iv) The velocity of sound in case of extended solid (crust of the earth)

$v = \sqrt{\frac{B + \frac{4}{3}\eta}{\rho}}$; B = Bulk modulus; η = Modulus of rigidity; ρ = Density

(2) **Newton's formula :** He assumed that when sound propagates through air temperature remains constant. *i.e.* the process is isothermal. For isothermal process

B = Isothermal elasticity (E_θ) = Pressure $(P) \Rightarrow v = \sqrt{\frac{B}{\rho}} = \sqrt{\frac{P}{\rho}}$

For air at NTP : $P = 1.01 \times 10^5$ N/m^2 and $\rho = 1.29$ kg/m^3.

$$\Rightarrow v_{air} = \sqrt{\frac{1.01 \times 10^5}{1.29}} \approx 280\, m/s$$

However the experimental value of sound in air is 332 m/sec which is greater than that given by Newton's formula.

(3) **Laplace correction :** He modified Newton's formula assuming that propagation of sound in gaseous medium is adiabatic process. For adiabatic process

B = Adiabatic elasticity $(E_\phi) = \gamma P$

$$\Rightarrow v = \sqrt{\frac{B}{\rho}} = \sqrt{\frac{E_\phi}{\rho}} = \sqrt{\frac{\gamma P}{\rho}} = \sqrt{\frac{\gamma RT}{M}}$$

For air : $\gamma = 1.41 \Rightarrow v = \sqrt{1.41} \times 280 \approx 332$ *m/sec*

(4) **Relation between velocity of sound and root mean square velocity :**

If sound travel in a gaseous medium then $v = \sqrt{\frac{\gamma RT}{M}}$ and *r.m.s.* velocity of gas $v = \sqrt{\frac{3RT}{M}}$

So $\frac{v_{rms}}{v_{sound}} = \sqrt{\frac{3}{\gamma}}$ or $v = [\gamma/3]^{1/2} v$.

Factors Affecting Velocity of Sound in Gaseous Medium

(1) **Effect of pressure at constant temperature :** Velocity of sound is independent of the pressure of gas, because as pressure increases, density also increases hence $\frac{P}{\rho}$ ratio remains constant. So from $v = \sqrt{\frac{\gamma P}{\rho}}$,

(2) **Effect of temperature :** With rise in temperature velocity of sound increases.

$$v = \sqrt{\frac{\gamma RT}{M}} \Rightarrow v \propto \sqrt{T} \Rightarrow \frac{v_1}{v_2} = \sqrt{\frac{T_1}{T_2}} = \sqrt{\frac{(273 + t_1 °C)}{(273 + t_2 °C)}}$$

When the temperature change is small then $v_t = v_0 + 0.61\, t$

where v_t = Velocity of sound at $t°C$

v_0 = Velocity of sound at $0°C$ = 332 *m/sec*

t = Small temperature change

If $t = 1°C$ then $v_t = (v_0 + 0.61)$ *m/sec*. Hence for $1°C$ rise, speed of sound in air increases by 0.61 *m/sec*.

(3) **Effect of density :** $v = \sqrt{\frac{\gamma P}{\rho}} \Rightarrow v \propto \frac{1}{\sqrt{\rho}}$

(4) **Effect of humidity :** With increase in humidity, density of air decreases. So with rise in humidity velocity of sound increases.

Sound travels faster in humid air (rainy season) than in dry air (summer) at the same temperature because

$$\rho_{moist\ air} < \rho_{dry\ air} \Rightarrow v_{moist\ air} > v_{dry\ air}$$

(5) **Effect of wind velocity :** Because wind drifts the medium (air) along its direction of motion therefore the velocity of sound in a particular direction is the algebraic sum of the velocity of sound and the component of wind velocity in that direction. Resultant velocity of sound towards observer $v' = v + w \cos\theta$.

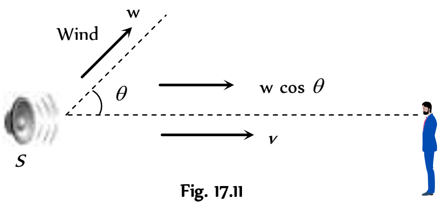


Fig. 17.11

(6) Sound of any frequency or wavelength travels through a given medium with the same velocity.

For a given medium velocity remains constant. All other factors like phase, loudness pitch, quality *etc.* have practically no effect on sound velocity.

Equation of a Plane Progressive Waves

(1) If during the propagation of a progressive wave, the particles of the medium perform SHM about their mean position, then the waves is known as a harmonic progressive wave.

(2) Suppose a plane simple harmonic wave travels from the origin along the positive direction of *x-axis* from left to right as shown in the figure.

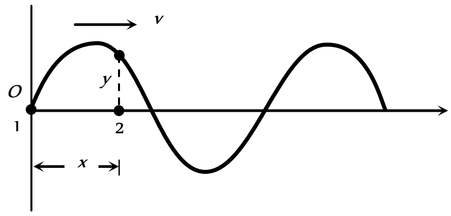


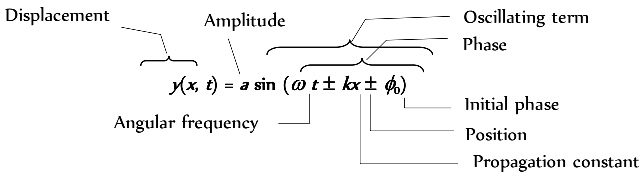
Fig. 17.12

The displacement y of a particle 1 at O from its mean position at any time t is given by $y = a \sin\omega t$.

The wave reaches the particle 2 after time $t = \frac{x}{v}$. Hence displacement y of a particle 2 is given by

$$y = a \sin\omega\left(t - \frac{x}{v}\right) = a\sin(\omega t - kx) \qquad \left(\because k = \frac{\omega}{v}\right)$$

The general equation of a plane progressive wave with initial phase is



(3) Various forms of progressive wave function.

(i) $y = a \sin(\omega t - kx)$

(ii) $y = a \sin\left(\omega t - \frac{2\pi}{\lambda} x\right)$

(iii) $y = a \sin 2\pi\left[\frac{t}{T} - \frac{x}{\lambda}\right]$

(iv) $y = a \sin\frac{2\pi}{T}\left(t - x\frac{T}{\lambda}\right)$

(v) $y = a \sin\frac{2\pi}{\lambda}(v t - x)$

(vi) $y = a \sin\omega\left(t - \frac{x}{v}\right)$

(4) **Particle velocity :** The rate of change of displacement y *w.r.t.* time t is known as particle velocity

Hence from $y = a \sin(\omega t - kx)$

Particle velocity $v_p = \frac{\partial y}{\partial t} = a\omega\cos(\omega t - kx)$

Maximum particle velocity $(v_p)_{max} = a\omega$

Also $\frac{\partial y}{\partial t} = -\frac{\omega}{k} \times \frac{\partial y}{\partial x}$ $\Rightarrow v_p = -v \times$ Slope of wave at that point

(5) **Important relations for numerical solving**

(i) Angular frequency ω = co-efficient of t

(ii) Propagation constant k = co-efficient of x

Wave speed $v = \frac{\text{co-efficient of } t}{\text{co-efficient of } x} = \frac{\omega}{k}$

(iii) Wave length $\lambda = \frac{\text{co-efficient of } x}{2\pi}$

(iv) Time period $T = \frac{2\pi}{\text{co-efficient of } t}$

(v) Frequency $n = \frac{\text{co-efficient of } t}{2\pi}$

(vi) $(v_p)_{max} = a\omega = a(2\pi n) = \frac{a2\pi}{T}$

(vii) If the sign between t and x terms is negative the wave is propagating along positive X-axis and if the sign is positive then the wave moves in negative X-axis direction.

(viii) Co-efficient of sin or cos functions *i.e.* Argument of sin or cos function is represented by phase *i.e.* $(\omega t - kx)$ = Phase.

(ix) **Phase difference and path difference :** At any instant t, if ϕ_1 and ϕ_2 are the phases of two particles whose distances from the origin are x_1 and x_2 respectively then $\phi_1 = (\omega t - kx_1)$ and $\phi_2 = (\omega t - kx_2)$ $\Rightarrow$ $\phi_1 - \phi_2 = k(x_2 - x_1)$

$\Rightarrow$ Phase difference $(\Delta\phi) = \frac{2\pi}{\lambda}$. Path difference (Δx)

(x) **Phase difference and time difference :** If the phases of a particle distance x from the origin is ϕ_1 at time t_1 and ϕ_2 at time t_2, then $\phi_1 = (\omega t_1 - kx)$ and $\phi_1 = (\omega t_2 - kx)$ $\Rightarrow$ $\phi_1 - \phi_2 = \omega(t_1 - t_2)$

$\Rightarrow$ Phase difference $(\Delta\phi) = \frac{2\pi}{T}$. Time difference (Δt)

Pressure Waves

A longitudinal sound wave can be expressed either in terms of the longitudinal displacement of the particles of the medium or in terms of excess pressure produced due to compression or rarefaction. (at compression, the pressure is more than the normal pressure of the medium and at rarefaction the pressure is lesser than the normal). The first type is called the displacement wave and the second type the pressure wave.

If the displacement wave is represented by $y = a\sin(\omega t - kx)$ then the corresponding pressure wave will be represented by $\Delta P = -B\frac{dy}{dx}$ (B = Bulk modulus of elasticity of medium)

$\Rightarrow \Delta P = \Delta P_0 \cos(\omega t - kx)$

where ΔP_0 = pressure amplitude $= akB$

Pressure wave is $\left(\frac{\pi}{2}\right)$ out of phase with displacement wave. *i.e.* pressure is maximum when displacement is minimum and vice-versa.

Reflection and Refraction of Waves

When waves are incident on a boundary between two media, a part of incident waves returns back into the initial medium (reflection) while the remaining is partly absorbed and partly transmitted into the second medium (refraction)

(1) **Rarer and denser medium :** A medium is said to be denser (relative to the other) if the speed of wave in this medium is less than the speed of the wave in other medium.

In comparison to air speed of sound is maximum in water, hence water is rarer medium for sound waves *w.r.t.* air. But it is not true for light (EM-waves). For light waves water is denser medium *w.r.t.* air.

(2) In reflection or refraction frequency remains same

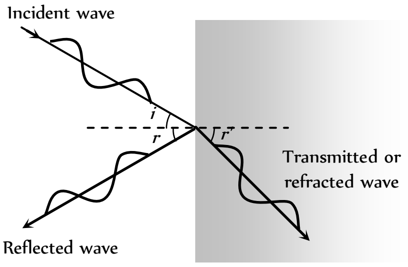


Fig. 17.13

(3) For reflection angle of incidence (i) = Angle of reflection (r)

(4) In case of refraction or transmission $\frac{\sin i}{\sin r'} = \frac{v_i}{v_t}$

(5) **Boundary conditions :** Reflection of a wave pulse from some boundary depends on the nature of the boundary.

(i) **Rigid end :** When the incident wave reaches a fixed end, it exerts an upward pull on the end, according to Newton's law the fixed end exerts an equal and opposite down ward force on the string. It result an inverted pulse or phase change of π.

Crest (C) reflects as trough (T) and vice-versa, Time changes by $\frac{T}{2}$ and Path changes by $\frac{\lambda}{2}$

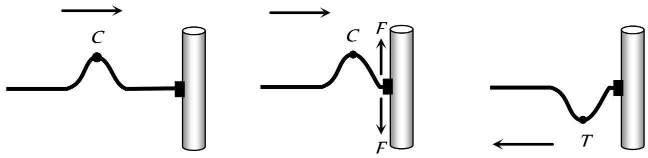


Fig. 17.14

(ii) **Free end :** When a wave or pulse is reflected from a free end, then there is no change of phase (as there is no reaction force).

Crest (C) reflects as crest (C) and trough (T) reflects as trough (T), Time changes by zero and Path changes by zero.

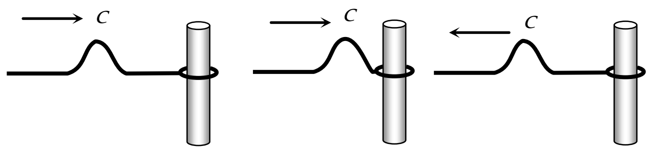


Fig. 17.15

(iii) **Exception :** Longitudinal pressure waves suffer no change in phase from rigid end *i.e.* compression pulse reflects as compression pulse. On the other hand if longitudinal pressure wave reflects from free end, it suffer a phase change of π *i.e.* compression reflects as rarefaction and vice-versa.

(iv) **Effect on different variables :** In case of reflection, because medium is same and hence, speed, frequency (ω) and wavelength λ (or k) do not changes. On the other hand in case of transmitted wave since medium changes and hence speed, wavelength (or k) changes but frequency (ω) remains the same.

(6) **Wave in a combination of string**

(i) **Wave goes from rarer to denser medium**

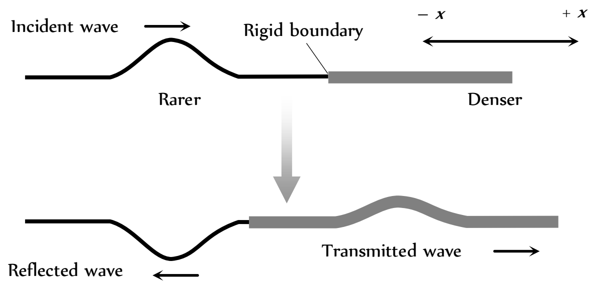


Fig. 17.16

Incident wave $y_i = a_i \sin(\omega t - k_1 x)$

Reflected wave $y_r = a_r \sin[\omega t - k_1(-x) + \pi] = -a \sin(\omega t + k_1 x)$

Transmitted wave $y_t = a_t \sin(\omega t - k_2 x)$

(ii) **Wave goes from denser to rarer medium**

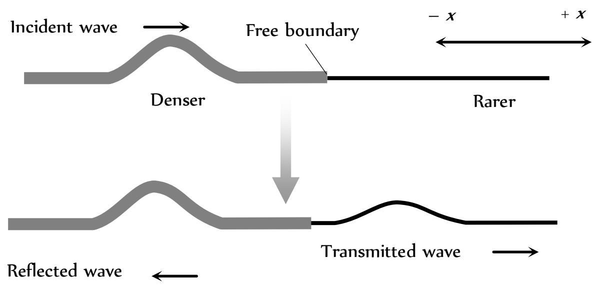


Fig. 17.17

Incident wave $y_i = a_i \sin(\omega t - k_1 x)$

Reflected wave $y_r = a_r \sin[\omega t - k_1(-x) + 0] = a \sin(\omega t + k_1 x)$

Transmitted wave $y_t = a_t \sin(\omega t - k_2 x)$

(iii) **Ratio of amplitudes :** It is given as follows

$$\frac{a_r}{a_i} = \frac{k_1 - k_2}{k_1 + k_2} = \frac{v_2 - v_1}{v_2 + v_1} \text{ and } \frac{a_t}{a_i} = \frac{2k_1}{k_1 + k_2} = \frac{2v_2}{v_1 + v_2}$$

Echo

An echo is simply the repetition of speaker's own voice caused by reflection at a distance surface *e.g.* a cliff. a row of building or any other extended surface.

If there is a sound reflector at a distance d from source, then the time interval between original source and it's echo at the site of source will be

$$t = \frac{d}{v} + \frac{d}{v} = \frac{2d}{v}$$

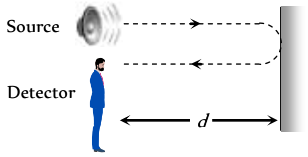


Fig. 17.18

As the persistence of hearing for human ear is 0.1 *sec*, therefore in order that an echo of short sound (*e.g.* clap or gun fire) will be heard if $t >$ 0.1 $\Rightarrow \frac{2d}{v} > 0.1 \Rightarrow d > \frac{v}{20}$

If v = Speed of sound = 340 *m/s* then d > 17 *m*.

Principle of Superposition

(1) The displacement at any time due to any number of waves meeting simultaneously at a point in a medium is the vector sum of the individual displacements due each one of the waves at that point at the same time.

(2) If $\vec{y}_1, \vec{y}_2, \vec{y}_3$ .... are the displacements at a particular time at a particular position, due to individual waves, then the resultant displacement.

$$\vec{y} = \vec{y}_1 + \vec{y}_2 + \vec{y}_3 + ...$$

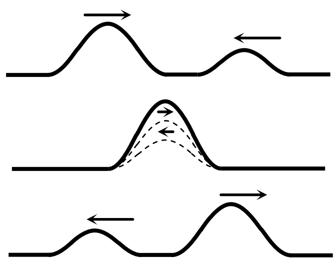


Fig. 17.19

(3) Important applications of superposition principle

(i) **Interference of waves :** Adding waves that differs in phase

(ii) **Formation of stationary waves :** Adding wave that differs in direction.

(iii) **Formation of beats :** Adding waves that differs in frequency.

(iv) **Formation of Lissaju's figure :** Adding two perpendicular simple harmonic motions. (See S.H.M. for more detail)

Interference of Sound Waves

(1) When two waves of same frequency, same wavelength, same velocity (nearly equal amplitude) moves in the same direction, Their superimposition results in the interference.

(2) Due to interference the resultant intensity of sound at that point is different from the sum of intensities due to each wave separately.

(3) Interference is of two type (i) Constructive interference (ii) Destructive interference.

(4) In interference energy is neither created nor destroyed but is redistributed.

(5) For observable interference, the sources (producing interfering waves) must be coherent.

(6) Let at a given point two waves arrives with phase difference ϕ and the equation of these waves is given by

$y_1 = a_1 \sin \omega t$, $y_2 = a_2 \sin(\omega t + \phi)$ then by the principle of superposition $\vec{y} = \vec{y}_1 + \vec{y}_2$

$\Rightarrow y = a_1 \sin \omega t + a_2 \sin(\omega t + \phi) = A \sin(\omega t + \theta)$

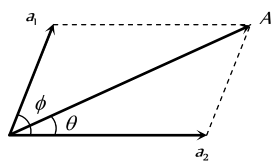


Fig. 17.20

where $A = \sqrt{a_1^2 + a_2^2 + 2a_1 a_2 \cos\phi}$

and tan $\theta = \dfrac{a_2 \sin\phi}{a_1 + a_2 \cos\phi}$

since Intensity (I) ∝ (Amplitude A)^2 $\Rightarrow \dfrac{I_1}{I_2} = \left(\dfrac{a_1}{a_2}\right)^2$

Therefore, the resultant intensity is given by

$$I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$$

Table 17.2 : Constructive and destructive interference

Constructive interference	Destructive interference
When the waves meets a point with same phase, constructive interference is obtained at that point (*i.e.* maximum sound).	When the wave meets a point with opposite phase, destructive interference is obtained at that point (*i.e.* minimum sound)
Phase difference between the waves at the point of observation $\phi = 0^o$ or $2n\pi$	Phase difference $\phi = 180^o$ or $(2n-1)\pi$; n = 1, 2, ...
Path difference between the waves at the point of observation $\Delta = n\lambda$ (*i.e.* even multiple of $\lambda/2$)	Path difference $\Delta = (2n-1)\dfrac{\lambda}{2}$ (*i.e.* odd multiple of $\lambda/2$)
Resultant amplitude at the point of observation will be maximum $A_{max} = a_1 + a_2$ If $a_1 = a_2 = a_0 \Rightarrow A_{max} = 2a_0$	Resultant amplitude at the point of observation will be minimum $A_{min} = a_1 - a_2$ If $a_1 = a_2 \Rightarrow A_{min} = 0$
Resultant intensity at the point of observation will be maximum $I_{max} = I_1 + I_2 + 2\sqrt{I_1 I_2}$ $= \left(\sqrt{I_1} + \sqrt{I_2}\right)^2$ If $I_1 = I_2 = I_0 \Rightarrow I_{max} = 4I_0$	Resultant intensity at the point of observation will be minimum $I_{min} = I_1 + I_2 - 2\sqrt{I_1 I_2}$ $= \left(\sqrt{I_1} - \sqrt{I_2}\right)^2$ If $I_1 = I_2 = I_0 \Rightarrow I_{min} = 0$

(7) $\dfrac{I_{max}}{I_{min}} = \left(\dfrac{\sqrt{I_1} + \sqrt{I_2}}{\sqrt{I_1} - \sqrt{I_2}}\right)^2 = \left(\dfrac{\sqrt{\dfrac{I_1}{I_2}} + 1}{\sqrt{\dfrac{I_1}{I_2}} - 1}\right)^2 = \left(\dfrac{a_1 + a_2}{a_1 - a_2}\right)^2 = \left(\dfrac{\dfrac{a_1}{a_2} + 1}{\dfrac{a_1}{a_2} - 1}\right)^2$

Quink's Tube

This is an apparatus used to demonstrate the phenomenon of interference and also used to measure velocity of sound in air. This is made up of two U-tube A and B as shown in figure. Here the tube B can slide in and out from the tube A. There are two openings P and Q in the tube A. At opening P, a tuning fork or a sound source of known frequency n_0 is placed and at the other opening a detector is placed to detect the resultant sound of interference occurred due to superposition of two sound waves coming from the tubes A and B.

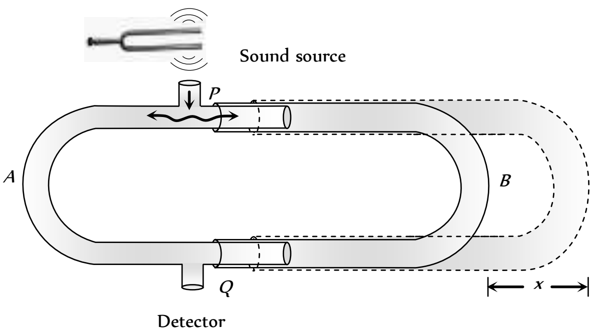


Fig. 17.21

Initially tube B is adjusted so that detector detects a maximum. At this instant if length of paths covered by the two waves from P and Q from the side of A and side of B are l_1 and l_2 respectively then for constructive interference we must have

$$l_2 - l_1 = N\lambda \qquad \text{.... (i)}$$

If now tube B is further pulled out by a distance x so that next maximum is obtained and the length of path from the side of B is l'_2 then we have

$$l'_2 = l_2 + 2x \qquad \text{.... (ii)}$$

where x is the displacement of the tube. For next constructive interference of sound at point Q, we have

$$l'_2 = l_1 = (N+1)\lambda \qquad \text{.... (iii)}$$

From equation (i), (ii) and (iii), we get

$$l'_2 - l_2 = 2 \times x = \lambda \Rightarrow x = \frac{\lambda}{2}$$

Thus by experiment we get the wavelength of sound as for two successive points of constructive interference, the path difference must be λ. As the tube B is pulled out by x, this introduces a path difference $2x$ in the path of sound wave through tube B. If the frequency of the source is known, n_0 the velocity of sound in the air filled in tube can be gives as $v = n_0.\lambda = 2n_0 x$

Standing Waves or Stationary Waves

When two sets of progressive wave trains of same type (both longitudinal or both transverse) having the same amplitude and same time period/frequency/wavelength travelling with same speed along the same straight line in opposite directions superimpose, a new set of waves are formed. These are called stationary waves or standing waves.

In practice, a stationary wave is formed when a wave train is reflected at a boundary. The incident and reflected waves then interfere to produce a stationary wave.

(1) Suppose that the two super imposing waves are incident wave $y_1 = a\sin(\omega t - kx)$ and reflected wave $y_2 = a\sin(\omega t + kx)$

(As y_2 is the displacement due to a reflected wave from a free boundary)

Then by principle of superposition

$$y = y_1 + y_2 = a[\sin(\omega t - kx) + \sin(\omega t + kx)]$$

(By using sin C + sin D = $2\sin\dfrac{C+D}{2}\cos\dfrac{C-D}{2}$)

$$\Rightarrow \quad y = 2a\cos kx \sin\omega t$$

(If reflection takes place from rigid end, then equation of stationary wave will be $y = 2a\sin kx \cos\omega t$)

(2) As this equation satisfies the wave equation

$\frac{\partial^2 y}{\partial t^2} = v^2 \frac{\partial^2 y}{\partial x^2}$. It represents a wave.

(3) As it is not of the form $f(ax \pm bt)$, the wave is not progressive.

(4) Amplitude of the wave $A_{SW} = 2a\cos kx$.

Table 17.3 : Amplitude in two different cases

Reflection at open end	Reflection at closed end
$A_{SW} = 2a\cos kx$	$A_{SW} = 2a\sin kx$
Amplitude is maximum when $\cos kx = \pm 1$ $\Rightarrow kx = 0, \pi, 2\pi, ... n\pi.$ $\Rightarrow x = 0, \frac{\lambda}{2}, \lambda .... \frac{n\lambda}{2}$ where $k = \frac{2\pi}{\lambda}$ and $n = 0, 1, 2, 3, ...$	Amplitude is maximum when $\sin kx = \pm 1$ $\Rightarrow kx = \frac{\pi}{2}, \frac{3\pi}{2} ..... \frac{(2n-1)\pi}{2}$ $\Rightarrow x = \frac{\lambda}{4}, \frac{3\lambda}{4} ....$ where $k = \frac{2\pi}{\lambda}$ and $n = 1, 2, 3, ...$
Amplitude is minimum when $\cos kx = 0$ $\Rightarrow kx = \frac{\pi}{2}, \frac{3\pi}{2} ..... \frac{(2n-1)\pi}{2}$ $\Rightarrow x = \frac{\lambda}{4}, \frac{3\lambda}{4} ....$	Amplitude is minimum when $\sin kx = 0$ $\Rightarrow kx = \frac{\pi}{2}, \frac{3\pi}{2} ..... \frac{(2n-1)\pi}{2}$ $\Rightarrow x = 0, \frac{\lambda}{2}, \lambda .... \frac{n\lambda}{2}$

(5) **Nodes** (*N*) **:** The points where amplitude is minimum are called nodes.

(i) Distance between two successive nodes is $\frac{\lambda}{2}$.

(ii) Nodes are at permanents rest.

(iii) At nodes air pressure and density both are high.

(6) **Antinodes** (*A*) **:** The points of maximum amplitudes are called antinodes.

(i) The distance between two successive antinodes is $\frac{\lambda}{2}$

(ii) At nodes air pressure and density both are low.

(iii) The distance between a node (*N*) and adjoining antinode (*A*) is $\frac{\lambda}{4}$.

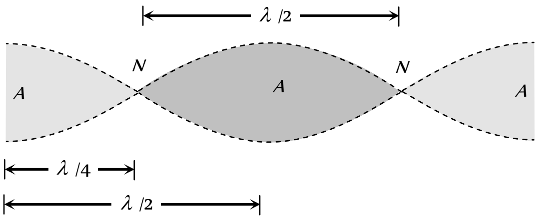


Fig. 17.22

Characteristics of Standing Waves

(1) Standing waves can be transverse or longitudinal.

(2) The disturbance confined to a particular region between the starting point and reflecting point of the wave.

(3) There is no forward motion of the disturbance from one particle to the adjoining particle and so on, beyond this particular region.

(4) The total energy associated with a stationary wave is twice the energy of each of incident and reflected wave. As in stationary waves nodes are permanently at rest. So no energy can be transmitted across then *i.e.* energy of one region (segment) is confined in that region. However this energy oscillates between elastic potential energy and kinetic energy of particles of the medium.

(5) The medium splits up into a number of segments. Each segment is vibrating up and down as a whole.

(6) All the particles in one particular segment vibrate in the same phase. Particles in two consecutive segments differ in phase by 180°.

(7) All the particles except those at nodes, execute simple harmonic motion about their mean position with the same time period.

(8) The amplitude of vibration of particles varies from zero at nodes to maximum at antinodes (2*a*).

(9) All points (except nodes) pass their mean position twice in one time period.

(10) Velocity of particles while crossing mean position varies from maximum $(\omega A_{SW} = \omega.2a)$ at antinodes to zero at nodes.

(11) In standing waves, if amplitude of component waves are not equal. Resultant amplitude at nodes will be minimum (but not zero). Therefore, some energy will pass across nodes and waves will be partially standing.

(12) Application of stationary waves

(i) Vibration in stretched string

(ii) Vibration in organ pipes (closed and open)

(iii) Kundt's tube

Table 17.4 : Progressive v/s stationary wave

Progressive wave	Stationary wave
These waves transfers energy	These wave does not transfers energy
All particles have the same amplitude	Between a node and an antinode all particles have different amplitudes
Over one wavelength span all particles have difference phase	Between a node and an antnodes all particles have same phase.
No point is at rest	Nodes are always at rest
All particles do not cross the mean position simultaneously.	All particles cross the mean position simultaneously.

Terms Related to the Application of Stationary Wave

(1) **Note :** Any musical sound produced by the simple harmonic oscillations of the source is called note.

(2) **Tone :** Every musical sound consists of a number of components of different frequencies every component is known as a Tone.

(3) **Fundamental note and fundamental frequency :** The note of lowest frequency produced by an instrument is called fundamental note. The frequency of this note is called fundamental frequency.

(4) **Harmonics :** The frequency which are the integral multiple of the fundamental frequency are known as harmonics *e.g.* if *n* be the fundamental frequency, then the frequencies *n*, 2*n*, 3*n* .... are termed as first, second, third .... harmonics.

(5) **Overtone :** The harmonics other than the first (fundamental note) which are actually produced by the instrument are called overtones. *e.g.* the tone with frequency immediately higher than the fundamental is defined as first overtone.

(6) **Octave :** The tone whose frequency is doubled the fundamental frequency is defined as Octave.

(i) If $n_2 = 2n_1$ it means n_2 is an octave higher than n_1 or n_1 is an octave lower than n_2.

(ii) If $n_2 = 2^3 n_1$, it means n_2 is 3-octave higher or n_1 is 3-octave lower.

(iii) Similarly if $n_2 = 2^n n_1$ it means n_2 is *n*-octave higher n_1 is *n* octave lower.

(7) **Unison :** If the interval is one *i.e.* two frequencies are equal then vibrating bodies are said to be in unison.

(8) **Resonance :** The phenomenon of making a body vibrate with its natural frequency under the influence of another vibrating body with the same frequency is called resonance.

Standing Waves on a String

(1) Consider a string of length *l*, stretched under tension *T* between two fixed points.

(2) If the string is plucked and then released, a transverse harmonic wave propagate along it's length and is reflected at the end.

(3) The incident and reflected waves will superimpose to produce transverse stationary waves in a string.

(4) Nodes (*N*) are formed at rigid end and antinodes (*A*) are formed in between them.

(5) Number of antinodes = Number of nodes – 1

(6) Velocity of wave (incident or reflected wave) is given by $v = \sqrt{\frac{T}{m}}$; m = Mass per unit length of the wire

(7) Frequency of vibration (n) = Frequency of wave

$$= \frac{v}{\lambda} = \frac{1}{\lambda}\sqrt{\frac{T}{m}}$$

(8) For obtaining p loops (p-segments) in string, it has to be plucked at a distance $\frac{l}{2p}$ from one fixed end.

(9) **Fundamental mode of vibration**

(i) Number of loops $p = 1$

(ii) Plucking at $\frac{l}{2}$

(from one fixed end)

(iii) $l = \frac{\lambda_1}{2} \Rightarrow \lambda_1 = 2l$

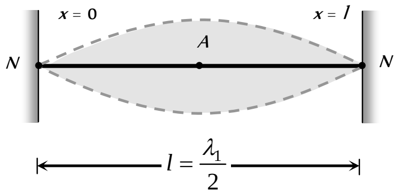


Fig. 17.23

(iv) Fundamental frequency or first harmonic

$$n_1 = \frac{1}{\lambda_1}\sqrt{\frac{T}{m}} = \frac{1}{2l}\sqrt{\frac{T}{m}}$$

(10) **Second mode of vibration** (First over tone or second harmonic)

(i) Number of loops $p = 2$

(ii) Plucking at $\frac{l}{2\times 2} = \frac{l}{4}$

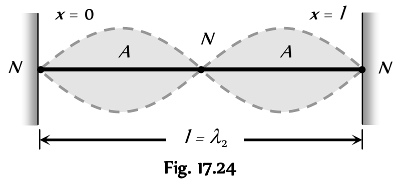


Fig. 17.24

(from one fixed end)

(iii) $l = \lambda_2$

(iv) Second harmonic or first over tone

$$n_2 = \frac{1}{\lambda_2}\sqrt{\frac{T}{m}} = \frac{1}{l}\sqrt{\frac{T}{m}} = 2n_1$$

(11) **Third normal mode of vibration** (Second over tone or third harmonic)

(i) Number of loops $p = 3$

(ii) Plucking at $\frac{l}{2\times 3} = \frac{l}{6}$

(from one fixed end)

(iii) $l = \frac{3\lambda_3}{2} \Rightarrow \lambda_3 = \frac{2l}{3}$

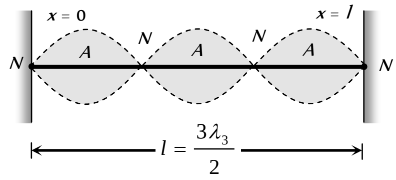


Fig. 17.25

(iv) Third harmonic or second over tone

$$n_3 = \frac{1}{\lambda_3}\sqrt{\frac{T}{m}} = \frac{3}{2l}\sqrt{\frac{T}{m}} = 3n_1$$

(12) **More about string vibration**

(i) In general, if the string is plucked at length $\frac{l}{2p}$, then it vibrates in p segments (loops) and we have the p harmonic is give $f_p = \frac{p}{2l}\sqrt{\frac{T}{m}}$

(ii) All even and odd harmonics are present. Ratio of harmonic = 1 : 2 : 3 .....

(iii) Ratio of over tones = 2 : 3 : 4 ....

(iv) General formula for wavelength $\lambda = \frac{2l}{N}$; where N = 1,2,3, ... correspond to 1st, 2nd, 3rd modes of vibration of the string.

(v) General formula for frequency $n = N \times \frac{v}{2l}$

(vi) **Position of nodes :** $x = 0, \frac{l}{N}, \frac{2l}{N}, \frac{3l}{N}..... l$

(vii) **Position of antinodes :** $x = \frac{l}{2N}, \frac{3l}{2N}, \frac{5l}{2N} .... \frac{(2N-1)l}{2N}$

Melde's Experiment

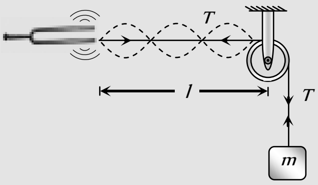
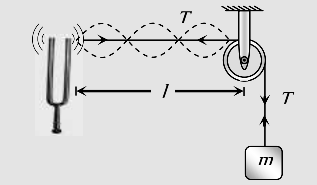
(1) It is an experimental representation of transverse stationary wave.

(2) In Melde's experiment, one end of a flexible piece of string is tied to the end of a tuning fork. The other end passes over a smooth pulley carries a suitable load.

(3) If p is the number of loop's formed in stretched string and T is the tension in the string then Melde's law is $p\sqrt{T}$ = constant

$$\Rightarrow \frac{p_1}{p_2} = \sqrt{\frac{T_2}{T_1}} \text{ (For comparing two cases)}$$

Table 17.5 ; Two arrangements of connecting a string to turning fork

Transversely	Example
	
Prongs of tuning fork vibrates at right angles to the thread.	Prongs vibrated along the length of the thread.
Frequency of vibration of turning fork : frequency of vibration of the thread.	Frequency of turning fork =2 × (Frequency of vibration of thread)
If number of loops in string is P then $l=\frac{p\lambda}{2} \Rightarrow \lambda=\frac{2l}{p}$ ⇒ Frequency of string $=\frac{v}{\lambda}=\frac{p}{2l}\sqrt{\frac{T}{m}}\left(\because v=\sqrt{\frac{T}{m}}\right)$ ⇒ Frequency of tuning fork $=\frac{p}{2l}\sqrt{\frac{T}{m}}$ ⇒ If l, m, $n \rightarrow$ constant then $p\sqrt{T}=$ constant	It number of loop so in string is p then $l=\frac{p\lambda}{2} \Rightarrow \lambda=\frac{2l}{p}$ ⇒ Frequency of string $=\frac{v}{\lambda}=\frac{p}{2l}\sqrt{\frac{T}{m}}$ ⇒ Frequency of turning fork $I=\frac{P}{l}\sqrt{\frac{T}{m}}$ ⇒ If l, m, $n \rightarrow$ constant then $p\sqrt{T}=$ constant

Sonometer

(1) It is an apparatus, used to produce resonance (matching frequency) of tuning fork (or any source of sound) with stretched vibrating string.

(2) It consists of a hollow rectangular box of light wood. The experimental fitted on the box as shown.

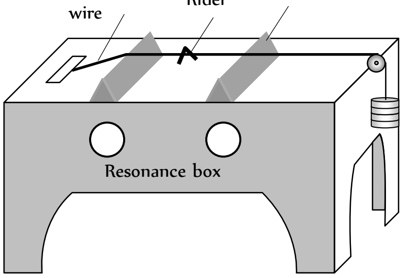


Fig. 17.26

(3) The box serves the purpose of increasing the loudness of the sound produced by the vibrating wire.

(4) If the length of the wire between the two bridges is l, then the frequency of vibration is $n=\frac{1}{2l}\sqrt{\frac{T}{m}}=\sqrt{\frac{T}{\pi r^2 d}}$

(r = Radius of the wire, d = Density of material of wire) m = mass per unit length of the wire)

(5) **Resonance :** When a vibrating tuning fork is placed on the box, and if the length between the bridges is properly adjusted then if $(n)_{Fork}=(n)_{String} \rightarrow$ rider is thrown off the wire.

(6) **Laws of string**

(i) **Law of length :** If T and m are constant then $n \propto \frac{1}{l}$

$\Rightarrow nl=$ constant $\Rightarrow n_1l_1=n_2l_2$

(ii) **Law of mass :** If T and l are constant then $n \propto \frac{1}{\sqrt{m}}$

$\Rightarrow n\sqrt{m}=$ constant $\Rightarrow \frac{n_1}{n_2}=\sqrt{\frac{m_2}{m_1}}$

(iii) **Law of density :** If T, l and r are constant then $n \propto \frac{1}{\sqrt{d}}$

$\Rightarrow n\sqrt{d}=$ constant $\Rightarrow \frac{n_1}{n_2}=\sqrt{\frac{d_2}{d_1}}$

(iv) **Law of tension :** If l and m are constant then $n \propto \sqrt{T}$

$\Rightarrow \frac{n}{\sqrt{T}}=$ constant $\Rightarrow \frac{n_1}{n_2}=\sqrt{\frac{T_2}{T_1}}$

Vibration of Composite Strings

Suppose two strings of different material and lengths are joined end to end and tied between clamps as shown. Now after plucking, stationary waves are established only at those frequencies which matches with any one harmonic of both the independent string S_1 and S_2

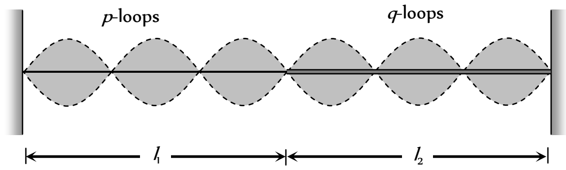


Fig. 17.27

As the frequency of the wave in both strings must be same so

$$\frac{p}{2l_1}\sqrt{\frac{T}{m_1}}=\frac{q}{2l_2}\sqrt{\frac{T}{m_2}} \Rightarrow \frac{p}{q}=\frac{l_1}{l_2}\sqrt{\frac{m_1}{m_2}}=\frac{l_1}{l_2}\sqrt{\frac{\rho_1}{\rho_2}}$$

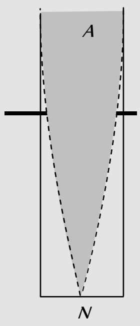
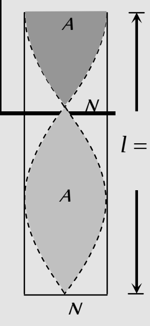
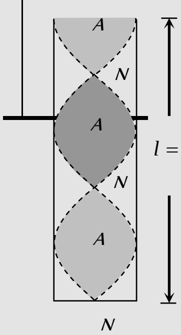
Standing Wave in a Organ Pipe

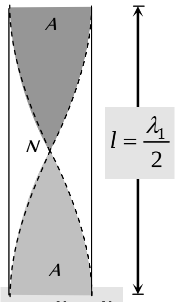
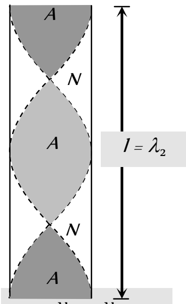
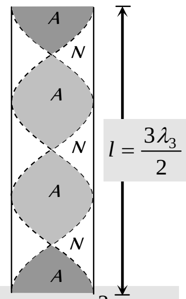
Organ pipes are the musical instrument which are used for producing musical sound by blowing air into the pipe. Longitudinal stationary waves are formed on account of superimposition of incident and reflected longitudinal waves.

Equation of standing wave y = $2a\cos\frac{2\pi vt}{\lambda}\sin\frac{2\pi x}{\lambda}$

Frequency of vibration $n=\frac{v}{\lambda}$

Table 17.6 : Different mode of vibration in organ pipe

Closed organ pipe		
Fundamental mode	Third harmonic First over tone	Fifth harmonic Second over tone
 $l=\frac{\lambda_1}{2}$	 $l=\frac{3\lambda_2}{4}$	 $l=\frac{5\lambda_3}{4}$

$n_1 = \frac{v}{4l}$	$n_2 = \frac{v}{\lambda_2} = \frac{3v}{4l} = 3n_1$	$n_3 = \frac{5v}{4l} = 5n_1$
Open organ pipe		
Fundamental mode	**Second harmonic**	**Third harmonic**
 $l = \frac{\lambda_1}{2}$	 $l = \lambda_2$	 $l = \frac{3\lambda_3}{2}$
$n_1 = \frac{v}{\lambda_1} = \frac{v}{2l}$	$n_2 = \frac{v}{\lambda_2} = \frac{v}{L} = 2n_1$	$n_3 = \frac{v}{\lambda_3} = \frac{3v}{2l} = 3n_1$

(1) **Closed organ pipe**

(i) In closed organ pipe only odd harmonic are present. Ratio of harmonic is $n_1 : n_2 : n_3$ ....= 1 : 3 : 5 ....

(ii) p^{th} overtone = $(2p + 1)^{th}$ harmonics

(iii) Ratio of overtones = 3 : 5 : 7 ....

(iv) The maximum possible wavelength is $4l$

(v) General formula for wavelength is $\lambda = \frac{4l}{(2N-1)}$; where N = 1, 2, 3, ... corresponds to order of mode of vibration.

(vi) General formula for frequency $n = \frac{(2N-1)v}{4l}$

(vii) Position of nodes from closed end $x = 0, \frac{\lambda}{2}, \lambda, \frac{3\lambda}{2}$.....

(viii) Position of antinodes from closed end $x = \frac{\lambda}{4}, \frac{3\lambda}{4}, \frac{5\lambda}{4}$...

(2) **Open organ pipe**

(i) In open organ pipe all (even and odd) harmonic are present. Ratio of harmonic is $n_1 : n_2 : n_3$ ....= 1 : 2 : 3 ....

(ii) p^{th} overtone = $(p + 1)^{th}$ harmonics

(iii) Ratio of overtones = 2 : 3 : 5 ....

(iv) The maximum possible wavelength is $2l$

(v) General formula for wavelength is $\lambda = \frac{2l}{N}$; where N = 1, 2, 3, ... corresponds to order of mode of vibration.

(vi) General formula for frequency $n = \frac{Nv}{2l}$

(vii) Position of nodes from one end $x = \frac{\lambda}{4}, \frac{3\lambda}{4}, \frac{5\lambda}{4}$.....

(viii) Position of antinodes from one end $x = 0, \frac{\lambda}{2}, \lambda, \frac{3\lambda}{2}$.....

Tuning Fork

(1) The tuning fork is a metallic device that produces sound of a single frequency.

(2) A tuning fork is really a transversely vibrating rod of rectangular cross-section bent into the shape of U as shown.

(3) The prongs execute transverse vibrations and the stem executes the longitudinal vibration. Both vibrate with the same frequency.

(4) The phase difference between the vibrations produced by both prongs of tuning fork is zero.

Fig. 17.28

(5) Tuning forks are generally taken as the standards of frequency of pure notes.

The frequency of the tuning fork is given by $n \propto \frac{t}{l^2} \cdot \sqrt{\frac{Y}{\rho}}$

where t = Thickness of the prongs, l = Length of the prongs, Y = Young's modulus of elasticity and ρ = Density of the material of tuning fork.

(6) If one prong is broken tuning fork does not vibrate.

Effect on frequency of tuning fork

(i) A fork of shorter prongs gives high frequency tone

(ii) The frequency of a tuning fork decreases when it's prongs are loaded (say with wax) near the end.

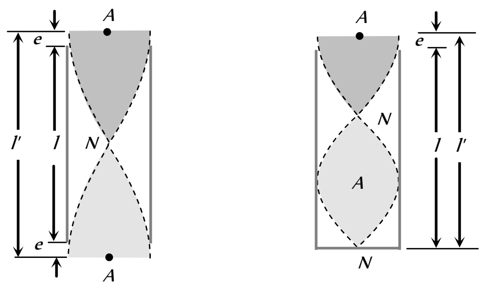
(iii) The frequency of tuning fork increases when prongs are filed near the ends.

(iv) The frequency of a tuning fork decreases if temperature of the fork is increases.

End Correction

Due to finite momentum of air molecules in organ pipe reflection takes place not exactly at open end but some what above it. Hence antinode is not formed exactly at the open end rater it is formed at a little distance away from open end outside it.

The distance of antinode from the open end is known as end correction (e). It is given by e = 0.6 r where r = radius of pipe.



(A) Open pipe (B) Closed pipe

Fig. 17.29

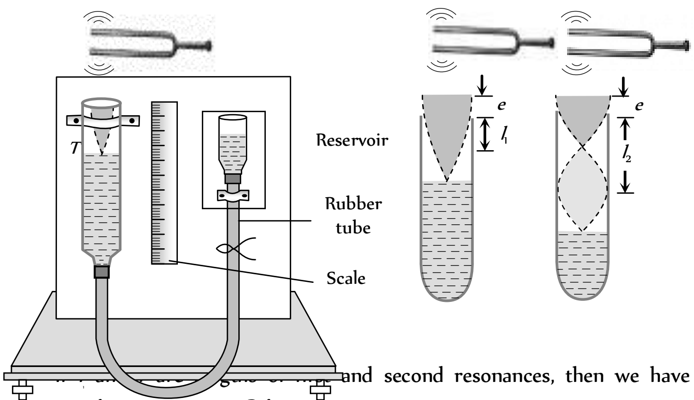
Effect length in open organ pipe l' = $(l + 2e)$

Effect length in closed organ pipe $l = (l + e)$

Resonance Tube

It is used to determine velocity of sound in air by the help of a tuning fork of known frequency.

It is a closed organ pipe having an air column of variable length. When a tuning fork is brought over it's mouth. It's air column vibrates with the frequency of the fork. If the length of the air column is varied until it's natural frequency equals the frequency of the fork, then the column resonants and emits a loud note.



... and second resonances, then we have $l_1 + e = \frac{\lambda}{4}$ and $l_2 + e = \frac{3\lambda}{4}$

Fig. 17.30

$$\Rightarrow l_2 - l_1 = \frac{\lambda}{2} \Rightarrow \lambda = 2(l_2 - l_1)$$

Speed of sound in air at room (temperature) $v = n\lambda = 2n(l_2 - l_1)$

Also $\frac{l_2 + e}{l_1 + e} = 3 \Rightarrow l_2 = 3l_1 + 2e$ *i.e.* second resonance is obtained at length more than thrice the length of first resonance.

Kundt's Tube

The apparatus consists of a long glass tube about 5 *cm* in diameter, fixed horizontally. A metal rod R clamped firmly at the centre is mounted so that its one end carrying a light disc P_1 (of cork or card board) projects some distance into the glass tube. The other end of the glass tube is closed with a moveable piston P_2. Any desired length of the air or gas can be enclosed in between the two discs P_1 and P_2. A small amount of dry lycopodium powder or cork dust is spread along base of the entire length of the tube.

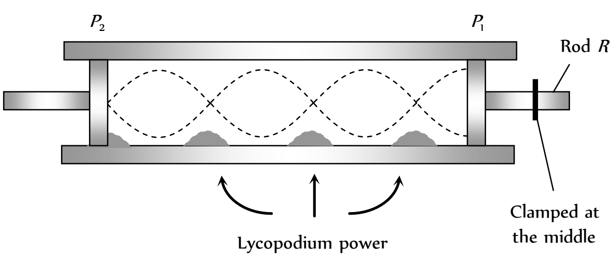


Fig. 17.31

The free end of the metal rod R is rubbed (stroked) along the length with resined cloth. The rod begins to vibrate longitudinally and emits a very high pitched shrill note. These vibrations are impressed upon the air column in the tube through disc P_1. Let disc P_2 is so adjusted, that the stationary waves are formed in the air (gas) column in the tube. At antinodes powder is set into oscillations vigorously while it remains uneffected at nodes. Heaps of power are formed at nodes.

Let n is the frequency of vibration of the rod then, this is also the frequency of sound wave in the air column in the tube.

For rod : $\frac{\lambda_{rod}}{2} = l_{rod}$,   For air : $\frac{\lambda_{air}}{2} = l_{air}$

where l_{air} is the distance between two heaps of power in the tube (*i.e.* distance between two nodes). If v_{air} and v_{rod} are velocity of sound waves in the air and rod respectively, then

$$n = \frac{v_{air}}{\lambda_{air}} = \frac{v_{rod}}{\lambda_{rod}}. \text{ Therefore } \frac{v_{air}}{v_{rod}} = \frac{\lambda_{air}}{\lambda_{rod}} = \frac{\lambda_{air}}{\lambda_{rod}}$$

Thus knowledge of v_{rod}, determiens v_{air}

Kundt's tube may be used for

(i) Comparison of velocities of sound in different gases.

(ii) Comparison of velocities of sound in different solids

(iii) Comparison of velocities of sound in a solid and in a gas.

(iv) Comparison of density of two gases.

(v) Determination of γ of a gas.

(vi) Determination of velocity of sound in a liquid.

Beats

When two sound waves of slightly different frequencies, travelling in a medium along the same direction, superimpose on each other, the intensity of the resultant sound at a particular position rises and falls regularly with time. This phenomenon of regular variation in intensity of sound with time at a particular position is called beats.

(1) **Persistence of hearing :** The impression of sound heard by our ears persist in our mind for 1/10th of a second. If another sound is heard before 1/10 second is over, the impression of the two sound mix up and our mind cannot distinguish between the two.

So for the formation of distinct beats, frequencies of two sources of sound should be nearly equal (difference of frequencies less than 10)

(2) **Equation of beats :** If two waves of equal amplitudes '*a*' and slightly different frequencies n_1 and n_2 travelling in a medium in the same direction are.

$y_1 = a \sin \omega_1 t = a \sin 2\pi n_1 t$; $y_2 = a \sin \omega_2 t = a \sin 2\pi n_2 t$

By the principle of super position : $\vec{y} = \vec{y_1} + \vec{y_2}$

$y = A \sin \pi(n_1 + n_2)t$ where $A = 2a \cos \pi (n_1 - n_2)t$ = Amplitude of resultant wave.

(3) **One beat :** If the intensity of sound is maximum at time $t = 0$, one beat is said to be formed when intensity becomes maximum again after becoming minimum once in between.

(4) **Beat period :** The time interval between two successive beats (*i.e.* two successive maxima of sound) is called beat period.

$$n = n_1 \sim n_2$$

(5) **Beat frequency :** The number of beats produced per second is called beat frequency.

$$T = \frac{1}{\text{Beat frequency}} = \frac{1}{n_1 \sim n_2}$$

Determination of Unknown Frequency

Suppose a tuning fork of known frequency (n) is sounded together with another tuning fork of unknown frequency (n) and x beats heard per second.

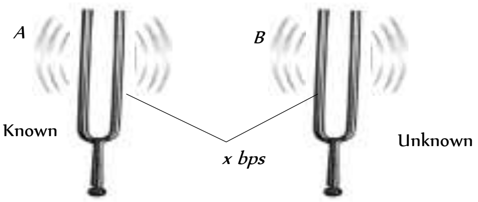


Fig. 17.32

There are two possibilities of known frequency of unknown tuning fork.

$$n_A - n_B = x \quad \text{... (i)}$$

or

$$n_B - n_A = x \quad \text{... (ii)}$$

To find the frequency of unknown tuning fork (n) following steps are taken.

(1) Loading or filing of one prong of known or unknown (by wax) tuning fork, so frequency changes (decreases after loading, increases after filing).

(2) Sound them together again, and count the number of heard beats per sec again, let it be x'. These are following four condition arises.

(i) $x' > x$ (ii) $x' < x$ (iii) $x' = 0$ (iv) $x' = x$

(3) With the above information, the exact frequency of the unknown tuning fork can be determined as illustrated below.

Suppose two tuning forks A (frequency n_A is known) and B (frequency n_B is unknown) are sounded together and gives x *beats/sec*. If one prong of unknown tuning fork B is loaded with a little wax (so n_B decreases) and it is sounded again together with known tuning fork A, then in the following four given condition n_B can be determined.

(4) If $x' > x$ than x, then this would happen only when the new frequency of B is more away from n_A. This would happen if originally (before loading), n_B was less than n_A.

Thus initially $n_B = n_A - x$.

(5) If $x' < x$ than x, then this would happen only when the new frequency of B is more nearer to n_A. This would happen if originally (before loading), n_B was more than n_A.

Thus initially $n_B = n_A + x$.

(6) If $x' = x$ then this would means that the new frequency (after loading) differs from n_A by the same amount as was the old frequency (before loading). This means initially $n_B = n_A + x$

(and now it has decreased to $n'_B = n_A - x$)

(7) If $x' = 0$, then this would happen only when the new frequency of B becomes equal to n_A. This would happen if originally n_B was more than n_A.

Thus initially $n_B = n_A + x$.

Table 17.7 ; Frequency of unknown tuning fork for various cases

By loading	
If B is loaded with wax so its frequency decreases	If A is loaded with wax its frequency decreases
If x increases $n_B = n_A - x$	If x increases $n_B = n_A + x$
If x decrease $n_B = n_A + x$	If x decrease $n_B = n_A - x$
If remains same $n_B = n_A + x$	If remains same $n_B = n_A - x$
If x becomes zero $n_B = n_A + x$	If x becomes zero $n_B = n_A - x$
By filing	
If B is filed, its frequency increases	**If A is filed, its frequency increases**
If x increases $n_B = n_A + x$	If x increases $n_B = n_A - x$
If x decrease $n_B = n_A - x$	If x decrease $n_B = n_A + x$
If remains same $n_B = n_A - x$	If remains same $n_B = n_A + x$
If x becomes zero $n_B = n_A - x$	If x becomes zero $n_B = n_A + x$

Doppler's Effect

Whenever there is a relative motion between a source of sound and the observer (listener), the frequency of sound heard by the observer is different from the actual frequency of sound emitted by the source.

The frequency observed by the observer is called the apparent frequency. It may be less than or greater than the actual frequency emitted by the sound source. The difference depends on the relative motion between the source and observer.

(1) **When observer and source are stationary**

(i) Sound waves propagate in the form of spherical wavefronts (shown as circles)

(ii) The distance between two successive circles is equal to wavelength λ.

(iii) Number of waves crossing the observer = Number of waves emitted by the source

(iv) Thus apparent frequency (n') = actual frequency (n).

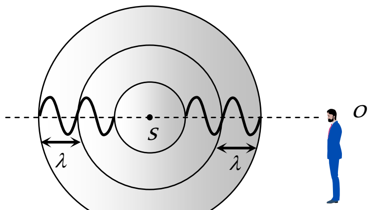


Fig. 17.33

(2) **When source is moving but observer is at rest**

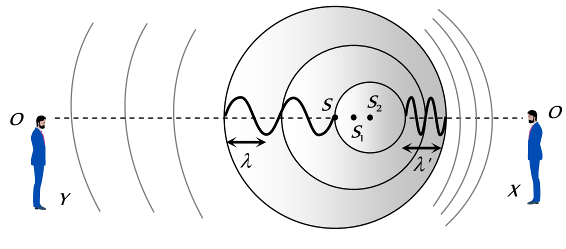


Fig. 17.34

(i) S_1, S_2, S_3 are the positions of the source at three different positions.

(ii) Waves are represented by non-concentric circles, they appear compressed in the forward direction and spread out in backward direction.

(iii) For observer (X)

Apparent wavelength $\lambda' <$ Actual wavelength λ

$\Rightarrow$ Apparent frequency n' > Actual frequency n

For observer (Y) : $\lambda' > \lambda \Rightarrow n' < n$

(3) **When source is stationary but observer is moving**

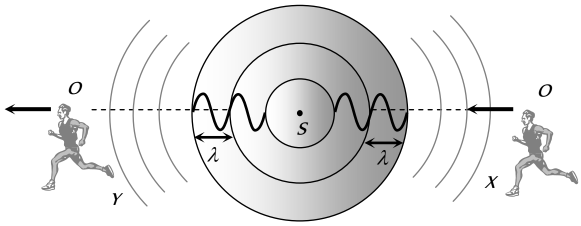


Fig. 17.35

(i) Waves are again represented by concentric circles.

(ii) No change in wavelength received by either observer X or Y.

(iii) Observer X (moving towards) receives wave fronts at shorter interval thus $n' > n$.

(iv) Observer Y receives wavelengths at longer interval thus $n' < n$.

(4) **General expression for apparent frequency** : Suppose observed (O) and source (S) are moving in the same direction along a line with velocities v_O and v_S respectively. Velocity of sound is v and velocity of medium is v_m then apparent frequency observed by observer is given by $n' = \left[\frac{(v+v_m)-v_0}{(v+v_m)-v_S}\right]n$

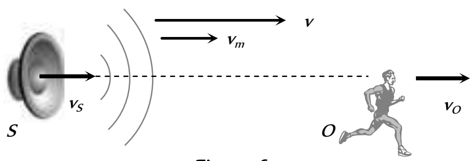


Fig. 17.36

If medium is stationary *i.e.* $v_m = 0$ then $n' = n\left(\frac{v-v_O}{v-v_S}\right)$

Sign convection for different situation

(i) The direction of v is always taken from source to observer.

(ii) All the velocities in the direction of v are taken positive.

(iii) All the velocities in the opposite direction of v are taken negative.

Common Cases in Doppler's Effect

***Case 1* : Source is moving but observer at rest.**

(1) Source is moving towards the observer

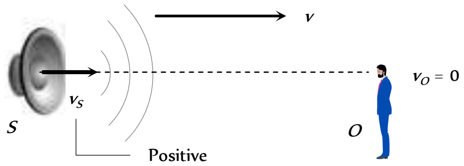


Fig. 17.37

Apparent frequency $n' = n\left[\frac{v-0}{v-(+v_S)}\right] = n\left(\frac{v}{v-v_S}\right)$

Apparent wavelength $\lambda' = \lambda\left(\frac{v-v_S}{v}\right)$

(2) Source is moving away from the observer.

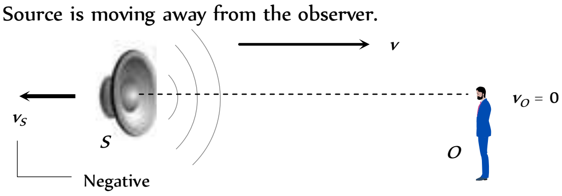


Fig. 17.38

Apparent frequency $n' = n\left[\frac{v-0}{v-(-v_S)}\right] = n\left(\frac{v}{v+v_S}\right)$

Apparent wavelength $\lambda' = \lambda\left(\frac{v+v_S}{v}\right)$

***Case* 2: Source is at rest but observer is moving.**

(1) Observer is moving towards the source.

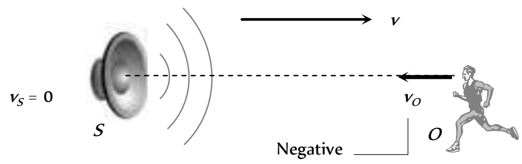


Fig. 17.39

Apparent frequency $n' = n\left[\frac{v-(-v_O)}{v-0}\right] = n\left[\frac{v+v_O}{v}\right]$

Apparent wavelength $\lambda' = \frac{(v+v_O)}{n'} = \frac{(v+v_O)}{n\frac{(v+v_O)}{v}} = \frac{v}{n} = \lambda$

(2) Observer is moving away from the source

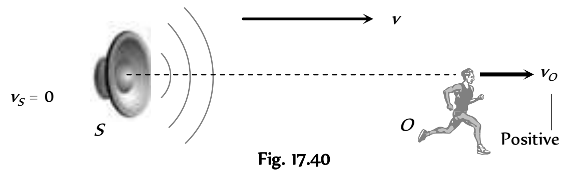


Fig. 17.40

Apparent frequency $n' = n\left[\frac{v-(+v_O)}{v-0}\right] = n\left[\frac{v-v_O}{v}\right]$

Apparent wavelength $\lambda' = \lambda$

***Case* 3: When source and observer both are moving**

(1) When both are moving towards each other

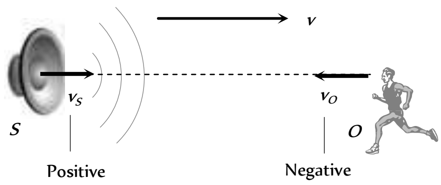


Fig. 17.41

(i) Apparent frequency $n' = n\left[\frac{v-(-v_O)}{v-(+v_S)}\right] = n\left[\frac{v+v_O}{v-v_S}\right]$

(ii) Apparent wavelength $\lambda' = \lambda\left(\frac{v-v_S}{v}\right)$

(iii) Velocity of wave with respect to observer $= (v+v_O)$

(2) When both are moving away from each other.

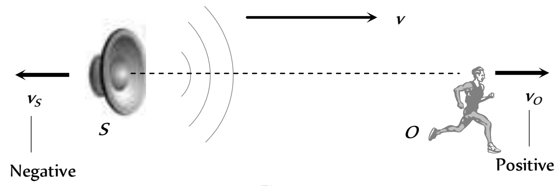


Fig. 17.42

(i) Apparent frequency $n' = n\left[\frac{v-(+v_O)}{v-(-v_S)}\right] = n\left[\frac{v-v_O}{v+v_S}\right]$

($n' < n$)

(ii) Apparent wavelength $\lambda' = \lambda\left(\frac{v+v_S}{v}\right)$

($\lambda' > \lambda$)

Velocity of waves with respect to observer = ($v - v$)

(3) When source is moving behind observer

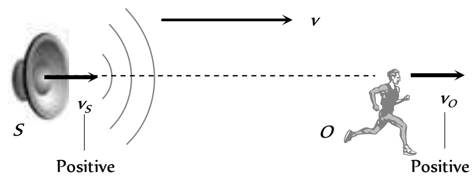


Fig. 17.43

(i) Apparent frequency $n' = n\left(\frac{v-v_O}{v-v_S}\right)$

(a) If $v_O < v_S$, then $n' > n$

(b) If $v_O > v_S$ then $n' < n$

(c) If $v_O = v_S$ then $n' = n$

(ii) Apparent wavelength $\lambda' = \lambda\left(\frac{v-v_S}{v}\right)$

(iii) Velocity of waves with respect to observer = $(v - v_O)$

(4) When observer is moving behind the source

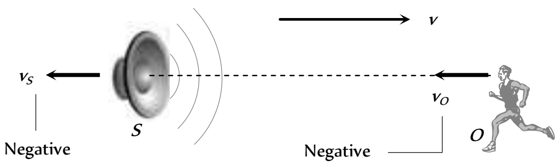


Fig. 17.44

(i) Apparent frequency $n' = n\left(\frac{v-(-v_O)}{v-(-v_S)}\right)$

(a) If $v_O > v_S$, then $n' > n$

(b) If $v_O < v_S$ then $n' < n$

(c) If $v_O = v_S$ then $n' = n$

(ii) Apparent wavelength $\lambda' = \lambda\left(\frac{v+v_S}{v}\right)$

(iii) The velocity of waves with respect to observer = $(v + v_O)$

***Case* 4: Crossing**

(1) Moving sound source crosses a stationary observer

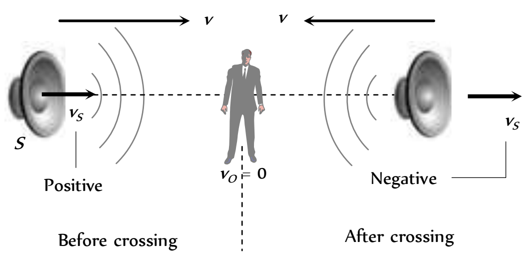


Fig. 17.45

Apparent frequency before crossing

$$n'_{Before} = n\left[\frac{v-0}{v-(+v_S)}\right] = n\left[\frac{v}{v-v_S}\right]$$

Apparent frequency

$$n'_{After} = n\left[\frac{v-0}{v-(-v_S)}\right] = n\left[\frac{v}{v+v_S}\right]$$

Ratio of two frequency $\frac{n'_{Before}}{n'_{After}} = \left[\frac{v+v_S}{v-v_S}\right] > 1$

Change in apparent frequency $n'_{Before} - n'_{After} = \frac{2nv_S v}{(v^2 - v_S^2)}$

If $v_S << v$ then $n'_{Before} - n'_{After} = \frac{2nv_S}{v}$

(2) **Moving observer crosses a stationary source**

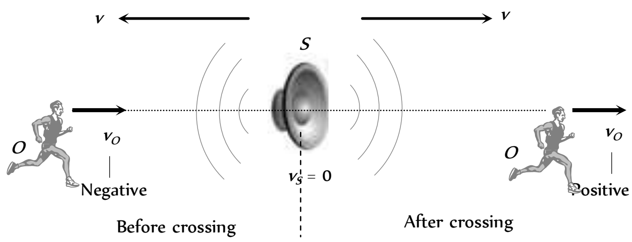


Fig. 17.46

Apparent frequency before crossing

$$n'_{Before} = n\left[\frac{v-(-v_O)}{v-0}\right] = n\left[\frac{v+v_O}{v}\right]$$

Apparent frequency

$$n'_{After} = n\left[\frac{v-(+v_O)}{v-0}\right] = n\left[\frac{v-v_O}{v}\right]$$

Ratio of two frequency $\frac{n'_{Before}}{n'_{After}} = \left[\frac{v+v_S}{v-v_S}\right]$

Change in apparent frequency $n'_{Before} - n'_{After} = \frac{2nv_O}{v}$

***Case* 5:** Both moves in the same direction with same velocity $n' = n$, *i.e.* there will be no Doppler effect because relative motion between source and listener is zero.

***Case* 6:** Source and listener moves at right angle to the direction of wave propagation. $n' = n$

It means there is no change in frequency of sound heard if there is a small displacement of source and listener at right angle to the direction of wave propagation but for a large displacement the frequency decreases because the distance between source of sound and listener increases.

Some Typical Cases of Doppler's Effect

(1) **Moving car towards wall :** When a car is moving towards a stationary wall as shown in figure. If the car sounds a horn, wave travels toward the wall and is reflected from the wall. When the reflected wave is

heard by the driver, it appears to be of relatively high pitch. If we wish to measure the frequency of reflected sound then the problem.

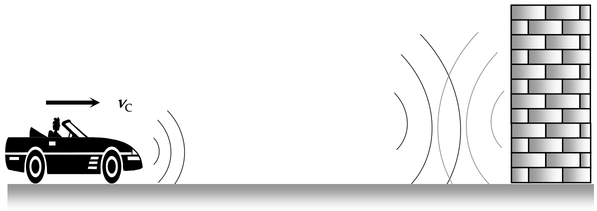


Fig. 17.47

Can be solved in a different manner by using method of sound images. In this procedure we assume the image of the sound source behind the reflector.

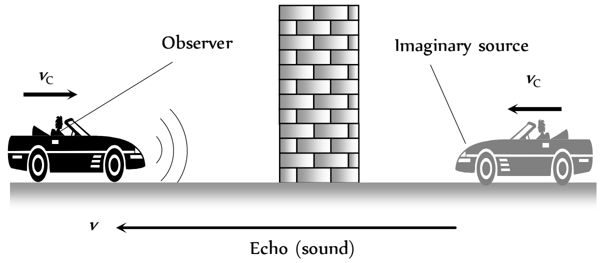


Fig. 17.48

Here we assume that the sound which is reflected by the stationary wall is coming from the image of car which is at the back of it and coming toward it with velocity v_c. Now the frequency of sound heard by car driver can directly be given as

$$n' = n\left[\frac{v-(-v_C)}{v-(+v_C)}\right] = n\left[\frac{v+v_C}{v-v_C}\right]$$

This method of images for solving problems of Doppler effect is very convenient but is used only for velocities of source and observer which are very small compared to the speed of sound and it should not be used frequently when the reflector of sound is moving.

(2) **Moving target :** Let a sound source S and observer O are at rest (stationary). The frequency of sound emitted by the source is n and velocity of waves is v.

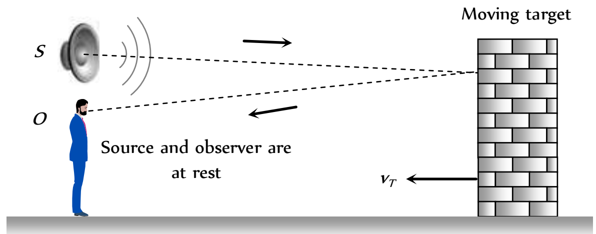


Fig. 17.49

A target is moving towards the source and observer, with a velocity v_t. Our aim is to find out the frequency observed by the observer, for the waves reaching it after reflection from the moving target. The formula is derived by applying Doppler equations twice, first with the target as observer and then with the target as source.

The frequency n' of the waves reaching surface of the moving target (treating it as observer) will be $n' = \left(\frac{v+v_T}{v}\right)n$

Now these waves are reflected by the moving target (which now acts as a source). Therefore the apparent frequency, for the real observer O will be $n'' = \frac{v}{v-v_T}n' \Rightarrow n'' = \frac{v+v_T}{v-v_T}n$

(i) If the target is moving away from the observer, then

$$n' = \frac{v-v_T}{v+v_T}n$$

(ii) If target velocity is much less than the speed of sound, $(v_T << v)$, then $n' = \left(1+\frac{2v_T}{v}\right)n$, for approaching target

and $n' = \left(1-\frac{2v_T}{v}\right)n$, for receding target

(3) **Transverse Doppler's effect**

(i) If a source is moving in a direction making an angle θ *w.r.t.* the observer

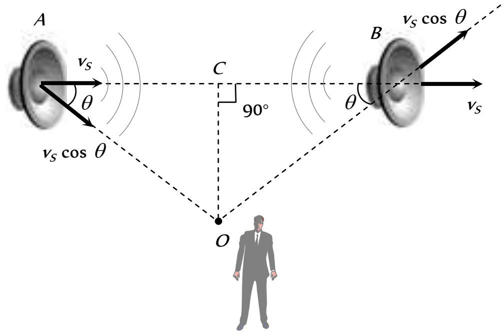


Fig. 17.50

The apparent frequency heard by observer O at rest

At point A : $n' = \frac{nv}{v - v_S\cos\theta}$

As source moves along AB, value of θ increases, $\cos\theta$ decreases, n' goes on decreasing.

At point C : $\theta = 90^o$, $\cos\theta = \cos 90^o = 0$, $n' = n$.

At point B : the apparent frequency of sound becomes

$$n'' = \frac{nv}{v + v_s\cos\theta}$$

(ii) When two cars are moving on perpendicular roads : When car-1 sounds a horn of frequency n, the apparent frequency of sound heard by car-2 can be given as $n' = n\left[\frac{v+v_2\cos\theta_2}{v-v_1\cos\theta_1}\right]$

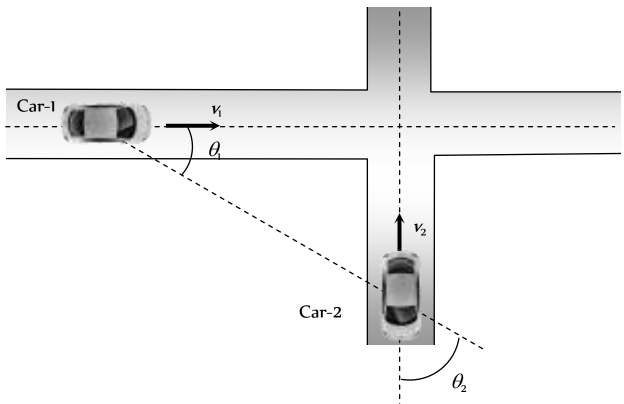


Fig. 17.51

(4) **Rotating source/observer :** Suppose that a source of sound/observer is rotating in a circle of radius r with angular velocity ω (Linear velocity $v_s = r\omega$)

(i) **When source is rotating**

(a) Towards the observer heard frequency will be maximum

i.e. $n_{max} = \frac{nv}{v - v_S}$

(b) Away from the observer heard frequency will be minimum

and $n_{min} = \frac{nv}{v + v_S}$

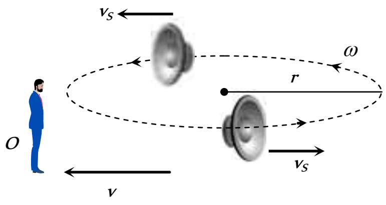


Fig. 17.52

(c) Ratio of maximum and minimum frequency

$$\frac{n_{max}}{n_{min}} = \frac{v + v_S}{v - v_S}$$

(ii) **When observer is rotating**

(a) Towards the source heard frequency will be maximum

i.e. $n_{max} = \frac{nv}{v - v_S}$

(b) Away from the source heard frequency will be minimum

and $n_{min} = \frac{nv}{v + v_S}$

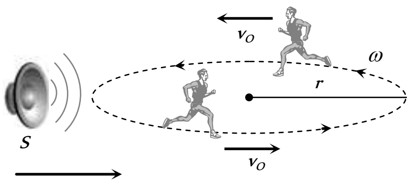


Fig. 17.53

(c) Ratio of maximum and minimum frequency

$$\frac{n_{max}}{n_{min}} = \frac{v + v_S}{v - v_S}$$

(iii) **Observer is situated at the centre of circle :** There will be no change in frequency of sound heard, if the source is situated at the centre of the circle along which listener is moving..

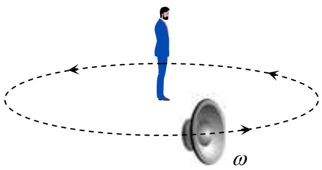


Fig. 17.54

(5) **SONAR :** Sonar means Sound Navigation and Ranging.

(i) Ultrasonic waves are used to detect the presence of big rocks, submarines *etc* in the sea.

(ii) The waves emitted by a source are reflected by the target and received back at the SONAR station.

(iii) If v is velocity of sound waves in water and v_{sub} is velocity of target (submarine), the apparent frequency of reflected waves will be $n' = \left(1 \pm \frac{2v_{sub}}{v}\right) n$

+ sign is for target approaching the receiver and – sign for target moving away.

Conditions for No Doppler's Effect

(1) When source (S) and listener (L) both are at rest.

(2) When medium alone is moving.

(3) When S and L move in such a way that distance between S and L remains constant.

(4) When source S and listener L, are moving in mutually perpendicular directions.

(5) If the velocity of source and listener is equal to or greater than the sound velocity then Doppler effect is not seen.

Musical Sound

other rapidly at regular interval of time without a sudden change in amplitude.

(1) **Noise :** A noise consists of a series of waves following each other at irregular intervals of time with sudden changes in amplitude.

(2) **Pitch :** The pitch of a sound is the characteristic which distinguishes between a shrill (or sharp) sound and a grave (or flat) sound.

(i) A sound of high pitch is said to be shrill and it's frequency is high.

(ii) A sound of low pitch is said to be grave and it's frequency is low.

(iii) The pitch of female voice is higher than the pitch of male voice.

(iv) The pitch of sound produced by roaring of lion is lower where as the pitch of sound produced by mosquito whisper is high.

(3) **Quality (or timbre) :** A musical instrument vibrates with many frequencies at the same time. The quality of any musical sound is determined by the number of overtones and their relative intensities.

(i) The quality of sound enables us to distinguish between two sounds having same intensity and pitch.

(ii) The sounds of different instruments (such as Tabla and Mridang) are said to differ in quality.

(iii) Due to quality of sound one can recognise the voice of his friend without seeing him.

(4) **Loudness :** Characteristic of sound, on account of which the sound appears to be intense or slow.

(i) The loudness that we sense is related to the intensity of sound though it is not directly proportional

(ii) The loudness depends on intensity as well as upon the sensitiveness of ear.

(iii) Our perception of loudness is better co–related with the sound level measured in decible (dB) and defined as follows $\beta = 10 \log_{10}\left(\frac{I}{I_0}\right)$;

where I_0 = The minimum intensity that can be heard called threshold of hearing = 10^{-12} W/m^2 at 1 KHz.

(iv) At the threshold of hearing β = 0. At the threshold of pain $\beta = 10 \log_{10} \frac{1}{10^{-2}} = 120\, dB$.

(v) When the intensity doubles, the intensity level changes by 3 dB.

(vi) When the intensity increases 10 times the level increases by 10 dB.

Table 17.8 ; Different sound intensity level

Source of sound	dB

Rustling leaves	10
Whisper	20
Quiet room	30
Normal level of speech (inside)	30
Street traffic (inside car)	65
Riveting tool	80
Thunder	100
Indoor rock concert	120

Interval : The ratio of the frequencies of the two notes is called the interval between them *e.g.* interval between two notes of frequencies 256 *Hz* and 512 *Hz* is 1 : 2.

Table 17.9 ; Different interval

Name of interval	Frequency ratio
Unison	1 : 1
Octave	2 : 1
Major tone	9 : 8
Minor tone	10 : 9
Semi tone	16 : 15

Musical scale : It consists of a series of notes of successively increasing frequency, having constant intervals. The note of the lowest frequency is called the key note.

These are many kinds of musical scales. The most commonly used scale is called major diatonic scale. It is formed by introducing six more notes between a given note and it's octave, so that these are eight notes in all.

Table 17.10 : Major diatonic scale

Symbol	Indian name	Western name	Frequency in the base of 256 *Hz*	Interval between successive notes
C	*SA*	*DO*	256	9/8
D	*RE*	*RE*	288	10/9
E	*GA*	*MI*	320	16/15
F	MA	*FA*	341	9/8
G	PA	SOL	384	10/9
A	*DHA*	*LA*	427	9/8
B	Ni	*SI*	480	16/15
C_1	*SA*	*DO*	512	

Accoustics of Buildings

Accounstics is the branch of physics that deals with the generation, propagation and reception of sound.

W.C. Sabine was the first to carry out the scientific study of architectural acoustics by laying down following rules.

The sound must be loud enough.

The quality of sound must be unaltered.

The successive sounds of speech or music must remain distinct.

These should not be unnecessary interference or resonance of sound in the auditorium.

These should be no echoes in the auditorium.

(1) **Reverberation :** Phenomenon of persistence or prolongation of sound in the auditorium is called reverberation.

(2) **Reverberation time :** The time gap between the initial direct note and the reflected note upto the minimum audibility level is called reverberation time.

(3) **Sabine law :** Sabine derived an expression of the reverberation time which is $t = K.\frac{V}{\alpha S}$; where *K* is constant, *V* = Volume of the hall, *S* = Surface area exposed to the sound α =Co-efficient of absorption.

(4) **Controlling the reverberation time :** It may be controlled as follows :

By hanging heavy curtains on the doors.

By having few open windows in the hall.

By having large audience.

By using absorbing materials in the walls and roofs of the hall.

Tips & Tricks

✍ In an open pipe all harmonics are present whereas in a closed organ pipe, only alternate harmonics of frequencies $n_1, 3n_1, 5n_1,.....$ *etc.* are present.

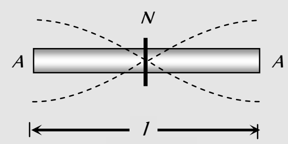
The harmonics of frequencies $2n_1, 4n_1, 6n_1....$ are missing. Hence musical sound produces by an open organ pipe is sweeter than that produced by a closed organ pipe.

✍ If an open pipe is half submerged in water, it will become a closed organ pipe of length half that of a open pipe. It's fundamental frequency will become $n' = \frac{v}{4\left(\frac{l}{2}\right)} = \frac{v}{2l} = n_1$ *i.e.,* equal to that of open pipe.

i.e., frequency remains unchanged.

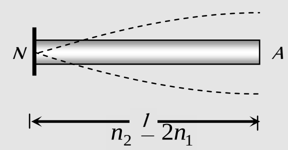
✍ **Vibrating clamped rod :** Frequency of vibration of clamped rod are same as that of organ pipes

Middle clamping : Similar to open organ pipe



$n_1 = \frac{v}{2l}$ $n_2 = 2n_1$ $n_3 = 3n_1$

End clamping : Similar to closed organ pipe



$n_1 = \frac{v}{4l}$ $n_2 = 2n_1$ $n_3 = 3n_1$

✍ Sound produced in air is not heard by the diver deep inside the water because most of the sound is reflected from the surface of water in comparison to the refraction.

✍ If the difference between the apparent frequency of a source of sound as perceived by an observer during it's approach and recession is x% of the natural frequency of source then speed of $v_s = \frac{v_{\text{sound}}}{200} x$ $(v^2 >> v_s^2)$

✍ In a Tabla, the membrane is loaded about the centre why? a note is musical when it is rich in harmonics and not partial overtones. Ordinarily a stretched membrane vibrates with such overtones. But when the stretched membrane is loaded at the centre, its overtones become nearly harmonics, so it's sound becomes fairly musical.

✍ All harmonics are overtones but all overtones are not harmonics.

✍ Stethoscope work on the principle of reflection of sound.

✍ Ultrasonic waves can be produced by utilizing piezoelectric effect.

✍ There is no atmosphere on moon, therefore propagation of sound is not possible there. To do conversation on moon, the astronaut uses an instrument which can transmit and detect electromagnetic waves.

✍ Doppler effect gives information regarding the change in frequency only. It does not says about intensity of sound.

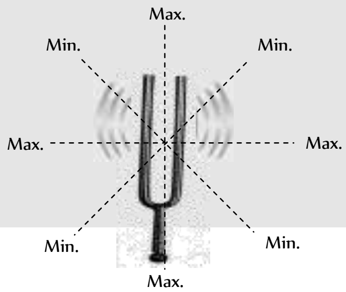
✍ Doppler effect in sound is asymmetric but in light it is symmetric.

✍ If three tuning forks of frequencies n, $n + x$ and $n + 2x$ are sounded together to produce waves of equal amplitude these three wave produces beats with beat frequency = x *beats/sec*

✍ If N tuning forks are so arranged that every fork gives x *beats per sec* with the next then the frequency of last fork will be

$$n_{Last} = n_{First} + (N-1)\,x$$

✍ If a vibrating tuning fork is rotated about it's stem, maximum and minimum number of beats heard by an observer in one revolution of tuning fork are 4.



✍ The tuning of radio receiving set to a particular station is based on forced vibration.

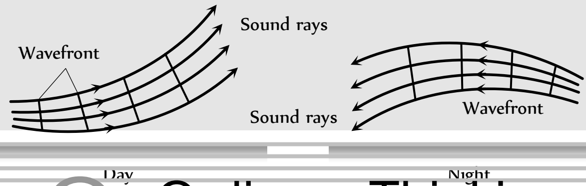
✍ Two avoid resonant vibration of the bridge, soldiers are orderd to break steps while crossing a bridge.

✍ **Confusion :** So many students often confuse whether the equation of a plan progressive wave should be

$y = a \sin(\omega t - kx)$ or $y = a \sin(kx - \omega t)$

Both the equations represent a travelling wave but these two are not same. These waves are differ by a phae difference of π.

✍ **Audibility of sound in day/night :** During the day temperature of air is maximum and it dimnished upwards. Therefore velocity of sound is also decreases upwards ($v \propto \sqrt{T}$). The plane wavefronts, initially vertical are turned, upwards so sound rays curl up during the day. At night the conditions are reversed hence audibility of sound is better in night as compare to day.



OT Ordinary Thinking

Objective Questions

Basics of Mechanical Waves

1. Which of the following statements is wrong [NCERT 1976, 79]
   (a) Sound travels in straight line
   (b) Sound is a form of energy
   (c) Sound travels in the form of waves
   (d) Sound travels faster in vacuum than in air

2. The relation between frequency 'n' wavelength 'λ' and velocity of propagation 'v' of wave is [EAMCET 1979; CPMT 1976, 85]
   (a) $n = v\lambda$ (b) $n = \lambda / v$
   (c) $n = v / \lambda$ (d) $n = 1 / v$

3. Ultrasonic, Infrasonic and audible waves travel through a medium with speeds V_u, V_i and V_a respectively, then

[CPMT 1989]

(a) V_u, V_i and V_a are nearly equal

(b) $V_u \geq V_a \geq V_i$

(c) $V_u \leq V_a \leq V_i$

(d) $V_a \leq V_u$ and $V_u \approx V_i$

4. The distance between two consecutive crests in a wave train produced in a string is 5 *cm*. If 2 complete waves pass through any point per second, the velocity of the wave is

[CPMT 1990]

(a) 10 *cm/sec* (b) 2.5 *cm/sec*

(c) 5 *cm/sec* (d) 15 *cm/sec*

5. A tuning fork makes 256 vibrations per second in air. When the velocity of sound is 330 *m/s*, then wavelength of the tone emitted is

MH CET 1999; CBSE PMT 1999]

(a) 0.56 *m* (b) 0.89 *m*

(c) 1.11 *m* (d) 1.29 *m*

6. A man sets his watch by a whistle that is 2 *km* away. How much will his watch be in error. (speed of sound in air 330 *m/sec*)

(a) 3 seconds fast (b) 3 seconds slow

(c) 6 seconds fast (d) 6 seconds slow

7. When a sound wave of frequency 300 *Hz* passes through a medium the maximum displacement of a particle of the medium is 0.1 *cm*. The maximum velocity of the particle is equal to [MNR 1992; UPSEAT 1998, 2000;

RPMT 2002; Pb. PET 2004]

(a) 60 π *cm/sec* (b) 30 π *cm/sec*

(c) 30 *cm/sec* (d) 60 *cm/sec*

8. Sound waves have the following frequencies that are audible to human beings [CPMT 1975]

(a) 5 *c/s* (b) 27000 *c/s*

(c) 5000 *c/s* (d) 50,000 *c/s*

9. Velocity of sound waves in air is 330 *m/sec*. For a particular sound in air, a path difference of 40 *cm* is equivalent to a phase difference of 1.6 π. The frequency of this wave is

[CBSE PMT 1990]

(a) 165 *Hz* (b) 150 *Hz*

(c) 660 *Hz* (d) 330 *Hz*

10. The wavelength of ultrasonic waves in air is of the order of

[EAMCET 1989]

(a) 5×10^{-5} *cm* (b) 5×10^{-8} *cm*

(c) 5×10^{5} *cm* (d) 5×10^{8} *cm*

11. The relation between phase difference ($\Delta\phi$) and path difference (Δx) is [MNR 1995; UPSEAT 1999, 2000]

(a) $\Delta\phi = \frac{2\pi}{\lambda}\Delta x$ (b) $\Delta\phi = 2\pi\lambda\Delta x$

(c) $\Delta\phi = \frac{2\pi\lambda}{\Delta x}$ (d) $\Delta\phi = \frac{2\Delta x}{\lambda}$

12. A hospital uses an ultrasonic scanner to locate tumours in a tissue. The operating frequency of the scanner is 4.2 *MHz*. The speed of sound in a tissue is 1.7 *km-s*. The wavelength of sound in the tissue is close to

[CBSE PMT 1995]

(a) $4 \times 10^{-4}\ m$ (b) $8 \times 10^{-3}\ m$

(c) $4 \times 10^{-3}\ m$ (d) $8 \times 10^{-4}\ m$

13. The minimum audible wavelength at room temperature is about

(a) 0.2 $\mathring{A}$ (b) 5 $\mathring{A}$

(c) 5 *cm* to 2 *metre* (d) 20 *mm*

14. The ratio of the speed of sound in nitrogen gas to that in helium gas, at 300 *K* is [IIT 1999]

(a) $\sqrt{2/7}$ (b) $\sqrt{1/7}$

(c) $\sqrt{3}/5$ (d) $\sqrt{6}/5$

15. In a sinusoidal wave, the time required for a particular point to move from maximum displacement to zero displacement is 0.170 second. The frequency of the wave is [KCET 1994; AFMC 1998;

[CBSE PMT 1998; AIIMS 2001;

AFMC 2002; CPMT 2004]

(a) 1.47 *Hz* (b) 0.36 *Hz*

(c) 0.73 *Hz* (d) 2.94 *Hz*

[MP PET 1991]

16. The number of waves contained in unit length of the medium is called [AIIMS 1998]

(a) Elastic wave (b) Wave number

(c) Wave pulse (d) Electromagnetic wave

17. The frequency of a rod is 200 *Hz*. If the velocity of sound in air is $340\, ms^{-1}$, the wavelength of the sound produced is

[EAMCET (Med.) 1995;

Pb. PMT 1999; CPMT 2000]

(a) 1.7 *cm* (b) 6.8 *cm*

(c) 1.7 *m* (d) 6.8 *m*

18. Frequency range of the audible sounds is

[EAMCET (Med.) 1995; RPMT 1997]

(a) 0 *Hz* – 30 *Hz* (b) 20 *Hz* – 20 *kHz*

(c) 20 *kHz* – 20,000 *kHz* (d) 20 *kHz* – 20 *MHz*

19. In a medium sound travels 2 *km* in 3 *sec* and in air, it travels 3 *km* in 10 *sec*. The ratio of the wavelengths of sound in the two media is

(a) 1 : 8 (b) 1 : 18

(c) 8 : 1 (d) 20 : 9

20. A stone is dropped into a lake from a tower 500 *metre* high. The sound of the splash will be heard by the man approximately after[CPMT 1992; JI

Kerala PMT 2005]

(a) 11.5 seconds (b) 21 seconds

(c) 10 seconds (d) 14 seconds

21. When sound waves travel from air to water, which of the following remains constant

[AFMC 1993; DCE 1999; CPMT 2004]

(a) Velocity (b) Frequency

(c) Wavelength (d) All the above

22. A stone is dropped in a well which is 19.6*m* deep. Echo sound is heard after 2.06 *sec* (after dropping) then the velocity of sound is

(a) 332.6 *m/sec* (b) 326.7 *m/sec*

(c) 300.4 *m/sec* (d) 290.5 *m/sec*

23. At what temperature velocity of sound is double than that of at $0°C$

(a) 819 *K* (b) $819°C$

(c) $600°C$ (d) 600 *K*

24. Velocity of sound is maximum in

[AFMC 1998; BCECE 2001; RPMT 1999, 02]

(a) Air (b) Water

(c) Vacuum (d) Steel

25. If velocity of sound in a gas is 360 *m/s* and the distance between a compression and the nearest rarefaction is 1*m*, then the frequency of sound is [KCET 1999]

(a) 90 *Hz* (b) 180 *Hz*

(c) 360 *Hz* (d) 720 *Hz*

26. If the density of oxygen is 16 times that of hydrogen, what will be the ratio of their corresponding velocities of sound waves [KCET 1999]

(a) 1 : 4 (b) 4 : 1

(c) 16 : 1 (d) 1 : 16

27. At which temperature the speed of sound in hydrogen will be same as that of speed of sound in oxygen at $100°C$

[UPSEAT 1999]

(a) $-148°C$ (b) $-212.5°C$

(c) $-317.5°C$ (d) $-249.7°C$

28. A tuning fork produces waves in a medium. If the temperature of the medium changes, then which of the following will change [EAMCET (Med.) 1998; Pb. PMT 1999; MH CET 2001]

(a) Amplitude (b) Frequency

(c) Wavelength (d) Time-period

29. The wave length of light in visible part (λ_V) and for sound (λ_S) are related as [RPMT 1999]

(a) $\lambda_V > \lambda_S$ (b) $\lambda_S > \lambda_V$

(c) $\lambda_S = \lambda_V$ (d) None of these

30. Which of the following is different from others

[AFMC 1994; CPMT 1999; Pb. PMT 2004]

(a) Velocity (b) Wavelength

(c) Frequency (d) Amplitude

31. The phase difference between two points separated by 1m in a wave of frequency 120 *Hz* is 90^o. The wave velocity is

[KCET 1999]

(a) 180 *m/s* (b) 240 *m/s*

(c) 480 *m/s* (d) 720 *m/s*

32. The echo of a gun shot is heard 8 sec. after the gun is fired. How far from him is the surface that reflects the sound (velocity of sound in air = 350 *m/s*) [JIPMER 1999]

(a) 1400 *m* (b) 2800 *m*

(c) 700 *m* (d) 350 *m*

33. A man sets his watch by the sound of a siren placed at a distance 1 *km* away. If the velocity of sound is 330 *m/s*

[JIPMER 1999]

(a) His watch is set 3 sec. faster

(b) His watch is set 3 sec. slower

(c) His watch is set correctly

(d) None of the above [RPMT 1999]

34. Velocity of sound in air is

[Pb. PMT 1999; UPSEAT 2000]

(a) Faster in dry air than in moist air

(b) Directly proportional to pressure

(c) Directly proportional to temperature

(d) Independent of pressure of air

35. Two monoatomic ideal gases 1 and 2 of molecular masses m_1 and m_2 respectively are enclosed in separate containers kept at the same temperature. The ratio of the speed of sound in gas 1 to that in gas 2 is given by

[IIT-JEE Screening 2000]

(a) $\sqrt{\frac{m_1}{m_2}}$ (b) $\sqrt{\frac{m_2}{m_1}}$

(c) $\frac{m_1}{m_2}$ (d) $\frac{m_2}{m_1}$

36. A man is standing between two parallel cliffs and fires a gun. If he hears first and second echoes after 1.5 *s* and 3.5*s* respectively, the distance between the cliffs is (Velocity of sound in air = 340 ms^{-1})

[EAMCET (Med.) 2000]

(a) 1190 *m* (b) 850 *m*

(c) 595 *m* (d) 510 *m*

37. When the temperature of an ideal gas is increased by 600 *K*, the velocity of sound in the gas becomes $\sqrt{3}$ times the initial velocity in it. The initial temperature of the gas is

[EAMCET (Med.) 2000]

(a) -73^oC (b) 27^oC

(c) 127^oC (d) 327^oC

38. The frequency of a sound wave is *n* and its velocity is *v*. If the frequency is increased to $4n$, the velocity of the wave will be

(a) *v* (b) $2v$

(c) $4v$ (d) $v/4$

39. The temperature at which the speed of sound in air becomes double of its value at 27^oC is

[CPMT 1997; UPSEAT 2000; DPMT 2003]

(a) 54^oC (b) 327^oC

(c) 927^oC (d) -123^oC

40. The speed of a wave in a certain medium is 960 *m/s*. If 3600 waves pass over a certain point of the medium in 1 minute, the wavelength is [MP PMT 2000]

(a) 2 *metres* (b) 4 *metres*

(c) 8 *metres* (d) 16 *metres*

41. Speed of sound at constant temperature depends on

[RPET 2000; AIIMS 1998]

(a) Pressure (b) Density of gas

(c) Above both (d) None of the above

42. A man standing on a cliff claps his hand hears its echo after 1 *sec*. If sound is reflected from another mountain and velocity of sound in air is 340 *m/sec*. Then the distance between the man and reflection point is **[RPET 2000]**

(a) 680 *m* (b) 340 *m*

(c) 85 *m* (d) 170 *m*

43. What will be the wave velocity, if the radar gives 54 waves per min and wavelength of the given wave is 10 *m* **[RPET 2000]**

(a) 4 *m/sec* (b) 6 *m/sec*

(c) 9 *m/sec* (d) 5 *m/sec*

44. Sound velocity is maximum in **[Pb. CET 2000; RPMT 2000]**

(a) H_2 (b) N_2

(c) He (d) O_2

45. The minimum distance of reflector surface from the source for listening the echo of sound is **[CPMT 1997; RPMT 1999; KCET 2000]**

(a) 28 *m* (b) 18 *m*

(c) 19 *m* (d) 16.5 *m*

46. The type of waves that can be propagated through solid is **[CPMT 2000]**

(a) Transverse (b) Longitudinal

(c) Both (a) and (b) (d) None of these

47. A man stands in front of a hillock and fires a gun. He hears an echo after 1.5 *sec*. The distance of the hillock from the man is (velocity of sound in air is 330 *m/s*) **[EAMCET (Eng.) 1998; CPMT 2000]**

(a) 220 *m* (b) 247.5 *m*

(c) 268.5 *m* (d) 292.5 *m*

48. Velocity of sound in air

I. Increases with temperature

II. Decreases with temperature

III. Increase with pressure

IV. Is independent of pressure

V. Is independent of temperature

Choose the correct answer. **[Kerala (Engg.) 2001]**

(a) Only I and II are true (b) Only I and III are true

(c) Only II and III are true (d) Only I and IV are true

49. The speed of a wave in a medium is 760 m/s. If 3600 waves are passing through a point, in the medium in 2 minutes, then its wavelength is **[AFMC 1998; CPMT 2001]**

(a) 13.8 *m* (b) 25.3 *m*

(c) 41.5 *m* (d) 57.2 *m*

50. If at same temperature and pressure, the densities for two diatomic gases are respectively d_1 and d_2, then the ratio of velocities of sound in these gases will be **[CPMT 2001]**

(a) $\sqrt{\frac{d_2}{d_1}}$ (b) $\sqrt{\frac{d_1}{d_2}}$

(c) $d_1 d_2$ (d) $\sqrt{d_1 d_2}$

51. The frequency of a tunning fork is 384 per second and velocity of sound in air is 352 *m/s*. How far the sound has traversed while fork completes 36 vibration **[KCET 2001]**

(a) 3 *m* (b) 13 *m*

(c) 23 *m* (d) 33 *m*

52. v_1 and v_2 are the velocities of sound at the same temperature in two monoatomic gases of densities ρ_1 and ρ_2 respectively. If $\rho_1 / \rho_2 = \frac{1}{4}$ then the ratio of velocities v_1 and v_2 will be **[KCET 2000; AIIMS**

(a) 1 : 2 (b) 4 : 1

(c) 2 : 1 (d) 1 : 4

53. The temperature at which the speed of sound in air becomes double of its value at $0^o C$ is **[AIEEE 2002]**

(a) $273K$ (b) $546K$

(c) $1092K$ (d) $0K$

54. If wavelength of a wave is $\lambda = 6000 Å$. Then wave number will be **[MH CET 2002]**

(a) 166×10^3 m (b) 16.6×10^{-1} m

(c) 1.66×10^6 m (d) 1.66×10^7 m

55. Velocity of sound measured in hydrogen and oxygen gas at a given temperature will be in the ratio **[RPET 2001; UPSEAT 2001; KCET 2002, 05]**

(a) 1 : 4 (b) 4 : 1

(c) 2 : 1 (d) 1 : 1

56. Find the frequency of minimum distance between compression & rarefaction of a wire. If the length of the wire is 1*m* & velocity of sound in air is 360 *m/s* **[CPMT 2003]**

(a) 90 *sec* (b) 180*s*

(c) 120 *sec* (d) 360 *sec*

57. The velocity of sound is v_s in air. If the density of air is increased to 4 times, then the new velocity of sound will be **[BHU 2003]**

(a) $\frac{v_s}{2}$ (b) $\frac{v_s}{12}$

(c) $12 v_s$ (d) $\frac{3}{2} v_s^2$

58. It takes 2.0 seconds for a sound wave to travel between two fixed points when the day temperature is 10^o *C*. If the temperature rise to 30^o *C* the sound wave travels between the same fixed parts in **[Orissa JEE 2**

(a) 1.9 *sec* (b) 2.0 *sec*

(c) 2.1 *sec* (d) 2.2 *sec*

59. If v_m is the velocity of sound in moist air, v_d is the velocity of sound in dry air, under identical conditions of pressure and temperature **[KCET 2002,**

(a) $v_m > v_d$ (b) $v_m < v_d$

(c) $v_m = v_d$ (d) $v_m v_d = 1$

60. A man, standing between two cliffs, claps his hands and starts hearing a series of echoes at intervals of one second. If the speed of sound in air is 340 *ms*, the distance between the cliffs is

(a) 340 *m* (b) 1620 *m*

(c) 680 *m* (d) 1700 *m*

61. A source of sound of frequency 600 *Hz* is placed inside water. The speed of sound in water is 1500 *m/s* and in air is 300 *m/s*. The frequency of sound recorded by an observer who is standing in air is

(a) 200 *Hz* (b) 3000 *Hz*

(c) 120 *Hz* (d) 600 *Hz*

62. If the temperature of the atmosphere is increased the following character of the sound wave is effected [AFMC 2004]

(a) Amplitude (b) Frequency

(c) Velocity (d) Wavelength

63. An underwater sonar source operating at a frequency of 60 *KHz* directs its beam towards the surface. If the velocity of sound in air is 330 *m/s*, the wavelength and frequency of waves in air are:

(a) 5.5 *mm*, 60 *KHz* (b) 330 *m*, 60 *KHz*

(c) 5.5 *mm*, 20 *KHz* (d) 5.5 *mm*, 80 *KHz*

64. Two sound waves having a phase difference of 60° have path difference of [CBSE PMT 1996; AIIMS 2001]

(a) 2λ (b) $\lambda/2$

(c) $\lambda/6$ (d) $\lambda/3$

65. It is possible to distinguish between the transverse and longitudinal waves by studying the property of [CPMT 1976; EAMCET 1994]

(a) Interference (b) Diffraction

(c) Reflection (d) Polarisation

66. Water waves are [EAMCET 1979; AIIMS 2004]

(a) Longitudinal

(b) Transverse

(c) Both longitudinal and transverse

(d) Neither longitudinal nor transverse

67. Sound travels in rocks in the form of [NCERT 1968]

(a) Longitudinal elastic waves only

(b) Transverse elastic waves only

(c) Both longitudinal and transverse elastic waves

(d) Non-elastic waves

68. The waves in which the particles of the medium vibrate in a direction perpendicular to the direction of wave motion is known as [EAMCT 1981; AIIMS 1998; DPMT 2000]

(a) Transverse wave (b) Longitudinal waves

(c) Propagated waves (d) None of these

69. A medium can carry a longitudinal wave because it has the property of [KCET 1994]

(a) Mass (b) Density

(c) Compressibility (d) Elasticity

70. Which of the following is the longitudinal wave [AFMC 1997]

(a) Sound waves (b) Waves on plucked string

(c) Water waves (d) Light waves

71. The nature of sound waves in gases is [KCET 2004]

[RPMT 1999; RPET 2000; J & K CET 2004]

(a) Transverse (b) Longitudinal

(c) Stationary (d) Electromagnetic

72. Transverse waves can propagate in [IIT-JEE Screening 2004]

[CPMT 1984; KCET 2000; RPET 2001]

(a) Liquids (b) Solids

(c) Gases (d) None of these

73. Sound waves in air are [RPET 2000; AFMC 2001]

(a) Transverse (b) Longitudinal

(c) De-Broglie waves (d) All the above

74. Which of the following is not the transverse wave [AFMC 1999; BHU 2001]

(a) X-rays (b) γ -rays

(c) Visible light wave (d) Sound wave in a gas

[DPMT 2004]

75. What is the phase difference between two successive crests in the wave [RPMT 2001, 02; MH CET 2004]

(a) π (b) $\pi/2$

(c) 2π (d) 4π

76. A wave of frequency 500 *Hz* has velocity 360 *m/sec*. The distance between two nearest points 60° out of phase, is [NCERT 1979; MP PET 1989; JIPMER 1997; RPMT 2002, 03; CPMT 1979, 90, 2003; BCECE 2005]

(a) 0.6 *cm* (b) 12 *cm*

(c) 60 *cm* (d) 120 *cm*

77. The following phenomenon cannot be observed for sound waves[NCERT 1982; C AFMC 2002; RPMT 2003]

(a) Refraction (b) Interference

(c) Diffraction (d) Polarisation

78. When an aeroplane attains a speed higher than the velocity of sound in air, a loud bang is heard. This is because [NCERT 1972; J & K CET 2002]

(a) It explodes

(b) It produces a shock wave which is received as the bang

(c) Its wings vibrate so violently that the bang is heard

(d) The normal engine noises undergo a Doppler shift to generate the bang

79. Ultrasonic waves are those waves [CPMT 1979]

(a) To which man can hear (b) Man can't hear

(c) Are of high velocity (d) Of high amplitude

80. A big explosion on the moon cannot be heard on the earth because

(a) The explosion produces high frequency sound waves which are inaudible

(b) Sound waves required a material medium for propagation

(c) Sound waves are absorbed in the moon's atmosphere

(d) Sound waves are absorbed in the earth's atmosphere

81. Sound waves of wavelength greater than that of audible sound are called [KCET 1999]

(a) Seismic waves (b) Sonic waves

(c) Ultrasonic waves (d) Infrasonic waves

82. 'SONAR' emits which of the following waves [AIIMS 1999]

(a) Radio waves (b) Ultrasonic waves

(c) Light waves (d) Magnetic waves

83. Which of the following do not require medium for transmission

(a) Cathode ray (b) Electromagnetic wave

(c) Sound wave (d) None of the above

84. Consider the following

I. Waves created on the surfaces of a water pond by a vibrating sources.

II. Wave created by an oscillating electric field in air.

III. Sound waves travelling under water.

Which of these can be polarized [AMU 2001]

(a) I and II (b) II only

(c) II and III (d) I, II and III

85. Mechanical waves on the surface of a liquid are [SCRA 1996]

(a) Transverse

(b) Longitudinal

(c) Torsional

(d) Both transverse and longitudinal

86. The ratio of densities of nitrogen and oxygen is 14:16. The temperature at which the speed of sound in nitrogen will be same at that in oxygen at $55^\circ C$ is [EAMCET (Engg.) 1999]

(a) $35^\circ C$ (b) $48^\circ C$

(c) $65^\circ C$ (d) $14^\circ C$

87. The intensity of sound increases at night due to [CPMT 2000]

(a) Increase in density of air (b) Decreases in density of air

(c) Low temperature (d) None of these

88. A wavelength 0.60 *cm* is produced in air and it travels at a speed of 300 ms^{-1}. It will be an [UPSEAT 2000]

(a) Audible wave (b) Infrasonic wave

(c) Ultrasonic wave (d) None of the above

89. Speed of sound in mercury at a certain temperature is 1450 *m/s*. Given the density of mercury as $13.6 \times 10^3\ kg/m^3$, the bulk modulus for mercury is [JIPMER 2000]

(a) $2.86 \times 10^{10}\ N/m^2$ (b) $3.86 \times 10^{10}\ N/m^2$

(c) $4.86 \times 10^{10}\ N/m^2$ (d) $5.86 \times 10^{10}\ N/m^2$

90. A micro-wave and an ultrasonic sound wave have the same wavelength. Their frequencies are in the ratio (approximately)

(a) $10^6 : 1$ (b) $10^4 : 1$

(c) $10^2 : 1$ (d) $10 : 1$

91. A point source emits sound equally in all directions in a non-absorbing medium, Two points P and Q are at distance of $2m$ and $3m$ respectively from the source. The ratio of the intensities of the waves at P and Q is [CBSE PMT 2005]

(a) 9 : 4 (b) 2 : 3

(c) 3 : 2 (d) 4 : 9

92. A wave has velocity u in medium P and velocity $2u$ in medium Q. If the wave is incident in medium P at an angle of 30° then the angle of refraction will be [J & K CET 2005]

(a) 30° (b) 45°

(c) 60° (d) 90°

[RPMT 2000]

93. An observer standing near the sea shore observes 54 waves per minute. If the wavelength of the water wave is $10m$ then the velocity of water wave is [Kerala (Engg.) 2005]

(a) 540 ms^{-1} (b) 5.4 ms^{-1}

(c) 0.184 ms^{-1} (d) 9 ms^{-1}

94. Ultrasonic signal sent from SONAR returns to it after reflection from a rock after a lapse of 1 *sec*. If the velocity of ultrasound in water is 1600 ms^{-1}, the depth of the rock in water is

(a) 300 *m* (b) 400 *m*

(c) 500 *m* (d) 800 *m*

Progressive Waves

1. The equation of a wave is $y = 2\sin\pi(0.5x - 200t)$, where x and y are expressed in cm and t in sec. The wave velocity is [MP PMT 1986]

(a) 100 *cm/sec* (b) 200 *cm/sec*

(c) 300 *cm/sec* (d) 400 *cm/sec*

2. Equation of a progressive wave is given by

$$y = 0.2\cos\pi\left(0.04t + .02x - \frac{\pi}{6}\right)$$

The distance is expressed in *cm* and time in second. What will be the minimum distance between two particles having the phase difference of $\pi/2$

(a) 4 *cm* (b) 8 *cm*

(c) 25 *cm* (d) 12.5 *cm*

3. A travelling wave passes a point of observation. At this point, the time interval between successive crests is 0.2 seconds and

(a) The wavelength is 5 *m*

(b) The frequency is 5 *Hz*

(c) The velocity of propagation is 5 *m/s*

(d) The wavelength is 0.2 *m*

4. The equation of a transverse wave is given by

$$y = 10\sin\pi(0.01x - 2t)$$

where x and y are in *cm* and t is in second. Its frequency is [MP PET 1990; MNR 1986; RPET 2003]

(a) $10\sec^{-1}$ (b) $2\sec^{-1}$

(c) $1\sec^{-1}$ (d) $0.01\sec^{-1}$

5. At a moment in a progressive wave, the phase of a particle executing S.H.M. is $\frac{\pi}{3}$. Then the phase of the particle 15 *cm* ahead and at the time $\frac{T}{2}$ will be, if the wavelength is 60 *cm* [Kerala (Engg.) 2002]

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

(c) Zero (d) $\frac{5\pi}{6}$

6. The equation of a wave travelling on a string is $y = 4\sin\frac{\pi}{2}\left(8t - \frac{x}{8}\right)$. If x and y are in *cm*, then velocity of wave is [MP PET 1990]
(a) 64 *cm/sec* in $-x$ direction
(b) 32 *cm/sec* in $-x$ direction
(c) 32 *cm/sec* in $+x$ direction
(d) 64 *cm/sec* in $+x$ direction

7. The equation of a progressive wave is given by
$$y = a\sin(628t - 31.4x)$$
If the distances are expressed in *cms* and time in seconds, then the wave velocity will be [DPMT 1999]
(a) 314 *cm/sec* (b) 628 *cm/sec*
(c) 20 *cm/sec* (d) 400 *cm/sec*

8. Two waves are given by $y_1 = a\sin(\omega t - kx)$ and $y_2 = a\cos(\omega t - kx)$ The phase difference between the two waves is [MP PMT 1993; SCRA 1996; CET 1998; EAMCET 1991; Orissa JEE 2002]
(a) $\frac{\pi}{4}$ (b) π
(c) $\frac{\pi}{8}$ (d) $\frac{\pi}{2}$

9. If amplitude of waves at distance r from a point source is A, the amplitude at a distance $2r$ will be [MP PMT 1985]
(a) $2A$ (b) A
(c) $A/2$ (d) $A/4$

10. The relation between time and displacement for two particles is given by
$$y_1 = 0.06\sin 2\pi(0.04t + \phi_1),\ y_2 = 0.03\sin 2\pi(1.04t + \phi_2)$$
The ratio of the intensity of the waves produced by the vibrations of the two particles will be [MP PMT 1991]
(a) 2 : 1 (b) 1 : 2
(c) 4 : 1 (d) 1 : 4

11. A wave is reflected from a rigid support. The change in phase on reflection will be [MP PMT 1990; RPMT 2002]
(a) $\pi/4$ (b) $\pi/2$
(c) π (d) 2π

12. A plane wave is represented by
$$x = 1.2\sin(314\,t + 12.56y)$$
Where x and y are distances measured along in x and y direction in meters and t is time in seconds. This wave has [MP PET 1991]
(a) A wavelength of 0.25 *m* and travels in + *ve x* direction
(b) A wavelength of 0.25 *m* and travels in + *ve y* direction
(c) A wavelength of 0.5 *m* and travels in – *ve y* direction
(d) A wavelength of 0.5 *m* and travels in – *ve x* direction

13. The displacement y (in *cm*) produced by a simple harmonic wave is $y = \frac{10}{\pi}\sin\left(2000\pi t - \frac{\pi x}{17}\right)$. The periodic time and maximum velocity of the particles in the medium will respectively be
(a) 10^{-3} *sec* and 330 *m/sec* (b) 10^{-4} sec and 20 *m/sec*
(c) 10^{-3} *sec* and 200 *m/sec* (d) 10^{-2} *sec* and 2000 *m/sec*

14. The equation of a wave travelling in a string can be written as $y = 3\cos\pi(100\,t - x)$. Its wavelength is [MNR 1985; CPMT 1991; MP PMT 1994, 97; Pb. PET 2004]
(a) 100 *cm* (b) 2 *cm*
(c) 5 *cm* (d) None of the above

15. A transverse wave is described by the equation $Y = Y_0\sin 2\pi\left(ft - \frac{x}{\lambda}\right)$. The maximum particle velocity is four times the wave velocity if [IIT 1984; MP PMT 1997; EAMCET; 1998; CBSE PMT 2000; AFMC 2000; MP PMT/PET 1998; 01; KCET 1999, 04; Pb. PET 2001; DPMT 2005]
(a) $\lambda = \frac{\pi Y_0}{4}$ (b) $\lambda = \frac{\pi Y_0}{2}$
(c) $\lambda = \pi Y_0$ (d) $\lambda = 2\pi Y_0$

16. A wave equation which gives the displacement along the Y direction is given by the equation $y = 10^4\sin(60t + 2x)$, where x and y are in *metres* and t is time in seconds. This represents a wave [MNR 1983; IIT 1982; RPMT 1998; MP PET 2001]
(a) Travelling with a velocity of 30 *m/sec* in the negative X direction
(b) Of wavelength π *metre*
(c) Of frequency $30/\pi$ *Hz*
(d) Of amplitude 10^4 *metre* travelling along the negative X direction

17. A transverse wave of amplitude 0.5 *m* and wavelength 1 *m* and frequency 2 *Hz* is propagating in a string in the negative *x*-direction. The expression for this wave is [AIIMS 1980]
(a) $y(x,t) = 0.5\sin(2\pi x - 4\pi t)$
(b) $y(x,t) = 0.5\cos(2\pi x + 4\pi t)$
(c) $y(x,t) = 0.5\sin(\pi x - 2\pi t)$
(d) $y(x,t) = 0.5\cos(2\pi x + 2\pi t)$

18. The displacement of a particle is given by $y = 5\times 10^{-4}\sin(100t - 50x)$, where x is in meter and t in sec, find out the velocity of the wave [CPMT 1982]
(a) 5000 *m/sec* (b) 2 *m/sec*
(c) 0.5 *m/sec* (d) 300 *m/sec*

19. Which one of the following does not represent a travelling wave
(a) $y = \sin(x - vt)$ (b) $y = y_m\sin k(x + vt)$
(c) $y = y_m\log(x - vt)$ (d) $y = f(x^2 - vt^2)$

20. A wave represented by the given equation $Y = A\sin\left(10\pi x + 15\pi t + \frac{\pi}{3}\right)$, where x is in meter and t is in second. The expression represents [IIT 1990]
(a) A wave travelling in the positive X direction with a velocity of 1.5 *m/sec*
(b) A wave travelling [CPMT 1986] in the negative X direction with a velocity of 1.5 *m/sec*

(c) A wave travelling in the negative X direction with a wavelength of 0.2 m

(d) A wave travelling in the positive X direction with a wavelength of 0.2 m

21. A plane wave is described by the equation $y = 3\cos\left(\frac{x}{4} - 10t - \frac{\pi}{2}\right)$. The maximum velocity of the particles of the medium due to this wave is [MP PMT 1994]

(a) 30 (b) $\frac{3\pi}{2}$

(c) 3/4 (d) 40

22. The path difference between the two waves $y_1 = a_1 \sin\left(\omega t - \frac{2\pi x}{\lambda}\right)$ and $y_2 = a_2 \cos\left(\omega t - \frac{2\pi x}{\lambda} + \phi\right)$ is [MP PMT 1994]

(a) $\frac{\lambda}{2\pi}\phi$ (b) $\frac{\lambda}{2\pi}\left(\phi + \frac{\pi}{2}\right)$

(c) $\frac{2\pi}{\lambda}\left(\phi - \frac{\pi}{2}\right)$ (d) $\frac{2\pi}{\lambda}\phi$

23. Wave equations of two particles are given by $y_1 = a\sin(\omega t - kx)$, $y_2 = a\sin(kx + \omega t)$, then [BHU 1995]

(a) They are moving in opposite direction

(b) Phase between them is 90°

(c) Phase between them is 180°

(d) Phase between them is 0°

24. A wave is represented by the equation $y = 0.5\sin(10t - x)m$. It is a travelling wave propagating along the + x direction with velocity [Roorkee 1995]

(a) 10 m/s (b) 20 m/s

(c) 5 m/s (d) None of these

25. A wave is represented by the equation

$$y = 7\sin\left(7\pi t - 0.04\,x\pi + \frac{\pi}{3}\right)$$

x is in *metres* and t is in seconds. The speed of the wave is [MP PET 1996; AMU (Engg.) 1999]

(a) 175 m/sec (b) 49 $\pi m/sec$

(c) 49 $\pi m/sec$ (d) 0.28 $\pi m/sec$

26. The equation of a transverse wave travelling on a rope is given by $y = 10\sin\pi(0.01x - 2.00t)$ where y and x are in cm and t in seconds. The maximum transverse speed of a particle in the rope is about [MP PET 1999; AIIMS 2000]

(a) 63 cm/s (b) 75 cm/s

(c) 100 cm/s (d) 121 cm/s

27. As a wave propagates [IIT-JEE 1999]

(a) The wave intensity remains constant for a plane wave

(b) The wave intensity decreases as the inverse of the distance from the source for a spherical wave

(c) The wave intensity decreases as the inverse square of the distance from the source for a spherical wave

(d) Total intensity of the spherical wave over the spherical surface centered at the source remains constant at all times

28. A transverse wave is represented by the equation

$$y = y_0 \sin\frac{2\pi}{\lambda}(vt - x)$$

For what value of λ, the maximum particle velocity equal to two times the wave velocity [CBSE PMT 1998; JIPMER 2001, 02; AFMC 2002]

(a) $\lambda = 2\pi y_0$ (b) $\lambda = \pi y_0 / 3$

(c) $\lambda = \pi y_0 / 2$ (d) $\lambda = \pi y_0$

29. A travelling wave in a stretched string is described by the equation $y = A\sin(kx - \omega t)$. The maximum particle velocity is [IIT 1997 Re-Exam; UPSEAT 2004]

(a) $A\omega$ (b) ω/k

(c) $d\omega/dk$ (d) x/t

30. A wave travels in a medium according to the equation of displacement given by

$$y(x,t) = 0.03\sin\pi(2t - 0.01x)$$

where y and x are in *metres* and t in seconds. The wavelength of the wave is [EAMCET 1994; CPMT 2004]

(a) 200 m (b) 100 m

(c) 20 m (d) 10 m

31. The particles of a medium vibrate about their mean positions whenever a wave travels through that medium. The phase difference between the vibrations of two such particles

(a) Varies with time

(b) Varies with distance separating them

(c) Varies with time as well as distance

(d) Is always zero

32. A wave is given by $y = 3\sin 2\pi\left(\frac{t}{0.04} - \frac{x}{0.01}\right)$, where y is in cm. Frequency of wave and maximum acceleration of particle will be

(a) $100\,Hz,\ 4.7\times10^3\ cm/s^2$ (b) $50\,Hz,\ 7.5\times10^3\ cm/s^2$

(c) $25\,Hz,\ 4.7\times10^4\ cm/s^2$ (d) $25\,Hz,\ 7.4\times10^4\ cm/s^2$

33. Equation of a progressive wave is given by

$$y = 4\sin\left\{\pi\left(\frac{t}{5} - \frac{x}{9}\right) + \frac{\pi}{6}\right\}$$

Then which of the following is correct [CBSE PMT 1993]

(a) $v = 5\,m/\sec$ (b) $\lambda = 18\,m$

(c) $a = 0.04\,m$ (d) $n = 50\,Hz$

34. With the propagation of a longitudinal wave through a material medium, the quantities transmitted in the propagation direction are [CBSE PMT

(a) Energy, momentum and mass

(b) Energy

(c) Energy and mass

(d) Energy and linear momentum

35. The frequency of the sinusoidal wave $y = 0.40\cos[2000\,t + 0.80\,x]$ would be [CBSE PMT 1992]

(a) 1000 π Hz (b) 2000 Hz

(c) 20 Hz (d) $\frac{1000}{\pi}Hz$

36. Which of the following equations represents a wave [CBSE PMT 1994; JIPMER 2000]

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

(c) $Y = A\cos kx$ (d) $Y = A\sin(at - bx + c)$

37. The equation of a transverse wave is given by

$$y = 100\sin\pi(0.04z - 2t)$$

where y and z are in *cm* ant t is in seconds. The frequency of the wave in *Hz* is [SCRA 1998]

(a) 1 (b) 2

(c) 25 (d) 100

38. The equation of a plane progressive wave is given by $y = 0.025\sin(100t + 0.25x)$. The frequency of this wave would be [CPMT 1993; JIPMER 2001, 02]

(a) $\frac{50}{\pi} Hz$ (b) $\frac{100}{\pi} Hz$

(c) 100 *Hz* (d) 50 *Hz*

39. The equation of a sound wave is

$$y = 0.0015\sin(62.4x + 316t)$$

The wavelength of this wave is

[CBSE PMT 1996; AFMC 2002; AIIMS 2002]

(a) 0.2 unit (b) 0.1 unit

(c) 0.3 unit (d) Cannot be calculated

40. In the given progressive wave equation, what is the maximum velocity of particle $Y = 0.5\sin(10\pi t - 5x)$ *cm*

[BHU 1997]

(a) 5 *cm/s* (b) 5π *cm/s*

(c) 10 *cm/s* (d) 10.5 *cm/s*

41. A pulse or a wave train travels along a stretched string and reaches the fixed end of the string. It will be reflected back with

(a) The same phase as the incident pulse but with velocity reversed

(b) A phase change of 180° with no reversal of velocity

(c) The same phase as the incident pulse with no reversal of velocity

(d) A phase change of 180° with velocity reversed

42. The equation of a travelling wave is

$$y = 60\cos(1800t - 6x)$$

where y is in microns, t in seconds and x in metres. The ratio of maximum particle velocity to velocity of wave propagation is [CBSE PMT 1997; JIPMER 2001, 02]

(a) 3.6×10^{-11} (b) 3.6×10^{-6}

(c) 3.6×10^{-4} (d) 3.6

43. The wave equation is $y = 0.30\sin(314t - 1.57x)$ where *t*, *x* and *y* are in second, meter and centimeter respectively. The speed of the wave is

[CPMT 1997; AFMC 1999; CPMT 2001]

(a) 100 *m/s* (b) 200 *m/s*

(c) 300 *m/s* (d) 400 *m/s*

44. Equation of the progressive wave is given by : $y = a\sin\pi(40t - x)$ where a and x are in *metre* and t in second. The velocity of the wave is [KCET 1999]

(a) 80 *m/s* (b) 10 *m/s*

(c) 40 *m/s* (d) 20 *m/s*

45. Progressive wave of sound is represented by $y = a\sin[400\pi t - \pi x / 6.85]$ where x is in m and t is in sec. Frequency of the wave will be [RPMT 1999]

(a) 200 *Hz* (b) 400 *Hz*

(c) 500 *Hz* (d) 600 *Hz*

46. Two waves of frequencies 20 *Hz* and 30 *Hz*. Travels out from a common point. The phase difference between them after 0.6 *sec* is

(a) Zero (b) $\frac{\pi}{2}$

(c) π (d) $\frac{3\pi}{4}$

47. The phase difference between two points separated by 0.8 *m* in a wave of frequency 120 *Hz* is 90^o. Then the velocity of wave will be

(a) 192 *m/s* (b) 360 *m/s*

(c) 710 *m/s* (d) 384 *m/s*

48. The equation of progressive wave is $y = 0.2\sin 2\pi\left[\frac{t}{0.01} - \frac{x}{0.3}\right]$, where x and y are in metre and t is in second. The velocity of propagation of the wave is

(a) 30 *m/s* (b) 40 *m/s*

(c) 300 *m/s* (d) 400 *m/s*

49. If the equation of transverse wave is $y = 5\sin 2\pi\left[\frac{t}{0.04} - \frac{x}{40}\right]$, where distance is in *cm* and time in second, then the wavelength of the wave is

[MH CET 2000; DPMT 2003]

(a) 60 *cm* (b) 40 *cm*

(c) 35 *cm* (d) 25 *cm*

50. A wave is represented by the equation : $y = a\sin(0.01x - 2t)$ where *a* and *x* are in *cm*. velocity of propagation of wave is [CBSE PMT 1997]

[EAMCET 1994; AIIMS 2000; Pb. PMT 2003]

(a) 10 *cm/s* (b) 50 *cm/s*

(c) 100 *cm/s* (d) 200 *cm/s*

51. A simple harmonic progressive wave is represented by the equation : $y = 8\sin 2\pi(0.1x - 2t)$ where x and y are in *cm* and t is in seconds. At any instant the phase difference between two particles separated by 2.0 *cm* in the *x*-direction is

[MP PMT 2000]

(a) 18° (b) 36°

(c) 54° (d) 72°

52. The intensity of a progressing plane wave in loss-free medium is

(a) Directly proportional to the square of amplitude of the wave

(b) Directly proportional to the velocity of the wave

(c) Directly proportional to the square of frequency of the wave

(d) Inversely proportional to the density of the medium

53. The equation of progressive wave is $y = a\sin(200t - x)$. where x is in meter and t is in second. The velocity of wave is

(a) 200 *m/sec* (b) 100 *m/sec*

(c) 50 *m/sec* (d) None of these

54. A wave is represented by the equation $y = 7\sin\{\pi(2t - 2x)\}$ where x is in *metres* and t in seconds. The velocity of the wave is

[CPMT 2000; CBSE PMT 2000; Pb. PET 2000]

(a) 1 *m/s* (b) 2 *m/s*

(c) 5 *m/s* (d) 10 *m/s*

55. The equation of a longitudinal wave is represented as $y = 20\cos\pi(50t - x)$. Its wavelength is

[UPSEAT 2001; Orissa PMT 2004]

(a) 5 *cm* (b) 2 *cm*

(c) 50 *cm* (d) 20 *cm*

56. A wave equation which gives the displacement along *y*-direction is given by $y = 0.001 \sin(100t + x)$ where *x* and *y* are in meterand *t* is time in second. This represented a wave

[UPSEAT 2001]

(a) Of frequency $\frac{100}{\pi}$ *Hz*

(b) Of wavelength one metre

(c) Travelling with a velocity of $\frac{50}{\pi}$ *ms* in the positive *X*-direction

(d) Travelling with a velocity of 100 *ms* in the negative *X*-direction

57. A transverse wave is given by $y = A\sin 2\pi\left(\frac{t}{T} - \frac{x}{\lambda}\right)$. The maximum particle velocity is equal to 4 times the wave velocity when [MP PMT 2001]

(a) $\lambda = 2\pi A$ (b) $\lambda = \frac{1}{2}\pi A$

(c) $\lambda = \pi A$ (d) $\lambda = \frac{1}{4}\pi A$

58. The equation of a wave is represented by $y = 10^{-4}\sin\left[100\,t - \frac{x}{10}\right]$. The velocity of the wave will be

[CBSE PMT 2001]

(a) 100 *m/s* (b) 250 *m/s*

(c) 750 *m/s* (d) 1000 *m/s*

59. A wave travelling in positive X-direction with $A = 0.2m$ has a velocity of 360 *m/sec*. if $\lambda = 60m$, then correct expression for the wave is [CBSE PMT 2002; KCET 2003]

(a) $y = 0.2\sin\left[2\pi\left(6t + \frac{x}{60}\right)\right]$ (b) $y = 0.2\sin\left[\pi\left(6t + \frac{x}{60}\right)\right]$

(c) $y = 0.2\sin\left[2\pi\left(6t - \frac{x}{60}\right)\right]$ (d) $y = 0.2\sin\left[\pi\left(6t - \frac{x}{60}\right)\right]$

60. The equation of a wave motion (with t in seconds and x in *metres*) is given by $y = 7\sin\left[7\pi t - 0.4\pi x + \frac{\pi}{3}\right]$. The velocity of the wave will be

[BHU 2002]

(a) 17.5 *m/s* (b) 49π *m/s*

(c) $\frac{49}{2\pi} m/s$ (d) $\frac{2\pi}{49} m/s$

61. Two waves represented by the following equations are travelling in the same medium $y_1 = 5\sin 2\pi(75t - 0.25x)$, $y_2 = 10\sin 2\pi(150t - 0.50x)$

The intensity ratio I_1 / I_2 of the two waves is

[UPSEAT 2002]

(a) 1 : 2 (b) 1 : 4

(c) 1 : 8 (d) 1 : 16

62. The equation of a progressive wave is $y = 8\sin\left[\pi\left(\frac{t}{10} - \frac{x}{4}\right) + \frac{\pi}{3}\right]$. The wavelength of the wave is

[MH CET 2002]

(a) 8 *m* (b) 4 *m*

(c) 2 *m* (d) 10 *m*

63. Which of the following is not true for this progressive wave $y = 4\sin 2\pi\left(\frac{t}{0.02} - \frac{x}{100}\right)$ where y and x are in cm & t in *sec* [CPMT 2003]

(a) Its amplitude is 4 *cm*

(b) Its wavelength is 100 *cm*

(c) Its frequency is 50 *cycles/sec*

(d) Its propagation velocity is 50×10^3 *cm/sec*

64. The equation of a wave is given as $y = 0.07\sin(12\pi x - 3000\pi t)$. Where x is in *metre* and t in sec, then the correct statement is

(a) $\lambda = 1/6m, v = 250m/s$ (b) $a = 0.07m, v = 300m/s$

(c) $n = 1500, v = 200m/s$ (d) None

65. The equation of the propagating wave is $y = 25\sin(20t + 5x)$, where y is displacement. Which of the following statement is not true [MP PET 2003]

(a) The amplitude of the wave is 25 units

(b) The wave is propagating in positive x -direction

(c) The velocity of the wave is 4 units

(d) The maximum velocity of the particles is 500 units

66. In a plane progressive wave given by $y = 25\cos(2\pi t - \pi x)$, the amplitude and frequency are respectively

[BCECE 2003]

(a) 25,100 (b) 25, 1

(c) 25, 2 (d) 50π, 2

67. The displacement y of a wave travelling in the *x*-direction is given by $y = 10^{-4}\sin\left(600t - 2x + \frac{\pi}{3}\right)$ metres, where x is expressed in metres and t in seconds. The speed of the wave-motion, in *ms*, is

(a) 200 (b) 300

(c) 600 (d) 1200

68. The displacement *y* of a particle in a medium can be expressed as: $y = 10^{-6}\sin(100t + 20x + \pi/4)m$, where *t* is in second and *x* in *meter*. The speed of wave is

[AIEEE 2004]

(a) 2000 *m/s* (b) 5 *m/s*

(c) 20 *m/s* (d) $5\pi\, m/s$

69. If the wave equation $y = 0.08\sin\frac{2\pi}{\lambda}(200t - x)$ then the velocity of the wave will be [BCECE 2004]

(a) $400\sqrt{2}$ (b) $200\sqrt{2}$

(c) 400 (d) 200

70. The phase difference between two points separated by 0.8 *m* in a wave of frequency is 120 *Hz* is $\frac{\pi}{2}$. The velocity of wave is

(a) 720 *m/s* (b) 384 *m/s*

(c) 250 *m/s* (d) 1 *m/s*

71. A plane progressive wave is represented by the equation

$y = 0.1\sin\left(200\pi t - \frac{20\pi x}{17}\right)$ where *y* is displacement in *m*, *t* in second and *x* is distance from a fixed origin in *meter*. The frequency, wavelength and speed of the wave respectively are

(a) 100 *Hz*, 1.7 *m*, 170 *m/s* (b) 150 *Hz*, 2.4 *m*, 200 *m/s*

(c) 80 *Hz*, 1.1 *m*, 90 *m/s* (d) 120 *Hz*, 1.25 *m*, 207 *m/s*

72. The equation of a travelling wave is given by

$y = 0.5\sin(20x - 400t)$ where *x* and *y* are in *meter* and *t* is in *second*. The velocity of the wave is **[UPSEAT 2004]**

(a) 10 *m/s* (b) 20 *m/s*

(c) 200 *m/s* (d) 400 *m/s*

73. A transverse progressive wave on a stretched string has a velocity of $10\,ms^{-1}$ and a frequency of 100 *Hz*. The phase difference between two particles of the string which are 2.5 *cm* apart will be

(a) $\frac{\pi}{8}$ (b) $\frac{\pi}{4}$

(c) $\frac{3\pi}{8}$ (d) $\frac{\pi}{2}$

74. A transverse sinusoidal wave of amplitude *a*, wavelength λ and frequency *n* is travelling on a stretched string. The maximum speed of any point on the string is *v*/10, where *v* is the speed of propagation of the wave. If $a = 10^{-3}\,m$ and $v = 10\,ms^{-1}$, then λ and *n* are given by **[IIT 1998]**

(a) $\lambda = 2\pi \times 10^{-2}\,m$ (b) $\lambda = 10^{-3}\,m$

(c) $n = \frac{10^3}{2\pi}\,Hz$ (d) $n = 10^4\,Hz$

75. When a longitudinal wave propagates through a medium, the particles of the medium execute simple harmonic oscillations about their mean positions. These oscillations of a particle are characterised by an invariant

[SCRA 1998]

(a) Kinetic energy

(b) Potential energy

(c) Sum of kinetic energy and potential energy

(d) Difference between kinetic energy and potential energy

76. Equation of a progressive wave is given by $y = a\sin\pi\left[\frac{t}{2} - \frac{x}{4}\right]$, where *t* is in seconds and *x* is in meters. The distance through which the wave moves in 8 *sec* is (in meter)

(a) 8 (b) 16

(c) 2 (d) 4

77. The phase difference between two waves represented by $y_1 = 10^{-6}\sin[100t + (x/50) + 0.5]m$

$y_2 = 10^{-6}\cos[100t + (x/50)]m$

where *x* is expressed in metres and *t* is expressed in seconds, is approximately **[CBSE PMT 2004]**

(a) 1.5 *rad* (b) 1.07 *rad*

(c) 2.07 *rad* **[Pb. PET 2000]** (d) 0.5 *rad*

78. Equation of motion in the same direction are given by

$y_1 = 2a\sin(\omega t - kx)$ and $y_2 = 2a\sin(\omega t - kx - \theta)$

The amplitude of the medium particle will be **[CPMT 2004]**

(a) $2a\cos\theta$ (b) $\sqrt{2}a\cos\theta$

(c) $4a\cos\theta/2$ (d) $\sqrt{2}a\cos\theta/2$

79. A particle on the trough of a wave at any instant will come to the mean position after a time (*T* = time period) **[Pb. PET 2001]**

[KCET 2005]

(a) $T/2$ (b) $T/4$

(c) T (d) $2T$

80. If the equation of transverse wave is $Y = 2\sin(kx - 2t)$, then the maximum particle velocity is **[Orissa JEE 2005]**

(a) 4 units (b) 2 units

(c) 0 (d) 6 units

Interference and Superposition of Waves

1. There is a destructive interference between the two waves of wavelength λ coming from two different paths at a point. To get maximum sound or constructive interference at that point, the path of one wave is to be increased by **[MP PMT 1994]**

[MP PET 1985]

(a) $\frac{\lambda}{4}$ (b) $\frac{\lambda}{2}$

(c) $\frac{3\lambda}{4}$ (d) λ

2. When two sound waves with a phase difference of $\pi/2$, and each having amplitude *A* and frequency ω, are superimposed on each other, then the maximum amplitude and frequency of resultant wave is **[MP PMT 1989]**

(a) $\frac{A}{\sqrt{2}} : \frac{\omega}{2}$ (b) $\frac{A}{\sqrt{2}} : \omega$

(c) $\sqrt{2}\,A : \frac{\omega}{2}$ (d) $\sqrt{2}\,A : \omega$

3. If the phase difference between the two wave is 2π during superposition, then the resultant amplitude is

[DPMT 2001]

(a) Maximum (b) Minimum

(c) Maximum or minimum (d) None of the above

4. The superposition takes place between two waves of frequency *f* and amplitude *a*. The total intensity is directly proportional to

(a) *a* (b) 2*a*

[KCET 1993] (c) $2a^2$ (d) $4a^2$

5. If two waves of same frequency and same amplitude respectively, on superimposition produced a resultant disturbance of the same amplitude, the waves differ in phase by

(a) π (b) $2\pi/3$

(c) $\pi/2$ (d) Zero

6. Two sources of sound *A* and *B* produces the wave of 350 *Hz*, they vibrate in the same phase. The particle P is vibrating under the influence of these two waves, if the amplitudes at the point *P* produced by the two waves is 0.3 *mm* and 0.4 *mm*, then the resultant amplitude of the point *P* will be when *AP* – *BP* = 25 *cm* and the velocity of sound is 350 *m/sec*

(a) 0.7 *mm* (b) 0.1 *mm*

(c) 0.2 *mm* (d) 0.5 *mm*

7. Two waves are propagating to the point *P* along a straight line produced by two sources *A* and *B* of simple harmonic and of equal frequency. The amplitude of every wave at *P* is '*a*' and the phase of *A* is ahead by $\frac{\pi}{3}$ than that of *B* and the distance *AP* is greater than *BP* by 50 *cm*. Then the resultant amplitude at the point *P* will be, if the wavelength is 1 *meter*

[BVP 2003]

(a) 2*a* (b) $a\sqrt{3}$

(c) $a\sqrt{2}$ (d) *a*

8. Coherent sources are characterized by the same

[KCET 1993]

(a) Phase and phase velocity

(b) Wavelength, amplitude and phase velocity

(c) Wavelength, amplitude and frequency

(d) Wavelength and phase

9. The minimum intensity of sound is zero at a point due to two sources of nearly equal frequencies, when

(a) Two sources are vibrating in opposite phase

(b) The amplitude of two sources are equal

(c) At the point of observation, the amplitudes of two S.H.M. produced by two sources are equal and both the S.H.M. are along the same straight line

(d) Both the sources are in the same phase

10. Two sound waves (expressed in CGS units) given by $y_1 = 0.3\sin\frac{2\pi}{\lambda}(vt - x)$ and $y_2 = 0.4\sin\frac{2\pi}{\lambda}(vt - x + \theta)$ interfere. The resultant amplitude at a place where phase difference is $\pi/2$ will be [MP PET 1991]

(a) 0.7 *cm* (b) 0.1 *cm*

(c) 0.5 *cm* (d) $\frac{1}{10}\sqrt{7}$ *cm*

11. If two waves having amplitudes 2*A* and *A* and same frequency and velocity, propagate in the same direction in the same phase, the resulting amplitude will be

[MP PET 1991; DPMT 1999]

(a) 3*A* (b) $\sqrt{5}A$

(c) $\sqrt{2}A$ (d) *A*

12. The intensity ratio of two waves is 1 : 16. The ratio of their amplitudes is [EAMCET 1983]

(a) 1 : 16 (b) 1 : 4

(c) 4 : 1 (d) 2 : 1

13. Out of the given four waves (1), (2), (3) and (4)

$y = a\sin(kx + \omega t)$ ......(1)

$y = a\sin(\omega t - kx)$ ......(2)

$y = a\cos(kx + \omega t)$ ......(3)

$y = a\cos(\omega t - kx)$ ......(4)

emitted by four different sources S_1, S_2, S_3 and S_4 respectively, interference phenomena would be observed in space under appropriate conditions when [CPMT 1988]

(a) Source S_1 emits wave (1) and S_2 emits wave (2)

(b) Source S_3 emits wave (3) and S_4 emits wave (4)

(c) Source S_2 emits wave (2) and S_4 emits wave (4)

(d) S_4 emits waves (4) and S_3 emits waves (3)

14. Two waves of same frequency and intensity superimpose with each other in opposite phases, then after superposition the

(a) Intensity increases by 4 times

(b) Intensity increases by two times

(c) Frequency increases by 4 times

(d) None of these

15. The superposing waves are represented by the following equations :

$y_1 = 5\sin 2\pi(10\,t - 0.1x)$, $y_2 = 10\sin 2\pi(20\,t - 0.2x)$

Ratio of intensities $\frac{I_{max}}{I_{min}}$ will be

[AIIMS 1995; KCET 2001]

(a) 1 (b) 9

(c) 4 (d) 16

16. The displacement of a particle is given by

$x = 3\sin(5\pi\,t) + 4\cos(5\pi\,t)$

The amplitude of the particle is [MP PMT 1999]

(a) 3 (b) 4

(c) 5 (d) 7

17. Two waves

$y_1 = A_1\sin(\omega t - \beta_1)$, $y_2 = A_2\sin(\omega t - \beta_2)$

Superimpose to form a resultant wave whose amplitude is

[CPMT 1999]

(a) $\sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos(\beta_1 - \beta_2)}$

(b) $\sqrt{A_1^2 + A_2^2 + 2A_1A_2\sin(\beta_1 - \beta_2)}$

(c) $A_1 + A_2$

(d) $|A_1 + A_2|$

18. If the ratio of amplitude of wave is 2 : 1, then the ratio of maximum and minimum intensity is [MH CET 1999]

(a) 9 : 1 (b) 1 : 9

(c) 4 : 1 (d) 1 : 4

19. The two interfering waves have intensities in the ratio 9 : 4. The ratio of intensities of maxima and minima in the interference pattern will be [AMU 2000]

(a) 1 : 25 (b) 25 : 1

(c) 9 : 4 (d) 4 : 9

20. If the ratio of amplitude of two waves is 4 : 3. Then the ratio of maximum and minimum intensity will be

[MHCET 2000]

(a) 16 : 18 (b) 18 : 16

(c) 49 : 1 (d) 1 : 49

21. Equation of motion in the same direction is given by $y_1 = A\sin(\omega t - kx)$, $y_2 = A\sin(\omega t - kx - \theta)$. The amplitude of the medium particle will be [BHU 2003]

(a) $2A\cos\frac{\theta}{2}$ (b) $2A\cos\theta$

(c) $\sqrt{2}A\cos\frac{\theta}{2}$ (d) $1.2f, 1.2\lambda$

22. Two waves having the intensities in the ratio of 9 : 1 produce interference. The ratio of maximum to the minimum intensity, is equal to

[CPMT 2001; Pb. PET 2004]

(a) 2 : 1 (b) 4 : 1

(c) 9 : 1 (d) 10 : 8

23. The displacement of the interfering light waves are $y_1 = 4\sin\omega t$ and $y_2 = 3\sin\left(\omega t + \frac{\pi}{2}\right)$. What is the amplitude of the resultant wave

[RPMT 1996; Orissa JEE 2005]

(a) 5 (b) 7

(c) 1 (d) 0

24. Two waves are represented by $y_1 = a\sin\left(\omega t + \frac{\pi}{6}\right)$ and $y_2 = a\cos\omega t$. What will be their resultant amplitude

[RPMT 1996]

(a) a (b) $\sqrt{2}\,a$

(c) $\sqrt{3}\,a$ (d) $2a$

25. The amplitude of a wave represented by displacement equation $y = \frac{1}{\sqrt{a}}\sin\omega t \pm \frac{1}{\sqrt{b}}\cos\omega t$ will be

[BVP 2003]

(a) $\frac{a+b}{ab}$ (b) $\frac{\sqrt{a}+\sqrt{b}}{ab}$

(c) $\frac{\sqrt{a}\pm\sqrt{b}}{ab}$ (d) $\sqrt{\frac{a+b}{ab}}$

26. Two waves having equations

$$x_1 = a\sin(\omega t + \phi_1),\ x_2 = a\sin(\omega t + \phi_2)$$

If in the resultant wave the frequency and amplitude remain equal to those of superimposing waves. Then phase difference between them is [CBSE PMT 2001]

(a) $\frac{\pi}{6}$ (b) $\frac{2\pi}{3}$

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

Beats

1. Two tuning forks when sounded together produced 4 *beats/sec*. The frequency of one fork is 256. The number of beats heard increases when the fork of frequency 256 is loaded with wax. The frequency of the other fork is

[CPMT 1976; MP PMT 1993]

(a) 504 (b) 520

(c) 260 (d) 252

2. Beats are the result of

[CPMT 1971; J & K CET 2002]

(a) Diffraction

(b) Destructive interference

(c) Constructive and destructive interference

(d) Superposition of two waves of nearly equal frequency

3. Two adjacent piano keys are struck simultaneously. The notes emitted by them have frequencies n_1 and n_2. The number of beats heard per second is

[CPMT 1974, 78; CBSE PMT 1993]

(a) $\frac{1}{2}(n_1 - n_2)$ (b) $\frac{1}{2}(n_1 + n_2)$

(c) $n_1 \sim n_2$ (d) $2(n_1 - n_2)$

4. A tuning fork of frequency 100 when sounded together with another tuning fork of unknown frequency produces 2 beats per second. On loading the tuning fork whose frequency is not known and sounded together with a tuning fork of frequency 100 produces one beat, then the frequency of the other tuning fork is

(a) 102 (b) 98

(c) 99 (d) 101

5. A tuning fork sounded together with a tuning fork of frequency 256 emits two beats. On loading the tuning fork of frequency 256, the number of beats heard are 1 per second. The frequency of tuning fork is

[NCERT 1975, 81; MP PET 1985]

(a) 257 (b) 258

(c) 256 (d) 254

6. If two tuning forks *A* and *B* are sounded together, they produce 4 beats per second. *A* is then slightly loaded with wax, they produce 2 beats when sounded again. The frequency of *A* is 256. The frequency of *B* will be

[CPMT 1976; RPET 1998]

(a) 250 (b) 252

(c) 260 (d) 262

7. The frequencies of two sound sources are 256 *Hz* and 260 *Hz*. At $t = 0$, the intensity of sound is maximum. Then the phase difference at the time $t = 1/16$ *sec* will be

(a) Zero (b) π

(c) $\pi/2$ (d) $\pi/4$

8. Two tuning forks have frequencies 450 *Hz* and 454 *Hz* respectively. On sounding these forks together, the time interval between successive maximum intensities will be

[MP PET 1989; MP PMT 2003]

(a) 1/4 *sec* (b) 1/2 *sec*

(c) 1 *sec* (d) 2 *sec*

9. When a tuning fork of frequency 341 is sounded with another tuning fork, six beats per second are heard. When the second tuning fork is loaded with wax and sounded with the first tuning fork, the number of beats is two per second. The natural frequency of the second tuning fork is

[MP PET 1989]

(a) 334 (b) 339

(c) 343 (d) 347

10. Two tuning forks of frequencies 256 and 258 vibrations/sec are sounded together, then time interval between consecutive maxima heard by the observer is

[MP PET/PMT 1988]

(a) 2 *sec* (b) 0.5 *sec*

(c) 250 *sec* (d) 252 *sec*

11. A tuning fork gives 5 beats with another tuning fork of frequency 100 *Hz*. When the first tuning fork is loaded with wax, then the number of beats remains unchanged, then what will be the frequency of the first tuning fork

[MP PMT 1985]

(a) 95 *Hz* (b) 100 *Hz*

(c) 105 *Hz* (d) 110 *Hz*

12. Tuning fork F_1 has a frequency of 256 *Hz* and it is observed to produce 6 beats/second with another tuning fork F_2. When F_2 is loaded with wax, it still produces 6 beats/second with F_1. The frequency of F_2 before loading was

[MP PET 1990]

(a) 253 *Hz* (b) 262 *Hz*

(c) 250 *Hz* (d) 259 *Hz*

13. A tuning fork and a sonometer wire were sounded together and produce 4 beats per second. When the length of sonometer wire is 95 *cm* or 100 *cm*, the frequency of the tuning fork is

(a) 156 *Hz* (b) 152 *Hz*

(c) 148 *Hz* (d) 160 *Hz*

14. Two tuning forks *A* and *B* vibrating simultaneously produce 5 beats. Frequency of *B* is 512. It is seen that if one arm of *A* is filed, then the number of beats increases. Frequency of A will be

(a) 502 (b) 507

(c) 517 (d) 522

15. The beats are produced by two sound sources of same amplitude and of nearly equal frequencies. The maximum intensity of beats will be ...... that of one source

[CPMT 1999]

(a) Same (b) Double

(c) Four times (d) Eight times

16. Beats are produced by two waves given by $y_1 = a\sin 2000\,\pi t$ and $y_2 = a\sin 2008\,\pi t$. The number of beats heard per second is

(a) Zero (b) One

(c) Four (d) Eight

17. A tuning fork whose frequency as given by manufacturer is 512 *Hz* is being tested with an accurate oscillator. It is found that the fork produces a beat of 2 *Hz* when oscillator reads 514 *Hz* but produces a beat of 6 *Hz* when oscillator reads 510 *Hz*. The actual frequency of fork is

[MNR 1979; RPMT 1999]

(a) 508 *Hz* (b) 512 *Hz*

(c) 516 *Hz* (d) 518 *Hz*

18. A tuning fork of frequency 480 *Hz* produces 10 beats per second when sounded with a vibrating sonometer string. What must have been the frequency of the string if a slight increase in tension produces lesser beats per second than before

(a) 460 *Hz* (b) 470 *Hz*

(c) 480 *Hz* (d) 490 *Hz*

19. When a tuning fork *A* of unknown frequency is sounded with another tuning fork *B* of frequency 256 *Hz*, then 3 beats per second are observed. After that *A* is loaded with wax and sounded, the again 3 beats per second are observed. The frequency of the tuning fork *A* is

[MP PMT 1994]

(a) 250 *Hz* (b) 253 *Hz*

(c) 259 *Hz* (d) 262 *Hz*

20. A source of sound gives five beats per second when sounded with another source of frequency $100\,s^{-1}$. The second harmonic of the source together with a source of frequency $205\,s^{-1}$ gives five beats per second. What is the frequency of the source

(a) $105\,s^{-1}$ (b) $205\,s^{-1}$

(c) $95\,s^{-1}$ (d) $100\,s^{-1}$

21. When two sound waves are superimposed, beats are produced when they have [MP PET 1995; CBSE PMT 1992, 99; DCE 2000; DPMT 2000, 01]

(a) Different amplitudes and phases

(b) Different velocities

(c) Different phases

(d) Different frequencies

22. Two tuning forks *A* and *B* give 4 beats per second. The frequency of *A* is 256 *Hz*. On loading *B* slightly, we get 5 beats in 2 seconds. The frequency of *B* after loading is [MP PMT 1990]

[Haryana CEE 1996]

(a) 253.5 *Hz* (b) 258.5 *Hz*

(c) 260 *Hz* [MP PMT 1991] (d) 252 *Hz*

23. A tuning fork *A* of frequency 200 *Hz* is sounded with fork *B*, the number of beats per second is 5. By putting some wax on *A*, the number of beats increases to 8. The frequency of fork *B* is

(a) 200 *Hz* (b) 195 *Hz*

(c) 192 *Hz* (d) 205 *Hz*

24. Two tuning forks, *A* and *B*, give 4 *beats per second* when sounded together. The frequency of *A* is 320 *Hz*. When some wax is added to *B* and it is sounded with *A*, 4 *beats per second* are again heard. The frequency of *B* is

[MP PMT 1997]

[CPMT 1990; DCE 1999]

(a) 312 *Hz* (b) 316 *Hz*

(c) 324 *Hz* (d) 328 *Hz*

25. Two tuning forks have frequencies 380 and 384 *Hz* respectively. When they are sounded together, they produce 4 beats. After hearing the maximum sound, how long will it take to hear the minimum sound

[MP PMT/PET 1998]

(a) $\frac{1}{2}$ *sec* (b) $\frac{1}{4}$ *sec*

(c) $\frac{1}{8}$ *sec* (d) $\frac{1}{16}$ *sec*

26. Beats are produced with the help of two sound waves of amplitudes 3 and 5 *units*. The ratio of maximum to minimum intensity in the beats is [MP PMT 1999]

(a) 2 : 1 (b) 5 : 3

(c) 4 : 1 (d) 16 : 1

27. Two waves of lengths 50 *cm* and 51 *cm* produced 12 beats per second. The velocity of sound is

[CBSE PMT 1999; Pb. PET 2001; AFMC 2003]

(a) 306 *m/s* (b) 331 *m/s*

(c) 340 *m/s* (d) 360 *m/s*

28. Two waves $y = 0.25 \sin 316\, t$ and $y = 0.25 \sin 310\, t$ are travelling in same direction. The number of beats produced per second will be

[CPMT 1993; JIPMER 2000]

(a) 6 (b) 3

(c) $3/\pi$ (d) 3π

29. The couple of tuning forks produces 2 beats in the time interval of 0.4 seconds. So the beat frequency is

[CPMT 1996]

(a) 8 *Hz* (b) 5 *Hz*

(c) 2 *Hz* (d) 10 *Hz*

30. An unknown frequency *x* produces 8 beats per seconds with a frequency of 250 *Hz* and 12 beats with 270 *Hz* source, then *x* is

(a) 258 *Hz* (b) 242 *Hz*

(c) 262 *Hz* (d) 282 *Hz*

31. Beats are produced by two waves

$$y_1 = a \sin 1000\pi t, \quad y_2 = a \sin 998\pi t$$

The number of beats heard/sec is [KCET 1998]

(a) 0 (b) 2

(c) 1 (d) 4

32. The wavelengths of two waves are 50 and 51 *cm* respectively. If the temperature of the room is 20°*C*, then what will be the number of beats produced per second by these waves, when the speed of sound at 0°*C* is 332 *m/sec*

[UPSEAT 1999]

(a) 14 (b) 10

(c) 24 (d) None of these

33. Maximum number of beats frequency heard by a human being is

(a) 10 (b) 4

(c) 20 (d) 6

34. Two sound waves of slightly different frequencies propagating in the same direction produce beats due to

[MP PET 2000]

(a) Interference (b) Diffraction

(c) Polarization (d) Refraction

35. On sounding tuning fork *A* with another tuning fork *B* of frequency 384 *Hz*, 6 *beats* are produced per second. After loading the prongs of *A* with some wax and then sounding it again with *B*, 4 beats are produced per second. What is the frequency of the tuning fork *A*

[MP PMT 2000]

(a) 388 *Hz* (b) 380 *Hz*

(c) 378 *Hz* (d) 390 *Hz*

36. It is possible to hear beats from the two vibrating sources of frequency [UPSEAT 2001]

(a) 100 *Hz* and 150 *Hz* (b) 20 *Hz* and 25 *Hz*

(c) 400 *Hz* and 500 *Hz* (d) 1000 *Hz* and 1500 *Hz*

37. A tuning fork gives 4 beats with 50 cm length of a sonometer wire. If the length of the wire is shortened by 1 cm, the number of beats is still the same. The frequency of the fork is

(a) 396 (b) 400

(c) 404 (d) 384

38. Two sound waves of wavelengths 5*m* and 6*m* formed 30 beats in 3 seconds. The velocity of sound is

[EAMCET 2001]

(a) 300 ms^{-1} (b) 310 ms^{-1}

(c) 320 ms^{-1} (d) 330 ms^{-1}

39. The wavelength of a particle is 99 cm and that of other is 100 cm. Speed of sound is 396 m/s. The number of beats heard is

(a) 4 (b) 5

(c) 1 (d) 8

40. A tuning fork arrangement (pair) produces 4 *beats/sec* with one fork of frequency 288 *cps*. A little wax is placed on the unknown fork and it then produces 2 *beats/sec*. The frequency of the unknown fork is

[CPMT 1997; KCET 2000] [KCET 1998; AIEEE 2002]

(a) 286 *cps* (b) 292 *cps*

(c) 294 *cps* (d) 288 *cps*

41. A tuning fork vibrates with 2 beats in 0.04 second. The frequency of the fork is [AFMC 2003]

(a) 50 *Hz* (b) 100 *Hz*

(c) 80 *Hz* (d) None of these

42. Two sound sources when sounded simultaneously produce four beats in 0.25 second. the difference in their frequencies must be

(a) 4 (b) 8

(c) 16 (d) 1

43. A tuning fork of known frequency 256 *Hz* makes 5 beats per second with the vibrating string of a piano. The beat frequency decreases to 2 beats per second when the tension in the piano string is slightly increased. The frequency of the piano string before increasing the tension was

[RPMT 2000] [AIEEE 2003]

(a) 256 + 5 *Hz* (b) 256 + 2*Hz*

(c) 256 – 2 *Hz* (d) 256 – 5*Hz*

44. When temperature increases, the frequency of a tuning fork

[AIEEE 2002]

(a) Increases

(b) Decreases

(c) Remains same

(d) Increases or decreases depending on the material

45. Two strings *X* and *Y* of a sitar produce a beat frequency 4 *Hz*. When the tension of the string *Y* is slightly increased the beat frequency is found to be 2 *Hz*. If the frequency of *X* is 300 *Hz*, then the original frequency of *Y* was

[UPSEAT 2000]

(a) 296 *Hz* (b) 298 *Hz*

(c) 302 *Hz* (d) 304 *Hz*

46. The frequency of tuning forks *A* and *B* are respectively 3% more and 2% less than the frequency of tuning fork *C*. When *A* and *B* are simultaneously excited, 5 beats per second are produced. Then the frequency of the tuning fork '*A*' (in *Hz*) is

(a) 98 (b) 100

(c) 103 (d) 105

47. When a tuning fork vibrates, the waves produced in the fork are

(a) Longitudinal (b) Transverse

(c) Progressive (d) Stationary

48. Two vibrating tuning forks produce progressive waves given by $Y_1 = 4\sin 500\pi t$ and $Y_2 = 2\sin 506\pi t$. Number of beats produced per minute is [CBSE PMT 2005]

(a) 360 (b) 180

(c) 3 (d) 60

49. When a tuning fork produces sound waves in air, which one of the following is same in the material of tuning fork as well as in air

(a) Wavelength (b) Frequency

(c) Velocity (d) Amplitude

50. The disc of a siren containing 60 holes rotates at a constant speed of 360 *rpm*. The emitted sound is in unison with a tuning fork of frequency [KCET 2005]

(a) 10 *Hz* (b) 360 *Hz*

(c) 216 *Hz* (d) 6 *Hz*

51. A sound source of frequency 170 *Hz* is placed near a wall. A man walking from a source towards the wall finds that there is a periodic rise and fall of sound intensity. If the speed of sound in air is 340 *m*/*s* the distance (in *metres*) separating the two adjacent positions of minimum intensity is

[MNR 1992; UPSEAT 2000; CPMT 2002]

(a) 1/2 (b) 1

(c) 3/2 (d) 2

Stationary Waves

1. The distance between the nearest node and antinode in a stationary wave is

[MP PET 1984; CBSE PMT 1993; AFMC 1996; RPET 2002]

(a) λ (b) $\frac{\lambda}{2}$

(c) $\frac{\lambda}{4}$ (d) 2λ

2. In stationary wave [MP PET 1987; BHU 1995]

(a) Strain is maximum at nodes

(b) Strain is maximum at antinodes

(c) Strain is minimum at nodes

(d) Amplitude is zero at all the points

3. The phase difference between the two particles situated on both the sides of a node is [MP PET 2002]

(a) 0° (b) 90°

(c) 180° (d) 360°

4. Which of the property makes difference between progressive and stationary waves [MP PMT 1987]

(a) Amplitude (b) Frequency

(c) Propagation of energy (d) Phase of the wave

5. Stationary waves are formed when

[NCERT 1983]

(a) Two waves of equal amplitude and equal frequency travel along the same path in opposite directions

(b) Two waves of equal wavelength and equal amplitude travel along the same path with equal speeds in opposite directions [EAMCET 2001]

(c) Two waves of equal wavelength and equal phase travel along the same path with equal speed

(d) Two waves of equal amplitude and equal speed travel along the same path in opposite direction [AFMC 2001]

6. For the stationary wave $y = 4\sin\left(\frac{\pi x}{15}\right)\cos(96\pi t)$, the distance between a node and the next antinode is

[MP PMT 1987]

(a) 7.5 (b) 15

(c) 22.5 (d) 30

7. The equation of stationary wave along a stretched string is given by $y = 5\sin\frac{\pi x}{3}\cos 40\pi t$, where *x* and *y* are in cm and *t* in second. The separation between two adjacent nodes is [CPMT 1990; MP PET 1999; AMU 19 [AFMC 2005] DPMT 2004; BHU 2005]

(a) 1.5 *cm* (b) 3 *cm*

(c) 6 *cm* (d) 4 *cm*

8. The equation $\vec{\phi}(x,t) = \vec{j}\sin\left(\frac{2\pi}{\lambda}vt\right)\cos\left(\frac{2\pi}{\lambda}x\right)$ represents

[MNR 1994]

(a) Transverse progressive wave

(b) Longitudinal progressive wave

(c) Longitudinal stationary wave

(d) Transverse stationary wave

9. The equation of a stationary wave is $y = 0.8\cos\left(\frac{\pi x}{20}\right)\sin 200\pi t$, where *x* is in *cm* and *t* is in *sec*. The separation between consecutive nodes will be

[MP PET 1994]

(a) 20 *cm* (b) 10 *cm*

(c) 40 *cm* (d) 30 *cm*

10. In a stationary wave, all particles are

[MP PMT 1994]

(a) At rest at the same time twice in every period of oscillation

(b) At rest at the same time only once in every period of oscillation

(c) Never at rest at the same time

(d) Never at rest at all

11. A wave represented by the given equation $y = a\cos(kx - \omega t)$ is superposed with another wave to form a stationary wave such that the point $x = 0$ is a node. The equation for the other wave is

AIIMS 1998; SCRA 1998; MP PET 2001; KCET 2001;

AIEEE 2002; UPSEAT 2004]

(a) $y = a\sin(kx + \omega t)$ (b) $y = -a\cos(kx + \omega t)$

(c) $y = -a\cos(kx - \omega t)$ (d) $y = -a\sin(kx - \omega t)$

12. At a certain instant a stationary transverse wave is found to have maximum kinetic energy. The appearance of string at that instant is

(a) Sinusoidal shape with amplitude $A/3$
(b) Sinusoidal shape with amplitude $A/2$
(c) Sinusoidal shape with amplitude A
(d) Straight line

13. The equation $y = 0.15\sin 5x \cos 300t$, describes a stationary wave. The wavelength of the stationary wave is

[MP PMT 1995]

(a) Zero (b) 1.256 *metres*
(c) 2.512 *metres* (d) 0.628 *metre*

14. In stationary waves, antinodes are the points where there is

[MP PMT 1996]

(a) Minimum displacement and minimum pressure change
(b) Minimum displacement and maximum pressure change
(c) Maximum displacement and maximum pressure change
(d) Maximum displacement and minimum pressure change

15. In stationary waves all particles between two nodes pass through the mean position

[MP PMT 1999; KCET 2001]

(a) At different times with different velocities
(b) At different times with the same velocity
(c) At the same time with equal velocity
(d) At the same time with different velocities

16. Standing waves can be produced [IIT-JEE 1999]

(a) On a string clamped at both the ends
(b) On a string clamped at one end and free at the other
(c) When incident wave gets reflected from a wall
(d) When two identical waves with a phase difference of π are moving in the same direction

17. A standing wave having 3 nodes and 2 antinodes is formed between two atoms having a distance 1.21 Å between them. The wavelength of the standing wave is

[CBSE PMT 1998; MH CET 2002; AIIMS 2000; BHU 2001]

(a) 1.21 Å (b) 2.42 Å
(c) 6.05 Å (d) 3.63 Å

18. In stationary waves, distance between a node and its nearest antinode is 20 *cm*. The phase difference between two particles having a separation of 60 *cm* will be

[CMEET Bihar 1995]

(a) Zero (b) $\pi/2$
(c) π (d) $3\pi/2$

19. Stationary waves of frequency 300 *Hz* are formed in a medium in which the velocity of sound is 1200 *metre/sec*. The distance between a node and the neighbouring antinode is

(a) 1 *m* (b) 2 *m*
(c) 3 *m* (d) 4 *m*

20. Which two of the given transverse waves will give stationary waves when get superimposed

[RPET 1997; MP PET 1993]

$z_1 = a\cos(kx - \omega t)$ .....(A)

[AIIMS 1995]

$z_2 = a\cos(kx + \omega t)$ .....(B)

$z_3 = a\cos(ky - \omega t)$ .....(C)

(a) A and B (b) A and C
(c) B and C (d) Any two

21. A standing wave is represented by

$$Y = A\sin(100t)\cos(0.01x)$$

where Y and A are in *millimetre*, t is in seconds and x is in *metre*. The velocity of wave is

[CBSE PMT 1994; AFMC 2002]

(a) $10^4\ m/s$
(b) $1\ m/s$
(c) $10^{-4}\ m/s$
(d) Not derivable from above data

22. A wave of frequency 100 *Hz* is sent along a string towards a fixed end. When this wave travels back after reflection, a node is formed at a distance of 10 *cm* from the fixed end of the string. The speed of incident (and reflected) wave are

[CBSE PMT 1994]

(a) 40 *m/s* (b) 20 *m/s*
(c) 10 *m/s* (d) 5 *m/s*

23. $y = a\cos(kx + \omega t)$ superimposes on another wave giving a stationary wave having node at $x = 0$. What is the equation of the other wave [BHU 1998; DPMT 2000]

(a) $-a\cos(kx + \omega t)$ (b) $a\cos(kx - \omega t)$
(c) $-a\cos(kx - \omega t)$ (d) $-a\sin(kx + \omega t)$

24. Two waves are approaching each other with a velocity of 20 *m/s* and frequency n. The distance between two consecutive nodes is

(a) $\frac{20}{n}$ (b) $\frac{10}{n}$
(c) $\frac{5}{n}$ (d) $\frac{n}{10}$

25. Energy is not carried by which of the following waves

[RPMT 1998; AIIMS 1998, 99]

(a) Stationary (b) Progressive
(c) Transverse (d) Electromagnetic

26. The stationary wave produced on a string is represented by the equation $y = 5\cos(\pi x/3)\sin 40\pi t$. Where x and y are in *cm* and t is in seconds. The distance between consecutive nodes is

(a) 5 *cm* (b) π cm
[SCRA 1994]
(c) 3 *cm* (d) 40 *cm*

27. Two sinusoidal waves with same wavelengths and amplitudes travel in opposite directions along a string with a speed 10 *ms*. If the minimum time interval between two instants when the string is flat is 0.5 *s*, the wavelength of the waves is

(a) 25 *m* (b) 20 *m*
(c) 15 *m* (d) 10 *m*

28. "Stationary waves" are so called because in them [MP PMT 2001]
(a) The particles of the medium are not disturbed at all
(b) The particles of the medium do not execute SHM
(c) There occurs no flow of energy along the wave
(d) The interference effect can't be observed

29. Two waves are approaching each other with a velocity of 16 *m/s* and frequency *n*. The distance between two consecutive nodes is
(a) $\frac{16}{n}$ (b) $\frac{8}{n}$
(c) $\frac{n}{16}$ (d) $\frac{n}{8}$

30. Stationary waves [Kerala (Med.) 2002]
(a) Transport energy
(b) Does not transport energy
(c) Have nodes and antinodes
(d) Both (b) and (c)

31. In a stationary wave all the particles [KCET 2002]
(a) On either side of a node vibrate in same phase
(b) In the region between two nodes vibrate in same phase
(c) In the region between two antinodes vibrate in same phase
(d) Of the medium vibrate in same phase

32. When a stationary wave is formed then its frequency is [Kerala (Engg.) 2002]
(a) Same as that of the individual waves
(b) Twice that of the individual waves
(c) Half that of the individual waves
(d) None of the above

33. In stationary waves [RPMT 1998; JIPMER 2002]
(a) Energy is uniformly distributed
(b) Energy is minimum at nodes and maximum at antinodes
(c) Energy is maximum at nodes and minimum at antinodes
(d) Alternating maximum and minimum energy producing at nodes and antinodes

34. Equation of a stationary wave is $y = 10\sin\frac{\pi x}{4}\cos 20\pi t$. Distance between two consecutive nodes is [MP PMT 2002]
(a) 4 (b) 2
(c) 1 (d) 8

35. At nodes in stationary waves [SCRA 1994; UPSEAT 2000; MP PET 2003; RPET 2003]
(a) Change in pressure and density are maximum
(b) Change in pressure and density are minimum
(c) Strain is zero
(d) Energy is minimum

36. Consider the three waves z_1, z_2 and z_3 as
$z_1 = A\sin(kx - \omega t)$, $z_2 = A\sin(kx + \omega t)$
and $z_3 = A\sin(ky - \omega t)$. Which of the following represents a standing wave [DCE 2004]
(a) $z_1 + z_2$ (b) $z_2 + z_3$
(c) $z_3 + z_1$ (d) $z_1 + z_2 + z_3$

37. The following equations represent progressive transverse waves $Z_1 = A\cos(\omega t - kx)$, $Z_2 = A\cos(\omega t + kx)$, $Z_3 = A\cos(\omega t + ky)$ and $Z_4 = A\cos(2\omega t - 2ky)$. A stationary wave will be formed by superposing [MP PET 1993]
(a) Z_1 and Z_2 (b) Z_1 and Z_4
(c) Z_2 and Z_3 (d) Z_3 and Z_4

38. Two travelling waves $y_1 = A\sin[k(x - ct)]$ and $y_2 = A\sin[k(x + ct)]$ are superimposed on string. The distance between adjacent nodes is [CPMT 2001; Pb. PMT 1999] [IIT 1992]
(a) ct/π (b) $ct/2\pi$
(c) $\pi/2k$ (d) π/k

39. A string vibrates according to the equation $y = 5\sin\left(\frac{2\pi x}{3}\right)\cos 20\pi t$, where *x* and *y* are in *cm* and *t* in *sec*. The distance between two adjacent nodes is [UPSEAT 2005]
(a) 3 *cm* (b) 4.5 *cm*
(c) 6 *cm* (d) 1.5 *cm*

Vibration of String

1. A string fixed at both the ends is vibrating in two segments. The wavelength of the corresponding wave is [SCRA 1994]
(a) $\frac{l}{4}$ (b) $\frac{l}{2}$
(c) l (d) $2l$

2. A 1 *cm* long string vibrates with fundamental frequency of 256 *Hz*. If the length is reduced to $\frac{1}{4}cm$ keeping the tension unaltered, the new fundamental frequency will be [BHU 1997]
(a) 64 (b) 256
(c) 512 (d) 1024

3. Standing waves are produced in a 10 *m* long stretched string. If the string vibrates in 5 segments and the wave velocity is 20 *m/s*, the frequency is [CBSE PMT 1997; AIIMS 1998; JIPMER 2000]
(a) 2 *Hz* (b) 4 *Hz*
(c) 5 *Hz* (d) 10 *Hz*

4. The velocity of waves in a string fixed at both ends is 2 *m/s*. The string forms standing waves with nodes 5.0 *cm* apart. The frequency of vibration of the string in *Hz* is [SCRA 1998]
(a) 40 (b) 30
(c) 20 (d) 10

5. Which of the following is the example of transverse wave [CPMT 1999]
(a) Sound waves
(b) Compressional waves in a spring
(c) Vibration of string
(d) All of these

6. A stretched string of 1*m* length and mass $5 \times 10^{-4} kg$ is having tension of 20*N*. If it is plucked at 25*cm* from one end then it will vibrate with frequency

[RPET 1999; RPMT 2002]

(a) 100 *Hz* (b) 200 *Hz*

(c) 256 *Hz* (d) 400 *Hz*

7. Two similar sonometer wires given fundamental frequencies of 500*Hz*. These have same tensions. By what amount the tension be increased in one wire so that the two wires produce 5 *beats/sec* [RPET 1999]

(a) 1% (b) 2%

(c) 3% (d) 4%

8. A string is producing transverse vibration whose equation is $y = 0.021\sin(x + 30t)$, Where x and y are in meters and t is in seconds. If the linear density of the string is 1.3×10^{-4} *kg/m*, then the tension in the string in N will be

[RPET 1999; RPMT 2002]

(a) 10 (b) 0.5

(c) 1 (d) 0.117

9. If the tension of sonometer's wire increases four times then the fundamental frequency of the wire will increase by

[RPMT 1999]

(a) 2 times (b) 4 times

(c) 1/2 times (d) None of the above

10. If vibrations of a string are to be increased by a factor of two, then tension in the string must be made

[AIIMS 1999; Pb. PET 2000]

(a) Half (b) Twice

(c) Four times (d) Eight times

11. Four wires of identical length, diameters and of the same material are stretched on a sonometre wire. If the ratio of their tensions is 1 : 4 : 9 : 16 then the ratio of their fundamental frequencies are [KCET 2000]

(a) 16 : 9 : 4 : 1 (b) 4 : 3 : 2 : 1

(c) 1 : 4 : 2 : 16 (d) 1 : 2 : 3 : 4

12. A tuning fork vibrating with a sonometer having 20 *cm* wire produces 5 beats per second. The beat frequency does not change if the length of the wire is changed to 21 *cm*. the frequency of the tuning fork (in Hertz) must be

[UPSEAT 2000; Pb. PET 2004]

(a) 200 (b) 210

(c) 205 (d) 215

13. A stretched string of length l, fixed at both ends can sustain stationary waves of wavelength λ, given by

[UPSEAT 2000; Pb. PET 2004; CPMT 2005]

(a) $\lambda = \frac{n^2}{2l}$ (b) $\lambda = \frac{l^2}{2n}$

(c) $\lambda = \frac{2l}{n}$ (d) $\lambda = 2l\,n$

14. If you set up the seventh harmonic on a string fixed at both ends, how many nodes and antinodes are set up in it

[AMU 2000]

(a) 8, 7 (b) 7, 7

(c) 8, 9 (d) 9, 8

15. If you set up the ninth harmonic on a string fixed at both ends, its frequency compared to the seventh harmonic

[AMU (Engg.) 2000]

(a) Higher (b) Lower

(c) Equal (d) None of the above

16. Frequency of a sonometer wire is *n*. Now its tension is increased 4 times and its length is doubled then new frequency will be

(a) *n*/2 (b) 4*n*

(c) 2*n* (d) *n*

17. A device used for investigating the vibration of a fixed string or wire is [BHU 2000]

(a) Sonometer (b) barometer

(c) Hydrometer (d) None of these

18. A string on a musical instrument is 50 *cm* long and its fundamental frequency is 270 *Hz*. If the desired frequency of 1000 *Hz* is to be produced, the required length of the string is

[EAMCET (Engg.) 1998; CPMT 2000; Pb. PET 2001]

(a) 13.5 *cm* (b) 2.7 *cm*

(c) 5.4 *cm* (d) 10.3 *cm*

19. The tension in a piano wire is 10N. What should be the tension in the wire to produce a note of double the frequency

(a) 5 *N* (b) 20 *N*

(c) 40 *N* (d) 80 *N*

20. To increase the frequency from 100 *Hz* to 400 *Hz* the tension in the string has to be changed by [RPET 2001]

(a) 4 times (b) 16 times

(c) 20 times (d) None of these

21. In order to double the frequency of the fundamental note emitted by a stretched string, the length is reduced to $\frac{3}{4}$ *th* of the original length and the tension is changed. The factor by which the tension is to be changed, is [EAMCET 2001]

(a) $\frac{3}{8}$ (b) $\frac{2}{3}$

(c) $\frac{8}{9}$ (d) $\frac{9}{4}$

22. A string of 7 *m* length has a mass of 0.035 *kg*. If tension in the string is 60.5 *N*, then speed of a wave on the string is

[CBSE PMT 2001]

(a) 77 *m/s* (b) 102 *m/s*

(c) 110 *m/s* (d) 165 *m/s*

23. A second harmonic has to be generated in a string of length l stretched between two rigid supports. The point where the string has to be plucked and touched are

[KCET 2001]

(a) Plucked at $\frac{l}{4}$ and touch at $\frac{l}{2}$

(b) Plucked at $\frac{l}{4}$ and touch at $\frac{3l}{4}$

(c) Plucked at $\frac{l}{2}$ and touched at $\frac{l}{4}$

(d) Plucked at $\frac{l}{2}$ and touched at $\frac{3l}{4}$

24. Transverse waves of same frequency are generated in two steel wires *A* and *B*. The diameter of *A* is twice of *B* and the tension in *A* is half that in *B*. The ratio of velocities of wave in *A* and *B* is

(a) $1:3\sqrt{2}$ (b) $1:2\sqrt{2}$

(c) $1:2$ (d) $\sqrt{2}:1$

25. A sonometer wire resonates with a given tuning fork forming standing waves with five antinodes between the two bridges when a mass of 9 *kg* is suspended from the wire. When this mass is replaced by a mass *M*, the wire resonates with the same tuning fork forming three antinodes for the same positions of the bridges. The value of *M* is

[IIT-JEE (Screening) 2002]

(a) 25 *kg* (b) 5 *kg*
(c) 12.5 *kg* (d) 1/25 *kg*

26. The tension of a stretched string is increased by 69%. In order to keep its frequency of vibration constant, its length must be increased by [KCET 2002]

(a) 20% (b) 30%
(c) $\sqrt{69}\%$ (d) 69%

27. The length of a sonometer wire tuned to a frequency of 250 *Hz* is 0.60 *metre*. The frequency of tuning fork with which the vibrating wire will be in tune when the length is made 0.40 *metre* is

(a) 250 *Hz* (b) 375 *Hz*
(c) 256 *Hz* (d) 384 *Hz*

28. Length of a string tied to two rigid supports is 40 *cm*. Maximum length (wavelength in *cm*) of a stationary wave produced on it is

(a) 20 (b) 80
(c) 40 (d) 120

29. A string in musical instrument is 50 *cm* long and its fundamental frequency is 800 *Hz*. If a frequency of 1000 *Hz* is to be produced, then required length of string is

[AIIMS 2002]

(a) 62.5 *cm* (b) 50 *cm*
(c) 40 *cm* (d) 37.5 *cm*

30. Two wires are in unison. If the tension in one of the wires is increased by 2%, 5 beats are produced per second. The initial frequency of each wire is [MP PET 2002]

(a) 200 *Hz* (b) 400 *Hz*
(c) 500 *Hz* (d) 1000 *Hz*

31. Two uniform strings *A* and *B* made of steel are made to vibrate under the same tension. if the first overtone of *A* is equal to the second overtone of *B* and if the radius of *A* is twice that of *B*, the ratio of the lengths of the strings is

[EAMCET 2003]

(a) 1: 2 (b) 1 : 3
(c) 1 : 4 (d) 1 : 6

32. If the length of a stretched string is shortened by 40% and the tension is increased by 44%, then the ratio of the final and initial fundamental frequencies is

[EAMCET 2003]

(a) 2 : 1 (b) 3 : 2
(c) 3 : 4 (d) 1 : 3

33. Two wires are fixed in a sonometer. Their tensions are in the ratio 8 : 1. The lengths are in the ratio $36:35$. The diameters are in the ratio 4 : 1. Densities of the materials are in the ratio 1 : 2. If the lower frequency in the setting is 360 *Hz*. the beat frequency when the two wires are sounded together is

(a) 5 (b) 8
(c) 6 (d) 10

34. The first overtone of a stretched wire of given length is 320 *Hz*. The first harmonic is : [DPMT 2004]

(a) 320 *Hz* (b) 160 *Hz*
(c) 480 *Hz* (d) 640 *Hz*

35. Two perfectly identical wires are in unison. When the tension in one wire is increased by 1%, then on sounding them together 3 beats are heard in 2 *sec*. The initial frequency of each wire is :

(a) $220s^{-1}$ (b) $320s^{-1}$
(c) $150s^{-1}$ (d) $300s^{-1}$

36. A tuning fork of frequency 392 *Hz*, resonates with 50 *cm* length of a string under tension (*T*). If length of the string is decreased by 2%, keeping the tension constant, the number of beats heard when the string and the tuning fork made to vibrate simultaneously is

(a) 4 (b) 6
(c) 8 (d) 12

37. The sound carried by air from a sitar to a listener is a wave of the following type [JIPMER 2002] [MP PMT 1987; RPET 2001]

(a) Longitudinal stationary (b) Transverse progressive
(c) Transverse stationary (d) Longitudinal progressive

38. In Melde's experiment in the transverse mode, the frequency of the [AIEEE 2002] tuning fork and the frequency of the waves in the strings are in the ratio [KCET 2004]

(a) 1 : 1 (b) 1 : 2
(c) 2 : 1 (d) 4 : 1

39. The frequency of transverse vibrations in a stretched string is 200 *Hz*. If the tension is increased four times and the length is reduced to one-fourth the original value, the frequency of vibration will be

(a) 25 *Hz* (b) 200 *Hz*
(c) 400 *Hz* (d) 1600 *Hz*

40. Three similar wires of frequency n_1, n_2 and n_3 are joined to make one wire. Its frequency will be

[CBSE PMT 2000]

(a) $n=n_1+n_2+n_3$ (b) $\frac{1}{n}=\frac{1}{n_1}+\frac{1}{n_2}+\frac{1}{n_3}$

(c) $\frac{1}{\sqrt{n}}=\frac{1}{\sqrt{n_1}}+\frac{1}{\sqrt{n_2}}+\frac{1}{\sqrt{n_3}}$ (d) $\frac{1}{n^1}=\frac{1}{n_1^2}+\frac{1}{n_2^2}+\frac{1}{n_3^2}$

41. A steel rod 100 *cm* long is clamped at its mid-point. The fundamental frequency of longitudinal vibrations of the rod is given to be 2.53 *kHz*. What is the speed of sound in steel

[AFMC 2000]

(a) 5.06 *km/s* (b) 6.06 *km/s*
(c) 7.06 *km/s* (d) 8.06 *km/s*

42. Two wires are producing fundamental notes of the same frequency. Change in which of the following factors of one wire will not produce beats between them

[BHU (Med.) 1999]

(a) Amplitude of the vibrations
(b) Material of the wire
[KCET 2003] (c) Stretching force
(d) Diameter of the wires

43. Calculate the frequency of the second harmonic formed on a string of length 0.5 *m* and mass 2×10^{-4} *kg* when stretched with a tension of 20 *N* **[BHU (Med.) 2000]**

(a) 274.4 *Hz* (b) 744.2 *Hz*

(c) 44.72 *Hz* (d) 447.2 *Hz*

44. The fundamental frequency of a string stretched with a weight of 4 *kg* is 256 *Hz*. The weight required to produce its octave is

(a) 4 *kg wt* (b) 8 *kg wt*

(c) 12 *kg wt* (d) 16 *kg wt*

45. Two vibrating strings of the same material but lengths L and $2L$ have radii $2r$ and r respectively. They are stretched under the same tension. Both the strings vibrate in their fundamental modes, the one of length L with frequency n_1 and the other with frequency n_2. The ratio n_1/n_2 is given by

[IIT-JEE (Screening) 2000]

(a) 2 (b) 4

(c) 8 (d) 1

46. If the tension and diameter of a sonometer wire of fundamental frequency n are doubled and density is halved then its fundamental frequency will become

[CBSE PMT 2001]

(a) $\frac{n}{4}$ (b) $\sqrt{2}\,n$

(c) n (d) $\frac{n}{\sqrt{2}}$

47. In a sonometer wire, the tension is maintained by suspending a 50.7 *kg* mass from the free end of the wire. The suspended mass has a volume of 0.0075 m^3. The fundamental frequency of the wire is 260 *Hz*. If the suspended mass is completely submerged in water, the fundamental frequency will become (take $g = 10\ ms^{-2}$)

[KCET 2001]

(a) 240 *Hz* (b) 230 *Hz*

(c) 220 *Hz* (d) 200 *Hz*

48. A string is rigidly tied at two ends and its equation of vibration is given by $y = \cos 2\pi t \sin \sin \pi x$. Then minimum length of string is **[RPMT 2001]**

(a) 1 *m* (b) $\frac{1}{2}m$

(c) 5 *m* (d) $2\pi m$

49. Fundamental frequency of sonometer wire is n. If the length, tension and diameter of wire are tripled, the new fundamental frequency is

(a) $\frac{n}{\sqrt{3}}$ (b) $\frac{n}{3}$

(c) $n\sqrt{3}$ (d) $\frac{n}{3\sqrt{3}}$

50. A string of length 2 *m* is fixed at both ends. If this string vibrates in its fourth normal mode with a frequency of 500 *Hz* then the waves would travel on its with a velocity of

[BCECE 2005]

(a) 125 *m/s* (b) 250 *m/s*

(c) 500 *m/s* (d) 1000 *m/s*

51. The fundamental frequency of a sonometre wire is n. If its radius is doubled and its tension becomes half, the material of the wire remains same, the new fundamental frequency will be **[BCECE 2005]**

(a) n (b) $\frac{n}{\sqrt{2}}$

(c) $\frac{n}{2}$ (d) $\frac{n}{2\sqrt{2}}$

52. In an experiment with sonometer a tuning fork of frequency 256 *Hz* resonates with a length of 25 *cm* and another tuning fork resonates with a length of 20 *cm*. Tension of the string remaining constant the frequency of the second tuning fork is **[J & K CET 2000]**

(a) 163.84 *Hz* (b) 400 *Hz*

(c) 320 *Hz* (d) 204.8 *Hz*

Organ Pipe (Vibration of Air Column)

1. The length of two open organ pipes are l and $(l + \Delta l)$ respectively. Neglecting end correction, the frequency of beats between them will be approximately

[MP PET 1994; BHU 1995]

(a) $\frac{v}{2l}$ (b) $\frac{v}{4l}$

(c) $\frac{v\Delta l}{2l^2}$ (d) $\frac{v\Delta l}{l}$

(Here v is the speed of sound)

2. A tube closed at one end and containing air is excited. It produces the fundamental note of frequency 512 *Hz*. If the same tube is open at both the ends the fundamental frequency that can be produced is

(a) 1024 *Hz* (b) 512 *Hz*

(c) 256 *Hz* (d) 128 *Hz*

3. A closed pipe and an open pipe have their first overtones identical in frequency. Their lengths are in the ratio

[Roorkee 1999]

(a) 1 : 2 (b) 2 : 3

(c) 3 : 4 (d) 4 : 5

4. The first overtone in a closed pipe has a frequency

[JIPMER 1999]

(a) Same as the fundamental frequency of an open tube of same length

(b) Twice the fundamental frequency of an open tube of same length

(c) Same as that of the first overtone of an open tube of same length

(d) None of the above **[DPMT 2002]**

5. An empty vessel is partially filled with water, then the frequency of vibration of air column in the vessel

[KCET 2000]

(a) Remains same

(b) Decreases

(c) Increases

(d) First increases then decreases

6. It is desired to increase the fundamental resonance frequency in a tube which is closed at one end. This can be achieved by

(a) Replacing the air in the tube by hydrogen gas

(b) Increasing the length of the tube

(c) Decreasing the length of the tube

(d) Opening the closed end of the tube

7. An air column in a pipe, which is closed at one end, will be in resonance with a vibrating body of frequency 166 *Hz*, if the length of the air column is **[UPSEAT 2001]**

(a) 2.00 *m* (b) 1.50 *m*

(c) 1.00 *m* (d) 0.50 *m*

8. If the velocity of sound in air is 350 *m/s*. Then the fundamental frequency of an open organ pipe of length 50 *cm*, will be [CPMT 1997; MH CET 2001; Pb. PMT 2001]

(a) 350 *Hz* (b) 175 *Hz*

(c) 900 *Hz* (d) 750 *Hz*

9. If the length of a closed organ pipe is 1m and velocity of sound is 330 *m/s*, then the frequency for the second note is

[AFMC 2001]

(a) $4\times\frac{330}{4}Hz$ (b) $3\times\frac{330}{4}Hz$

(c) $2\times\frac{330}{4}Hz$ (d) $2\times\frac{4}{330}Hz$

10. The fundamental note produced by a closed organ pipe is of frequency f. The fundamental note produced by an open organ pipe of same length will be of frequency

[BHU 2001]

(a) $\frac{f}{2}$ (b) f

(c) $2f$ (d) $4f$

11. If the velocity of sound in air is 336 m/s. The *maximum* length of a closed pipe that would produce a just audible sound will be [KCET 2001]

(a) 3.2 *cm* (b) 4.2 *m*

(c) 4.2 *cm* (d) 3.2 *m*

12. An organ pipe P_1 closed at one end vibrating in its first overtone and another pipe P_2 open at both ends vibrating in its third overtone are in resonance with a given tuning fork. The ratio of lengths of P_1 and P_2 is

[EAMCET 1997; MH CET 1999; AFMC 2001]

(a) 1 : 2 (b) 1 : 3

(c) 3 : 8 (d) 3 : 4

13. A resonance air column of length 20 *cm* resonates with a tuning fork of frequency 250 *Hz*. The speed of sound in air is

[AFMC 1999; BHU 2000; CPMT 2001]

(a) 300 *m/s* (b) 200 *m/s*

(c) 150 *m/s* (d) 75 *m/s*

14. A cylindrical tube, open at both ends, has a fundamental frequency f_0 in air. The tube is dipped vertically into water such that half of its length is inside water. The fundamental frequency of the air column now is

[RPET 1999; RPMT 1998, 2000; J & K CET 2000; KCET 2002; BHU 2002; BCECE 2003]

(a) $3f_0/4$ (b) f_0

(c) $f_0/2$ (d) $2f_0$

15. If the length of a closed organ pipe is 1.5 *m* and velocity of sound is 330 *m/s*, then the frequency for the second note is

[CBSE PMT 2002]

(a) 220 *Hz* (b) 165 *Hz*

(c) 110 *Hz* (d) 55 *Hz*

16. A pipe 30 *cm* long is open at both ends. Which harmonic mode of the pipe is resonantly excited by a 1.1 *kHz* source ? (Take speed of sound in air = 330 *ms*$^{-1}$)

[AMU 2002]

(a) First (b) Second

(c) Third (d) Fourth

17. Two closed organ pipes, when sounded simultaneously gave 4 beats per sec. If longer pipe has a length of 1*m*. Then length of shorter pipe will be, (v = 300 *m/s*)

[Pb. PMT 2002]

(a) 185.5 *cm* (b) 94.9 *cm*

(c) 90 *cm* (d) 80 *cm*

18. A source of sound placed at the open end of a resonance column sends an acoustic wave of pressure amplitude ρ_0 inside the tube. If the atmospheric pressure is ρ_A, then the ratio of maximum and minimum pressure at the closed end of the tube will be

(a) $\frac{(\rho_A+\rho_0)}{(\rho_A-\rho_0)}$ (b) $\frac{(\rho_A+2\rho_0)}{(\rho_A-2\rho_0)}$

(c) $\frac{\rho_A}{\rho_A}$ (d) $\frac{\left(\rho_A+\frac{1}{2}\rho_0\right)}{\left(\rho_A-\frac{1}{2}\rho_0\right)}$

19. Two closed pipe produce 10 beats per second when emitting their fundamental nodes. If their length are in ratio of 25 : 26. Then their fundamental frequency in *Hz*, are

[MH CET 2002]

(a) 270, 280 (b) 260, 270

(c) 260, 250 (d) 260, 280

20. A closed organ pipe and an open organ pipe are tuned to the same fundamental frequency. What is the ratio of lengths

(a) 1 : 2 (b) 2 : 1

(c) 2 : 3 (d) 4 : 3

21. An open pipe resonates with a tuning fork of frequency 500 *Hz*. it is observed that two successive nodes are formed at distances 16 and 46 *cm* from the open end. The speed of sound in air in the pipe is

(a) 230 *m/s* (b) 300 *m/s*

(c) 320 *m/s* (d) 360 *m/s*

22. Find the fundamental frequency of a closed pipe, if the length of the air column is 42 *m*. (speed of sound in air = 332 *m/sec*)

(a) 2 *Hz* (b) 4 *Hz*

(c) 7 *Hz* (d) 9 *Hz*

23. If v is the speed of sound in air then the shortest length of the closed pipe which resonates to a frequency n

[KCET 2003]

(a) $\frac{v}{4n}$ (b) $\frac{v}{2n}$

(c) $\frac{2n}{v}$ (d) $\frac{4n}{v}$

24. The frequency of fundamental tone in an open organ pipe of length 0.48 *m is* 320 *Hz*. Speed of sound is 320 *m/sec*. Frequency of fundamental tone in closed organ pipe will be

[MP PMT 2003]

(a) 153.8 *Hz* (b) 160.0 *Hz*

(c) 320.0 *Hz* (d) 143.2 *Hz*

25. If fundamental frequency of closed pipe is 50 *Hz* then frequency of 2nd overtone is [AFMC 2004]

(a) 100 *Hz* (b) 50 *Hz*

(c) 250 *Hz* (d) 150 *Hz*

26. Two open organ pipes of length 25 *cm* and 25.5 *cm* produce 10 *beat/sec*. The velocity of sound will be [Pb. PMT 2004]

(a) 255 *m/s* (b) 250 *m/s*

(c) 350 *m/s* (d) None of these

27. What is minimum length of a tube, open at both ends, that resonates with tuning fork of frequency 350 *Hz* ? [velocity of sound in air = 350 *m/s*] [DPMT 2004]

(a) 50 *cm* (b) 100 *cm*

(c) 75 *cm* (d) 25 *cm*

28. Two open organ pipes give 4 *beats/sec* when sounded together in their fundamental nodes. If the length of the pipe are 100 *cm* and 102.5 *cm* respectively, then the velocity of sound is : [Pb. PET 2000; CPMT 2001]

(a) 496 *m/s* (b) 328 *m/s*

(c) 240 *m/s* (d) 160 *m/s*

29. The harmonics which are present in a pipe open at one end are [UPSEAT 2000; MHCET 2004]

(a) Odd harmonics

(b) Even harmonics

(c) Even as well as odd harmonics

(c) None of these

30. An open pipe is suddenly closed at one end with the result that the frequency of third harmonic of the closed pipe is found to be higher by 100 *Hz*, then the fundamental frequency of open pipe is: [UPSEAT 2001; Pb. PET 2004]

(a) 480 *Hz* (b) 300 *Hz*

(c) 240 *Hz* (d) 200 *Hz*

31. Tube *A* has both ends open while tube *B* has one end closed, otherwise they are identical. The ratio of fundamental frequency of tube *A* and *B* is [AIEEE 2002; CPMT 2004]

(a) 1 : 2 (b) 1 : 4

(c) 2 : 1 (d) 4 : 1

32. If the temperature increases, then what happens to the frequency of the sound produced by the organ pipe [RPET 1996; DPMT 2000; RPMT 2001]

(a) Increases (b) Decreases

(c) Unchanged (d) Not definite

33. Apparatus used to find out the velocity of sound in gas is [AFMC 2004]

(a) Melde's apparatus (b) Kundt's tube

(c) Quincke's tube (d) None of these

34. Standing stationary waves can be obtained in an air column even if the interfering waves are [CPMT 1972]

(a) Of different pitches

(b) Of different amplitudes

(c) Of different qualities

(d) Moving with different velocities

35. The stationary wave $y = 2a\sin kx\cos\omega t$ in a closed organ pipe is the result of the superposition of $y = a\sin(\omega t - kx)$ and

(a) $y = -a\cos(\omega t + kx)$ (b) $y = -a\sin(\omega t + kx)$

(c) $y = a\sin(\omega t + kx)$ (d) $y = a\cos(\omega t + kx)$

36. Stationary waves are set up in air column. Velocity of sound in air is 330 *m/s* and frequency is 165 *Hz*. Then distance between the nodes is [EAMCET (Engg.) 1995; CPMT 1999]

(a) 2 *m* (b) 1 *m*

(c) 0.5 *m* (d) 4 *m*

37. An open pipe of length *l* vibrates in fundamental mode. The pressure variation is maximum at [EAMCET (Med.) 1999]

(a) 1/4 from ends

(b) The middle of pipe

(c) The ends of pipe

(d) At 1/8 from ends of pipe middle of the pipe

38. Fundamental frequency of pipe is 100 *Hz* and other two frequencies are 300 *Hz* and 500 *Hz* then [RPMT 1998, 2003; CPMT 2001]

(a) Pipe is open at both the ends

(b) Pipe is closed at both the ends

(c) One end open and another end is closed

(d) None of the above

39. Fundamental frequency of an open pipe of length 0.5 *m* is equal to the frequency of the first overtone of a closed pipe of length *l*. The value of *l* is (*m*) [KCET 1999]

(a) 1.5 (b) 0.75

(c) 2 (d) 1

40. In a closed organ pipe the frequency of fundamental note is 50 *Hz*. The note of which of the following frequencies will not be emitted by it [J & K CET 2000]

(a) 50 *Hz* (b) 100 *Hz*

(c) 150 *Hz* (d) None of the above

41. On producing the waves of frequency 1000 *Hz* in a Kundt's tube, the total distance between 6 successive nodes is 85 *cm*. Speed of sound in the gas filled in the tube is [AFMC 1999]

(a) 330 *m/s* (b) 340 *m/s*

(c) 350 *m/s* (d) 300 *m/s*

42. What is the base frequency if a pipe gives notes of frequencies 425, 255 and 595 and decide whether it is closed at one end or open at both ends [UPSEAT 2001]

(a) 17, closed (b) 85, closed

(c) 17, open (d) 85, open

43. A student determines the velocity of sound with the help of a closed organ pipe. If the observed length for fundamental frequency is 24.7 *m*, the length for third harmonic will be [RPET 2002]

(a) 74 [Roorkee 1994] (b) 72.7 *cm*

(c) 75.4 *cm* (d) 73.1 *cm*

44. An open pipe of length 33 *cm* resonates with frequency of 100 *Hz*. If the speed of sound is 330 *m/s*, then this frequency is

(a) Fundamental frequency of the pipe

(b) Third harmonic of the pipe

(c) Second harmonic of the pipe

(d) Fourth harmonic of the pipe

45. In a resonance tube the first resonance with a tuning fork occurs at 16 *cm* and second at 49 *cm*. If the velocity of sound is 330 *m/s*, the frequency of tuning fork is [DPMT 2002]

(a) 500 (b) 300

(c) 330 (d) 165

46. Two closed organ pipes of length 100 *cm* and 101 *cm* 16 beats in 20 *sec*. When each pipe is sounded in its fundamental mode calculate the velocity of sound [AFMC 2003]

(a) 303 *ms* (b) 332 *ms*

(c) 323.2 *ms* (d) 300 *ms*

47. In open organ pipe, if fundamental frequency is n then the other frequencies are [BCECE 2005]

(a) $n, 2n, 3n, 4n$ (b) $n, 3n, 5n$

(c) $n, 2n, 4n, 8n$ (d) None of these

48. If in an experiment for determination of velocity of sound by resonance tube method using a tuning fork of 512 *Hz*, first resonance was observed at 30.7 *cm* and second was obtained at 63.2 *cm*, then maximum possible error in velocity of sound is (consider actual speed of sound in air is 332 *m/s*)

(a) 204 *cm/sec* (b) 110 *cm/sec*

(c) 58 *cm/sec* (d) 80 *cm/sec*

49. An organ pipe, open from both end produces 5 beats per second when vibrated with a source of frequency 200 *Hz*. The second harmonic of the same pipes produces 10 beats per second with a source of frequency 420 *Hz*. The frequency of source is

(a) 195 *Hz* (b) 205 *Hz*

(c) 190 *Hz* (d) 210 *Hz*

50. In one metre long open pipe what is the harmonic of resonance obtained with a tuning fork of frequency 480 *Hz* [J & K CET 2005]

(a) First (b) Second

(c) Third (d) Fourth

51. An organ pipe open at one end is vibrating in first overtone and is in resonance with another pipe open at both ends and vibrating in third harmonic. The ratio of length of two pipes is

(a) 1 : 2 (b) 4 : 1

(c) 8 : 3 (d) 3 : 8

52. In a resonance pipe the first and second resonances are obtained at depths 22.7 *cm* and 70.2 *cm* respectively. What will be the end correction [J & K CET 2005]

(a) 1.05 *cm* (b) 115.5 *cm*

(c) 92.5 *cm* (d) 113.5 *cm*

53. An open tube is in resonance with string (frequency of vibration of tube is n). If tube is dipped in water so that 75% of length of tube is inside water, then the ratio of the frequency of tube to string now will be [J & K CET 2005]

(a) 1 (b) 2

(c) $\frac{2}{3}$ (d) $\frac{3}{2}$

Doppler's Effect

1. Doppler shift in frequency does not depend upon [MP PMT 1993; DPMT 2000]

(a) The frequency of the wave produced

(b) The velocity of the source

(c) The velocity of the observer

(d) Distance from the source to the listener

2. A source of sound of frequency 450 *cycles/sec* is moving towards a stationary observer with 34 *m/sec* speed. If the speed of sound is 340 *m/sec*, then the apparent frequency will be

(a) 410 *cycles/sec* (b) 500 *cycles/sec*

(c) 550 *cycles/sec* (d) 450 *cycles/sec*

3. The wavelength is 120 *cm* when the source is stationary. If the source is moving with relative velocity of 60 *m/sec* towards the observer, then the wavelength of the sound wave reaching to the observer will be (velocity of sound = 330 *m/s*)

(a) 98 *cm* (b) 140 *cm*

(c) 120 *cm* (d) 144 *cm*

4. The frequency of a whistle of an engine is 600 *cycles/sec* is moving with the speed of 30 *m/sec* towards an observer. The apparent frequency will be (velocity of sound = 330 *m/s*) [IIT-JEE (Screening) 2005

(a) 600 *cps* (b) 660 *cps*

(c) 990 *cps* (d) 330 *cps*

5. A source of sound emits waves with frequency f *Hz* and speed V *m/sec*. Two observers move away from this source in opposite directions each with a speed 0.2 V relative to the source. The ratio of frequencies heard by the two observers will be [DCE 2005]

(a) 3 : 2 (b) 2 : 3

(c) 1 : 1 (d) 4 : 10

6. The source producing sound and an observer both are moving along the direction of propagation of sound waves. If the respective velocities of sound, source and an observer are v, v_s and v_o, then the apparent frequency heard by the observer will be (n = frequency of sound) [MP PMT 1989]

(a) $\frac{n(v+v_o)}{v-v_o}$ [DCE 2005] (b) $\frac{n(v-v_o)}{v-v_s}$

(c) $\frac{n(v-v_o)}{v+v_s}$ (d) $\frac{n(v+v_o)}{v+v_s}$

7. An observer moves towards a stationary source of sound of frequency n. The apparent frequency heard by him is $2n$. If the velocity of sound in air is 332 m/sec, then the velocity of the observer is [MP PET 1990]

(a) 166 *m/sec* (b) 664 *m/sec*

(c) 332 *m/sec* (d) 1328 *m/sec*

8. An observer is moving towards the stationary source of sound, then

(a) Apparent frequency will be less than the real frequency

(b) Apparent frequency will be greater than the real frequency

(c) Apparent frequency will be equal to real frequency

(d) Only the quality of sound will change

9. A whistle sends out 256 waves in a second. If the whistle approaches the observer with velocity 1/3 of the velocity of sound in air, the number of waves per second the observer will receive [MP PET 1990; DPMT 2002]

(a) 384 (b) 192

(c) 300 (d) 200

10. A person feels 2.5% difference of frequency of a motor-car horn. If the motor-car is moving to the person and the velocity of sound is 320 *m/sec*, then the velocity of car will be

(a) 8 *m/s* (approx.) (b) 800 *m/s*

(c) 7 *m/s* (d) 6 *m/s* (approx.)

11. Two passenger trains moving with a speed of 108 *km/hour* cross each other. One of them blows a whistle whose frequency is 750 *Hz*. If sound speed is 330 *m/s*, then passengers sitting in the other train, after trains cross each other will hear sound whose frequency will be

[MP PMT 1991]

(a) 900 *Hz* (b) 625 *Hz*

(c) 750 *Hz* (d) 800 *Hz*

12. With what velocity an observer should move relative to a stationary source so that he hears a sound of double the frequency of source

(a) Velocity of sound towards the source

(b) Velocity of sound away from the source

(c) Half the velocity of sound towards the source

(d) Double the velocity of sound towards the source

13. A source of sound emitting a note of frequency 200 *Hz* moves towards an observer with a velocity v equal to the velocity of sound. If the observer also moves away from the source with the same velocity v, the apparent frequency heard by the observer is

(a) 50 *Hz* (b) 100 *Hz*

(c) 150 *Hz* (d) 200 *Hz*

14. Doppler's effect will not be applicable when the velocity of sound source is

(a) Equal to that of the sound velocity

(b) Less than the velocity of sound

(c) Greater than the velocity of sound

(d) Zero

15. An observer while going on scooter hears sound of two sirens of same frequencies from two opposite directions. If he travels along the direction of one of the siren, then he

(a) Listens resonance

(b) Listens beats

(c) Will not listen sound due to destructive interference

(d) Will listen intensive sound due to constructive interference

16. A source of sound is travelling towards a stationary observer. The frequency of sound heard by the observer is of three times the original frequency. The velocity of sound is v *m/sec*. The speed of source will be

[MP PET 1991]

(a) $\frac{2}{3}v$ (b) v

(c) $\frac{3}{2}v$ (d) $3v$

17. A sound source is moving towards a stationary observer with 1/10 of the speed of sound. The ratio of apparent to real frequency is

[CPMT 1977; NCERT 1977; KCET 2001, 03]

(a) 10/9 (b) 11/10

(c) $(11/10)^2$ (d) $(9/10)^2$

18. The speed of sound in air at a given temperature is 350 *m/s*. An engine blows whistle at a frequency of 1200 *cps*. It is approaching the observer with velocity 50 *m/s*. The apparent frequency in *cps* heard by the observer will be [CPMT 1981; MP PET 1989]

[CPMT 1976; RPET 1999; BHU 1997, 2001]

(a) 600 (b) 1050

(c) 1400 (d) 2400

19. Suppose that the speed of sound in air at a given temperature is 400 *m/sec*. An engine blows a whistle at 1200 *Hz* frequency. It is approaching an observer at the speed of 100 *m/sec*. What is the apparent frequency as heard by the observer

(a) 600 *Hz* (b) 1200 *Hz*

(c) 1500 *Hz* (d) 1600 *Hz*

[MP PMT 1991]

20. A source of frequency 150 *Hz* is moving in the direction of a person with a velocity of 110 *m/s*. The frequency heard by the person will be (speed of sound in medium = 330 *m/s*)

(a) 225 *Hz* (b) 200 *Hz*

(c) 150 *Hz* (d) 100 *Hz*

21. The Doppler's effect is applicable for

[AFMC 1998]

(a) Light waves (b) Sound waves

[MP PMT 1990]

(c) Space waves (d) Both (a) and (b)

22. A source of sound is moving with constant velocity of 20 *m/s* emitting a note of frequency 1000 *Hz*. The ratio of frequencies observed by a stationary observer while the source is approaching him and after it crosses him will be

[MP PET 1994]

(a) 9 : 8 (b) 8 : 9

(c) 1 : 1 (d) 9 : 10

(Speed of sound v = 340 *m/s*)

23. A source of sound S is moving with a velocity 50*m/s* towards a stationary observer. The observer measures the frequency of the source as 1000 *Hz*. What will be the apparent frequency of the source when it is moving away from the observer after crossing him ? The velocity of sound in the medium is 350 *m/s*

(a) 750 *Hz* (b) 857 *Hz*

(c) 1143 *Hz* (d) 1333 *Hz*

24. A source and listener are both moving towards each other with speed $v/10$, where v is the speed of sound. If the frequency of the note emitted by the source is f, the frequency heard by the listener would be nearly

[MP PMT 1994; MP PET 2001]

(a) 1.11 f (b) 1.22 f

(c) f (d) 1.27 f

25. A table is revolving on its axis at 5 revolutions per second. A sound source of frequency 1000 *Hz* is fixed on the table at 70 *cm* from the axis. The minimum frequency heard by a listener standing at a distance from the table will be (speed of sound = 352 *m/s*)

(a) 1000 *Hz* (b) 1066 *Hz*

(c) 941 *Hz* (d) 352 *Hz*

26. A source of sound *S* of frequency 500 *Hz* situated between a stationary observer *O* and a wall *W*, moves towards the wall with a speed of 2 *m/s*. If the velocity of sound is 332 *m/s*, then the number of beats per second heard by the observer is (approximately)

(a) 8 (b) 6

(c) 4 (d) 2

27. A motor car blowing a horn of frequency 124 *vib/sec* moves with a velocity 72 *km/hr* towards a tall wall. The frequency of the reflected sound heard by the driver will be (velocity of sound in air is 330 *m/s*) [MP PET 1997]

(a) 109 *vib/sec* (b) 132 *vib/sec*

(c) 140 *vib/sec* (d) 248 *vib/sec*

28. A source of sound of frequency *n* is moving towards a stationary observer with a speed *S*. If the speed of sound in air is *V* and the frequency heard by the observer is n_1, the value of n_1 / n is

(a) $(V+S)/V$ (b) $V/(V+S)$

(c) $(V-S)/V$ (d) $V/(V-S)$

29. A vehicle with a horn of frequency *n* is moving with a velocity of 30 *m/s* in a direction perpendicular to the straight line joining the observer and the vehicle. The observer perceives the sound to have a frequency $n + n_1$. Then (if the sound velocity in air is 300 *m/s*)

[CBSE PMT 1998; AIIMS 2000]

(a) $n_1 = 10n$ (b) $n_1 = 0$

(c) $n_1 = 0.1n$ (d) $n_1 = -0.1n$

30. A whistle giving out 450 *Hz* approaches a stationary observer at a speed of 33 *m/s*. The frequency heard by the observer in *Hz* is

(a) 409 (b) 429

(c) 517 (d) 500

31. An observer is moving away from source of sound of frequency 100 *Hz*. His speed is 33 *m/s*. If speed of sound is 330 *m/s*, then the observed frequency is

[EAMCET (Engg.) 1995; CPMT 1999]

(a) 90 *Hz* (b) 100 *Hz*

(c) 91 *Hz* (d) 110 *Hz*

32. An observer standing at station observes frequency 219 *Hz* when a train approaches and 184 *Hz* when train goes away from him. If velocity of sound in air is 340 *m*/s, then velocity of train and actual frequency of whistle will be

[RPET 1997]

(a) $15.5\,ms^{-1}$, $200\,Hz$ (b) $19.5\,ms^{-1}$, $205\,Hz$

(c) $29.5\,ms^{-1}$, $200\,Hz$ (d) $32.5\,ms^{-1}$, $205\,Hz$

33. At what speed should a source of sound move so that stationary observer finds the apparent frequency equal to half of the original frequency [RPMT 1996]

(a) $\frac{v}{2}$ (b) $2v$

(c) $\frac{v}{4}$ (d) v

34. A boy is walking away from a wall towards an observer at a speed of 1 *metre/sec* and blows a whistle whose frequency is 680 *Hz*. The number of beats heard by the observer per second is (Velocity of sound in air = 340 *metres/sec*

[MP PMT 1995]

(a) Zero (b) 2

(c) 8 (d) 4

35. The driver of a car travelling with speed 30 *metres per second* towards a hill sounds a horn of frequency 600 *Hz*. If the velocity of sound in air is 330 *metres per second*, the frequency of the reflected sound as heard by the driver is

[MP PMT 1996]

(a) 720 *Hz* (b) 555.5 *Hz*

(c) 550 *Hz* (d) 500 *Hz*

36. Two sirens situated one kilometer apart are producing sound of frequency 330 *Hz*. An observer starts moving from one siren to the other with a speed of 2 *m/s*. If the speed of sound be 330 *m/s*, what will be the beat frequency heard by the observer [MP PMT 1997] [RPMT 1996; CPMT 2002]

(a) 8 (b) 4

(c) 6 (d) 1

37. A source of sound is travelling with a velocity 40 *km/hour* towards observer and emits sound of frequency 2000 *Hz*. If velocity of sound is 1220 *km/hour*, then what is the apparent frequency heard by an observer [AFMC 1997]

(a) 2210 *Hz* (b) 1920 *Hz*

(c) 2068 *Hz* (d) 2086 *Hz*

38. A source of sound and listener are approaching each other with a speed of 40 *m/s*. The apparent frequency of note produced by the source is 400 *cps*. Then, its true frequency (in *cps*) is (velocity of sound in air = 360 *m/s*) [IIT 1997 Cancelled]

[KCET 1999]

(a) 420 (b) 360

(c) 400 (d) 320

39. A siren emitting sound of frequency 500 *Hz* is going away from a static listener with a speed of 50 *m/sec*. The frequency of sound to be heard, directly from the siren, is

[AIIMS 1999; Pb. PMT 2003]

(a) 434.2 *Hz* (b) 589.3 *Hz*

(c) 481.2 *Hz* (d) 286.5 *Hz*

40. A man sitting in a moving train hears the whistle of the engine. The frequency of the whistle is 600 *Hz*

[JIPMER 1999]

(a) The apparent frequency as heard by him is smaller than 600 *Hz*

(b) The apparent frequency is larger than 600 *Hz*

(c) The frequency as heard by him is 600 *Hz*

(d) None of the above

41. A source of sound of frequency 500 *Hz* is moving towards an observer with velocity 30 *m/s*. The speed of sound is 330 *m/s*. the frequency heard by the observer will be

[MP PET 2000; Kerala PMT 2005; UPSEAT 2005]

(a) 550 *Hz* (b) 458.3 *Hz*

(c) 530 *Hz* (d) 545.5 *Hz*

42. A source of sound of frequency 90 vibrations/ *sec* is approaching a stationary observer with a speed equal to 1/10 the speed of sound. What will be the frequency heard by the observer

(a) 80 vibrations/*sec* (b) 90 vibrations/*sec*

(c) 100 vibrations/*sec* (d) 120 vibrations/*sec*

43. A whistle of frequency 500 *Hz* tied to the end of a string of length 1.2 *m* revolves at 400 *rev*/*min*. A listener standing some distance away in the plane of rotation of whistle hears frequencies in the range (speed of sound = 340 *m*/*s*)

[KCET 2000; AMU 1999; Pb. PET 2003]

(a) 436 to 586 (b) 426 to 574

(c) 426 to 584 (d) 436 to 674

44. A train moves towards a stationary observer with speed 34 *m*/*s*. The train sounds a whistle and its frequency registered by the observer is f_1. If the train's speed is reduced to 17 *m*/*s*, the frequency registered is f_2. If the speed of sound is 340 *m*/*s* then the ratio f_1 / f_2 is

[IIT-JEE (Screening) 2000]

(a) 18/19 (b) 1/2

(c) 2 (d) 19/18

45. If source and observer both are relatively at rest and if speed of sound is increased then frequency heard by observer will

[RPET 2000; J & K CET 2004]

(a) Increases (b) Decreases

(c) Can not be predicted (d) Will not change

46. A source and an observer move away from each other with a velocity of 10 *m/s* with respect to ground. If the observer finds the frequency of sound coming from the source as 1950 *Hz*, then actual frequency of the source is (velocity of sound in air = 340 *m/s*)

MH CET 2000; AFMC 2000; CBSE PMT 2001]

(a) 1950 *Hz* (b) 2068 *Hz*

(c) 2132 *Hz* (d) 2486 *Hz*

47. A source is moving towards an observer with a speed of 20 *m*/*s* and having frequency of 240 *Hz*. The observer is now moving towards the source with a speed of 20 *m*/*s*. Apparent frequency heard by observer, if velocity of sound is 340 *m*/*s*, is [CPMT 2000; KCET 2001; MH CET 2004]

(a) 240 *Hz* (b) 270 *Hz*

(c) 280 *Hz* (d) 360 *Hz*

48. A siren placed at a railway platform is emitting sound of frequency 5 *kHz*. *A* passenger sitting in a moving train *A* records a frequency of 5.5 *kHz* while the train approaches the siren. During his return journey in a different train *B* he records a frequency of 6.0 *kHz* while approaching the same siren. The ratio of the velocity of train *B* to that of train *A* is

[IIT-JEE (Screening) 2002]

(a) 242/252 (b) 2

(c) 5/6 (d) 11/6

49. A whistle revolves in a circle with an angular speed of 20 *rad/sec* using a string of length 50 *cm*. If the frequency of sound from the whistle is 385 *Hz*, then what is the minimum frequency heard by an observer, which is far away from the centre in the same plane ? (v = 340 *m/s*) [MP PMT 2000]

[CBSE PMT 2002]

(a) 333 *Hz* (b) 374 *Hz*

(c) 385 *Hz* (d) 394 *Hz*

50. A Siren emitting sound of frequency 800 *Hz* is going away from a static listener with a speed of 30 *m/s*, frequency of the sound to be heard by the listener is (take velocity of sound as 330 *m/s*)

[CPMT 1996; AIIMS 2002; Pb. PMT 2001]

(a) 733.3 *Hz* (b) 644.8 *Hz*

(c) 481.2 *Hz* (d) 286.5 *Hz*

51. A car sounding a horn of frequency 1000 *Hz* passes an observer. The ratio of frequencies of the horn noted by the observer before and after passing of the car is 11 : 9. If the speed of sound is *v*, the speed of the car is

[MP PET 2002]

(a) $\frac{1}{10}v$ (b) $\frac{1}{2}v$

(c) $\frac{1}{5}v$ (d) v

52. What should be the velocity of a sound source moving towards a stationary observer so that apparent frequency is double the actual frequency (Velocity of sound is *v*)

[MP PMT 2002]

(a) v (b) $2v$

(c) $\frac{v}{2}$ (d) $\frac{v}{4}$

[EAMCET 1997;

53. Two trains are moving towards each other at speeds of 20 *m/s* and 15 *m/s* relative to the ground. The first train sounds a whistle of frequency 600 *Hz*. the frequency of the whistle heard by a passenger in the second train before the train meets is (the speed of sound in air is 340 *m/s*)

[UPSEAT 2002]

(a) 600 *Hz* (b) 585 *Hz*

(c) 645 *Hz* (d) 666 *Hz*

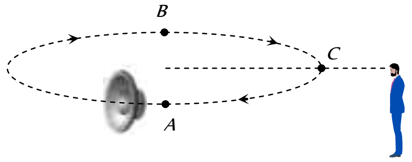
54. A small source of sound moves on a circle as shown in the figure and an observer is standing on O. Let n_1, n_2 and n_3 be the frequencies heard when the source is at A, B and C respectively. Then [UPSEAT 2002]

(a) $n_1 > n_2 > n_3$

(b) $n_2 > n_3 > n_1$

(c) $n_1 = n_2 > n_3$

(d) $n_2 > n_1 > n_3$



55. A source and an observer approach each other with same velocity 50 *m/s*. If the apparent frequency is 435 *sec*, then the real frequency is [CPMT 2003]

(a) 320 *s* (b) 360 *sec*

(c) 390 *sec* (d) 420 *sec*

56. A source emits a sound of frequency of 400 *Hz*, but the listener hears it to be 390 *Hz*. Then

[Orissa JEE 2003]

(a) The listener is moving towards the source

(b) The source is moving towards the listener

(c) The listener is moving away from the source

(d) The listener has a defective ear

57. Doppler effect is applicable for [AFMC 2003]

(a) Moving bodies

(b) One is moving and other are stationary

(c) For relative motion

(d) None of these

58. A source and an observer are moving towards each other with a speed equal to $\frac{v}{2}$ where v is the speed of sound. The source is emitting sound of frequency *n*. The frequency heard by the observer will be [MP PET 2003]

(a) Zero (b) n

(c) $\frac{n}{3}$ (d) $3n$

59. When an engine passes near to a stationary observer then its apparent frequencies occurs in the ratio 5/3. If the velocity of engine is [MP PMT 2003]

(a) 540 *m/s* (b) 270 *m/s*

(c) 85 *m/s* (d) 52.5 *m/s*

60. A police car horn emits a sound at a frequency 240 *Hz* when the car is at rest. If the speed of the sound is 330 *m/s*, the frequency heard by an observer who is approaching the car at a speed of 11 *m/s*, is :

(a) 248 *Hz* (b) 244 *Hz*

(c) 240 *Hz* (d) 230 *Hz*

61. A person carrying a whistle emitting continuously a note of 272 *Hz* is running towards a reflecting surface with a speed of 18 *km/hour*. The speed of sound in air is $345 ms^{-1}$. The number of beats heard by him is

[Kerala (Engg.) 2002]

(a) 4 (b) 6

(c) 8 (d) 3

62. A bus is moving with a velocity of 5 *m/s* towards a huge wall. the driver sounds a horn of frequency 165 *Hz*. If the speed of sound in air is 355 *m/s*, the number of beats heard per second by a passenger on the bus will be

[KCET 2001; BHU 2002]

(a) 6 (b) 5

(c) 3 (d) 4

63. A source of sound of frequency 256 *Hz* is moving rapidly towards a wall with a velocity of 5 *m/s*. The speed of sound is 330 *m/s*. If the observer is between the wall and the source, then beats per second heard will be [UPSEAT 2002]

(a) 7.8 *Hz* (b) 7.7 *Hz*

(c) 3.9 *Hz* (d) Zero

64. The apparent frequency of a note, when a listener moves towards a stationary source, with velocity of 40 *m/s* is 200 *Hz*. When he moves away from the same source with the same speed, the apparent frequency of the same note is 160 *Hz*. The velocity of sound in air is (in *m/s*) [KCET 1998]

(a) 360 (b) 330

(c) 320 (d) 340

65. An observer moves towards a stationary source of sound, with a velocity one-fifth of the velocity of sound. What is the percentage increase in the apparent frequency

[AIEEE 2005]

(a) 5% (b) 20%

(c) Zero (d) 0.5%

Musical Sound

1. The walls of the halls built for music concerts should

[NCERT 1979]

(a) Amplify sound (b) Transmit sound

(c) Reflect sound (d) Absorb sound

2. A spherical source of power 4 *W* and frequency 800 *Hz* is emitting sound waves. The intensity of waves at a distance 200 *m* is[CPMT 1999; JIPMER

(a) $8 \times 10^{-6}\ W/m^2$ (b) $2 \times 10^{-4}\ W/m^2$

(c) $1 \times 10^{-4}\ W/m^2$ (d) $4\ W/m^2$

3. If the pressure amplitude in a sound wave is tripled, then the intensity of sound is increased by a factor of

[CPMT 1992; JIPMER 2000]

(a) 9 (b) 3

(c) 6 (d) $\sqrt{3}$

4. If the amplitude of sound is doubled and the frequency reduced to one-fourth, the intensity of sound at the same point will be [UPSEAT 2004]

(a) Increased by a factor of 2

(b) Decreased by a factor of 2

(c) Decreased by a factor of 4

(d) Unchanged

5. Intensity level of a sound of intensity *I* is 30 *dB*. The ratio $\frac{I}{I_0}$ is (Where I_0 is the threshold of hearing)

[KCET 1999; J & K CET 2005]

(a) 3000 (b) 1000

(c) 300 (d) 30

6. Decibel is unit of [RPMT 2000]

(a) Intensity of light (b) X-rays radiation capacity

(c) Sound loudness (d) Energy of radiation

7. Quality of a musical note depends on

[MP PMT 1998; KCET 1999; RPET 2000]

(a) Harmonics present

(b) Amplitude of the wave

(c) Fundamental frequency

(d) Velocity of sound in the medium

8. When we hear a sound, we can identify its source from

[KCET (Med.) 2001]

(a) Amplitude of sound

(b) Intensity of sound

(c) Wavelength of sound

(d) Overtones present in the sound

9. A man X can hear only upto 10 *kHz* and another man y upto 20 *kHz*. A note of frequency 500 *Hz* is produced before them from a stretched string. Then [KCET 2002]

(a) Both will hear sounds of same pitch but different quality

(b) Both will hear sounds of different pitch but same quality

(c) Both will hear sounds of different pitch and different quality

(d) Both will hear sounds of same pitch and same quality

10. The amplitude of two waves are in ratio 5 : 2. If all other conditions for the two waves are same, then what is the ratio of their energy densities [MH CET 2004]

(a) 5 : 2 (b) 10: 4

(c) 2.5 : 1 (d) 25 : 4

11. *A* is singing a note and at the same time *B* is singing a note with exactly one-eighth the frequency of the note of *A*. The energies of two sounds are equal, the amplitude of the note of *B* is [NCERT 1981; AIIMS 2001]

(a) Same that of *A* (b) Twice as that of *A*

(c) Four times as that of *A* (d) Eight times as that of *A*

12. The loudness and pitch of a sound depends on [KCET 2004; Pb. PET 2003]

(a) Intensity and velocity

(b) Frequency and velocity

(c) Intensity and frequency

(d) Frequency and number of harmonics

13. If T is the reverberation time of an auditorium of volume V then

(a) $T \propto \frac{1}{V}$ (b) $T \propto \frac{1}{V^2}$

(c) $T \propto V^2$ (d) $T \propto V$

14. The intensity of sound from a radio at a distance of 2 *metres* from its speaker is $1 \times 0^{-2}\,\mu\,W/m^2$. The intensity at a distance of 10 meters would be [CPMT 2005]

(a) $0.2 \times 10^{-2}\,\mu\,W/m^2$ (b) $1 \times 10^{-2}\,\mu\,W/m^2$

(c) $4 \times 10^{-4}\,\mu\,W/m^2$ (d) $5 \times 10^{-2}\,\mu\,W/m^2$

15. The intensity of sound wave while passing through an elastic medium falls down by 10% as it covers one metre distance through the medium. If the initial intensity of the sound wave was 100 *decibels,* its value after it has passed through 3 *metre* thickness of the medium will be [CPMT 1988]

(a) 70 *decibel* (b) 72.9 *decibel*

(c) 81 *decibel* (d) 60 *decibel*

16. A musical scale is constructed by providing intermediate frequencies between a note and its octave which [CPMT 1972; NCERT 1980]

(a) Form an arithmetic progression

(b) Form a geometric progression

(c) Bear a simple ratio with their neighbours

(d) Form a harmonic progression

17. In a harmonium the intermediate notes between a note and its octave form [CPMT 1973]

(a) An arithmetic progression

(b) A geometric progression

(c) A harmonic progression

(d) An exponential progression

18. The power of a sound from the speaker of a radio is 20 *mW*. By turning the knob of the volume control, the power of the sound is increased to 400 *mW*. The power increase in decibels as compared to the original power is

(a) 13 *dB* (b) 10 *dB*

(c) 20 *dB* (d) 800 *dB*

19. If separation between screen and source is increased by 2% what would be the effect on the intensity [CPMT 2003]

(a) Increases by 4% (b) Increases by 2%

(c) Decreases by 2% (d) Decreases by 4%

20. The musical interval between two tones of frequencies 320 *Hz* and 240 *Hz* is [MP PMT 1992; AFMC 1992]

(a) 80 (b) $\left(\frac{4}{3}\right)$

(c) 560 (d) 320×240

21. In an orchestra, the musical sounds of different instruments are distinguished from one another by which of the following characteristics [CBSE PMT 1993]

(a) Pitch (b) Loudness

(c) Quality (d) Overtones

22. The intensity level due to two waves of the same frequency in a given medium are 1 *bel* and 5 *bel*. Then the ratio of amplitudes is [KCET 2003]

(a) 1 : 4 (b) 1 : 2

(c) $1 : 10^4$ (d) $1 : 10^2$

23. It is possible to recognise a person by hearing his voice even if he is hidden behind a wall. This is due to the fact that his voice

(a) Has a definite pitch (b) Has a definite quality

(c) Has a definite loudness (d) Can penetrate the wall

24. Of the following the one which emits sound of higher pitch is

(a) Mosquito (b) Lion

(c) Man (d) Woman

25. In the musical octave 'Sa', 'Re', 'Ga'

(a) The frequency of the note 'Sa' is greater than that of 'Re', 'Ga'

(b) The frequency of the note 'Sa' is smaller than that of 'Re', 'Ga'

(c) The frequency of all the notes 'Sa', 'Re', 'Ga' is the same

(d) The frequency decreases in the sequence 'Sa', 'Re', 'Ga'

26. Tone *A* has frequency of 240 *Hz*. Of the following tones, the one which will sound least harmonious with *A* is

(a) 240 (b) 480

(c) 360 (d) 450

27. Learned Indian classical vocalists do not like the accompaniment of a harmonium because [MP PMT 1992]

(a) Intensity of the notes of the harmonium is too large

(b) Notes of the harmonium are too shrill

(c) Diatonic scale is used in the harmonium

(d) Tempered scale is used in the harmonium

28. Each of the properties of sound listed in column A primarily depends on one of the quantities in column B. Choose the matching pairs from two columns

Column A	Column B
Pitch	Waveform
Quality	Frequency
Loudness	Intensity

[IIT 1980]

(a) Pitch-waveform, Quality-frequency; Loudness-intensity

(b) Pitch-frequency, Quality-waveform; Loudness-intensity

(c) Pitch-intensity, Quality-waveform; Loudness- frequency

(d) Pitch-waveform, Quality- intensity; Loudness-frequency

29. Intensity level 200 *cm* from a source of sound is 80 *dB*. If there is no loss of acoustic power in air and intensity of threshold hearing is $10^{-12}\,Wm^{-2}$ then, what is the intensity level at a distance of 400 *cm* from source

(a) Zero (b) 54 *dB*

(c) 64 *dB* (d) 44 *dB*

30. A point source emits sound equally in all directions in a non-absorbing medium. Two points P and Q are at distances of $2m$ and $3m$ respectively from the source. The ratio of the intensities of the waves at P and Q is [CBSE PMT 2005]

(a) 9 : 4 (b) 2 : 3

(c) 3 : 2 (d) 4 : 9

31. Quality depends on [AFMC 2003]

(a) Intensity (b) Loudness

(c) Timbre (d) Frequency

32. Two waves having sinusoidal waveforms have different wavelengths and different amplitude. They will be having

[BHU 2005]

(a) Same pitch and different intensity

(b) Same quality and different intensity

(c) Different quality and different intensity

(d) Same quality and different pitch

CT Critical Thinking

Objective Questions

1. A wave disturbance in a medium is described by $y(x,t) = 0.02\cos\left(50\,\pi t + \frac{\pi}{2}\right)\cos(10\pi x)$, where x and y are in *metres* and t in seconds [IIT 1995]

(a) A displacement node occurs at x = 0.15 *m*

(b) An antinode occurs at x = 0.3 *m*

(c) The wavelength of the wave is 0.2 *m*

(d) The speed of the wave is 5.0 *m/s*

2. The (x, y) coordinates of the corners of a square plate are (0, 0), (L, 0), (L, L) and (0, L). The edges of the plate are clamped and transverse standing waves are set up in it. If $u(x, y)$ denotes the displacement of the plate at the point (x, y) at some instant of time, the possible expression(s) for u is(are) (a = positive constant)

[IIT 1998; Orissa PMT 2004]

(a) $a\cos\frac{\pi x}{2L}\cos\frac{\pi y}{2L}$ (b) $a\sin\frac{\pi x}{L}\sin\frac{\pi y}{L}$

(c) $a\sin\frac{\pi x}{L}\sin\frac{2\pi y}{L}$ (d) $a\cos\frac{2\pi x}{L}\cos\frac{\pi y}{L}$

3. The ends of a stretched wire of length L are fixed at $x = 0$ and $x = L$. In one experiment, the displacement of the wire is $y_1 = A\sin(\pi x/L)\sin\omega t$ and energy is E_1, and in another experiment its displacement is $y_2 = A\sin(2\pi x/L)\sin 2\omega t$ and energy is E_2. Then

[IIT-JEE (Screening) 2001]

(a) $E_2 = E_1$ (b) $E_2 = 2E_1$

(c) $E_2 = 4E_1$ (d) $E_2 = 16E_1$

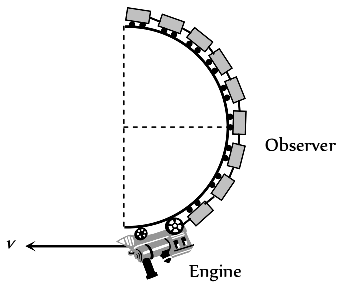
4. In a large room, a person receives direct sound waves from a source 120 *metres* away from him. He also receives waves from the same source which reach him, being reflected from the 25 *metre* high ceiling at a point halfway between them. The two waves interfere constructively for wavelength of

[Roorkee 1982]

(a) 20, 20/3, 20/5 *etc* (b) 10, 5, 2.5 *etc*

(c) 10, 20, 30 *etc* (d) 15, 25, 35 *etc*

5. A train has just complicated a *U*-curve in a track which is a semicircle. The engine is at the forward end of the semi circular part of the track while the last carriage is at the rear end of the semicircular track. The driver blows a whistle of frequency 200 *Hz*. Velocity of sound is 340 *m/sec*. Then the apparent frequency as observed by a passenger in the middle of a train when the speed of the train is 30 *m/sec* is



(a) 209 *Hz* (b) 288 *Hz*

(c) 200 *Hz* (d) 181 *Hz*

6. Two identical flutes produce fundamental notes of frequency 300 *Hz* at 27^o *C*. If the temperature of air in one flute is increased to 31^o *C*, the number of the beats heard per second will be

(a) 1 (b) 2

(c) 3 (d) 4

7. In the experiment for the determination of the speed of sound in air using the resonance column method, the length of the air column that resonates in the fundamental mode, with a tuning fork is 0.1 *m*. when this length is changed to 0.35 *m*, the same tuning fork resonates with the first overtone. Calculate the end correction

[IIT-JEE (Screening) 2003]

(a) 0.012m (b) 0.025m

(c) 0.05m (d) 0.024m

8. A closed organ pipe of length L and an open organ pipe contain gases of densities ρ_1 and ρ_2 respectively. The compressibility of gases are equal in both the pipes. Both the pipes are vibrating in their first overtone with same frequency. The length of the open organ pipe is

[IIT-JEE (Screening) 2004]

(a) $\frac{L}{3}$ (b) $\frac{4L}{3}$

(c) $\frac{4L}{3}\sqrt{\frac{\rho_1}{\rho_2}}$ (d) $\frac{4L}{3}\sqrt{\frac{\rho_2}{\rho_1}}$

9. A string of length 0.4 m and mass $10^{-2}\,kg$ is tightly clamped at its ends. The tension in the string is 1.6 N. Identical wave pulses are produced at one end at equal intervals of time Δt. The minimum value of Δt which allows constructive interference between successive pulses is [IIT 1998]

(a) 0.05 s (b) 0.10 s
(c) 0.20 s (d) 0.40 s

10. Two identical stringed instruments have frequency 100 Hz. If tension in one of them is increased by 4% and they are sounded together then the number of beats in one second is

[EAMCET (Engg.) 1995]

(a) 1 (b) 8
(c) 4 (d) 2

11. The difference between the apparent frequency of a source of sound as perceived by an observer during its approach and recession is 2% of the natural frequency of the source. If the velocity of sound in air is 300 m/sec, the velocity of the source is (It is given that velocity of source << velocity of sound) [CPMT 1982; RPET 1998]

(a) 6 m/sec (b) 3 m/sec
(c) 1.5 m/sec (d) 12 m/sec

12. A sound wave of frequency ν travels horizontally to the right. It is reflected from a large vertical plane surface moving to the left with a speed v. The speed of sound in the medium is c, then

(a) The frequency of the reflected wave is $\dfrac{\nu(c+v)}{c-v}$

(b) The wavelength of the reflected wave is $\dfrac{c(c-v)}{\nu(c+v)}$

(c) The number of waves striking the surface per second is $\dfrac{\nu(c+v)}{c}$

(d) The number of beats heard by a stationary listener to the left of the reflecting surface is $\dfrac{v\,\nu}{c-v}$

13. Two cars are moving on two perpendicular roads towards a crossing with uniform speeds of 72 km/hr and 36 km/hr. If first car blows horn of frequency 280 Hz, then the frequency of horn heard by the driver of second car when line joining the cars make 45° angle with the roads; will be

[RPET 1997]

(a) 321 Hz (b) 298 Hz
(c) 289 Hz (d) 280 Hz

14. Two whistles A and B produces notes of frequencies 660 Hz and 596 Hz respectively. There is a listener at the mid-point of the line joining them. Now the whistle B and the listener start moving with speed 30 m/s away from the whistle A. If speed of sound be 330 m/s, how many beats will be heard by the listener

(a) 2 (b) 4
(c) 6 (d) 8

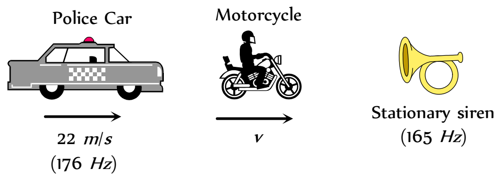
15. A source producing sound of frequency 170 Hz is approaching a stationary observer with a velocity 17 ms^{-1}. The apparent change in the wavelength of sound heard by the observer is (speed of sound in air = 340 ms^{-1})

[EAMCET (Engg.) 2000]

(a) 0.1m (b) 0.2m
(c) 0.4m (d) 0.5m

16. A police car moving at 22 m/s, chases a motorcyclist. The police man sounds his horn at 176 Hz, while both of them move towards a stationary siren of frequency 165 Hz. Calculate the speed of the motorcycle, if it is given that he does not observes any beats

[IIT-JEE (Screening) 2003]



(a) 33 m/s (b) 22 m/s
(c) Zero (d) 11 m/s

17. An observer moves towards a stationary source of sound with a speed 1/5th of the speed of sound. The wavelength and frequency of the source emitted are λ and f respectively. The apparent frequency and wavelength recorded by the observer are respectively[CBSE PMT

(a) $1.2\,f, \lambda$ (b) $f, 1.2\lambda$
(c) $0.8f, 0.8\lambda$ (d) $1.2f, 1.2\lambda$

18. A light pointer fixed to one prong of a tuning fork touches a vertical plate. The fork is set vibrating and the plate is allowed to fall freely. If eight oscillations are counted when the plate falls through 10 cm, the frequency of the tuning fork is [IIT 1977; KCET 2002]
[IIT 1995; BCECE 2005]

(a) 360 Hz (b) 280 Hz
(c) 560 Hz (d) 56 Hz

19. Oxygen is 16 times heavier than hydrogen. Equal volumes of hydrogen and oxygen are mixed. The ratio of speed of sound in the mixture to that in hydrogen is [KCET 2004]

(a) $\sqrt{\dfrac{1}{8}}$ (2) $\sqrt{\dfrac{32}{17}}$
(c) $\sqrt{8}$ (d) $\sqrt{\dfrac{2}{17}}$

20. The equation of displacement of two waves are given as $y_1 = 10\sin\left(3\pi t + \dfrac{\pi}{3}\right)$; $y_2 = 5(\sin 3\pi t + \sqrt{3}\cos 3\pi t)$. Then what is the ratio of their amplitudes

[AIIMS 1997; Haryana PMT 2000]

(a) 1 : 2 (b) 2 : 1
(c) 1 : 1 (d) None of these

21. The equation $y = A\cos^2\left(2\pi\,nt - 2\pi\dfrac{x}{\lambda}\right)$ represents a wave with

(a) Amplitude $A/2$, frequency $2n$ and wavelength $\lambda/2$
(b) Amplitude $A/2$, frequency $2n$ and wavelength λ [RPET 1996]
(c) Amplitude A, frequency $2n$ and wavelength 2λ
(d) Amplitude A, frequency n and wavelength λ

22. In a wave motion $y = a\sin(kx - \omega t)$, y can represent

[IIT-JEE 1999]

(a) Electric field (b) Magnetic field
(c) Displacement (d) Pressure

23. Consider ten identical sources of sound all giving the same frequency but having phase angles which are random. If the average

intensity of each source is I_0, the average of resultant intensity I due to all these ten sources will be

[MP PMT 1990]

(a) $I = 100\, I_0$ (b) $I = 10\, I_0$

(c) $I = I_0$ (d) $I = \sqrt{10}\, I_0$

24. Ten tuning forks are arranged in increasing order of frequency in such a way that any two nearest tuning forks produce 4 *beats/sec*. The highest frequency is twice of the lowest. Possible highest and the lowest frequencies are

[MP PMT 1990; MHCET 2002]

(a) 80 and 40 (b) 100 and 50

(c) 44 and 22 (d) 72 and 36

25. 41 forks are so arranged that each produces 5 *beats per sec* when sounded with its near fork. If the frequency of last fork is double the frequency of first fork, then the frequencies of the first and last fork are respectively

[MP PET 1997; KCET 2002]

(a) 200, 400 (b) 205, 410

(c) 195, 390 (d) 100, 200

26. Two identical wires have the same fundamental frequency of 400 *Hz*. when kept under the same tension. If the tension in one wire is increased by 2% the number of beats produced will be

(a) 4 (b) 2

(c) 8 (d) 1

27. 25 tunning forks are arranged in series in the order of decreasing frequency. Any two successive forks produce 3 beats/sec. If the frequency of the first turning fork is the octave of the last fork, then the frequency of the 21st fork is

[Kerala (Engg.) 2001]

(a) 72 *Hz* (b) 288 *Hz*

(c) 84 *Hz* (d) 87 *Hz*

28. 16 tunning forks are arranged in the order of increasing frequencies. Any two successive forks give 8 beats per sec when sounded together. If the frequency of the last fork is twice the first, then the frequency of the first fork is

[CBSE PMT 2000; MP PET 2001]

(a) 120 (b) 160

(c) 180 (d) 220

29. Two identical straight wires are stretched so as to produce 6 beats per second when vibrating simultaneously. On changing the tension in one of them, the beat frequency remains unchanged. Denoting by T_1, T_2, the higher and the lower initial tensions in the strings, then it could be said that while making the above change in tension[IIT 1991]

(a) T_2 was decreased (b) T_2 was increased

(c) T_1 was increased (d) T_1 was kept constant

30. The frequency of a stretched uniform wire under tension is in resonance with the fundamental frequency of a closed tube. If the tension in the wire is increased by 8 *N*, it is in resonance with the first overtone of the closed tube. The initial tension in the wire is

(a) 1 *N* (b) 4 *N*

(c) 8 *N* (d) 16 *N*

31. A metal wire of linear mass density of 9.8 *g/m* is stretched with a tension of 10 *kg* weight between two rigid supports 1 *metre* apart. The wire passes at its middle point between the poles of a permanent magnet, and it vibrates in resonance when carrying an alternating current of frequency *n*. The frequency *n* of the alternating source is

[AIEEE 2003]

(a) 25 *Hz* (b) 50 *Hz*

(c) 100 *Hz* (d) 200 *Hz*

32. A wire of density 9×10^3 kg /m^3 is stretched between two clamps 1 m apart and is subjected to an extension of 4.9×10^{-4} m. The lowest frequency of transverse vibration in the wire is ($Y = 9 \times 10^{10}$ N / m^2)[UPSEAT 200

(a) 40 *Hz* (b) 35 *Hz*

(c) 30 *Hz* (d) 25 *Hz*

33. A man is watching two trains, one leaving and the other coming in with equal speeds of 4 *m*/sec. If they sound their whistles, each of frequency 240 *Hz*, the number of beats heard by the man (velocity of sound in air = 320 *m/sec*) will be equal to

MP PET 1999; RPMT 2000; BHU 2004, 05]

(a) 6 (b) 3

(c) 0 [JIPMER 1999] (d) 12

34. An open pipe is in resonance in its 2nd harmonic with tuning fork of frequency f_1. Now it is closed at one end. If the frequency of the tuning fork is increased slowly from f_1 then again a resonance is obtained with a frequency f_2. If in this case the pipe vibrates n^{th} harmonics then

[IIT-JEE (Screening) 2005]

(a) $n = 3,\ f_2 = \frac{3}{4} f_1$ (b) $n = 3,\ f_2 = \frac{5}{4} f_1$

(c) $n = 5,\ f_2 = \frac{5}{4} f_1$ (d) $n = 5,\ f_2 = \frac{3}{4} f_1$

35. Two speakers connected to the same source of fixed frequency are placed 2.0 *m* apart in a box. A sensitive microphone placed at a distance of 4.0*m* from their midpoint along the perpendicular bisector shows maximum response. The box is slowly rotated until the speakers are in line with the microphone. The distance between the midpoint of the speakers and the microphone remains unchanged. Exactly five maximum responses are observed in the microphone in doing this. The wavelength of the sound wave is

(a) 0.2 *m* (b) 0.4 *m*

(c) 0.6 *m* (d) 0.8 *m*

36. A wire of $9.8 \times 10^{-3} kgm^{-1}$ passes over a frictionless light pulley fixed on the top of a frictionless inclined plane which makes an angle of 30° with the horizontal. Masses *m* and *M* are tied at the two ends of wire such that *m* rests on the plane and *M* hangs freely vertically downwards. The entire system is in equilibrium and a transverse wave propagates along the wire with a velocity of 100 ms^{-1}.

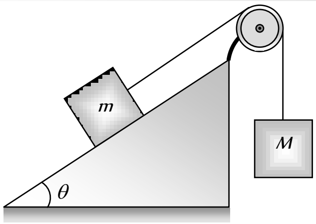
[EAMCET (Engg.) 2000] Choose the correct option

(a) $m = 20\,kg$

(b) $m = 5\,kg$

(c) $m = 2\,kg$

(d) $m = 7\,kg$

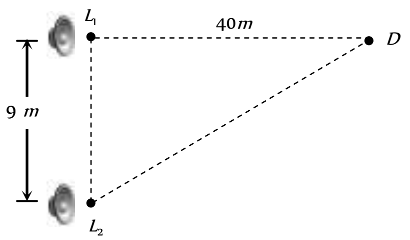


37. A man standing in front of a mountain beats a drum at regular intervals. The rate of drumming is generally increased and he finds that the echo is not heard distinctly when the rate becomes 40 per minute. He then moves nearer to the mountain by 90 *m* and finds that echo is again not heard when the drumming rate becomes 60 per minute. The distance between the mountain and the initial position of the man is

(a) 205 *m* (b) 300 *m*

(c) 180 *m* (d) 270 *m*

38. Two loudspeakers L_1 and L_2 driven by a common oscillator and amplifier, are arranged as shown. The frequency of the oscillator is gradually increased from zero and the detector at *D* records a series of maxima and minima. If the speed of sound is 330 *ms* then the frequency at which the first maximum is observed is



(a) 165 *Hz* (b) 330 *Hz*

(c) 496 *Hz* (d) 660 *Hz*

39. The displacement due to a wave moving in the positive *x*-direction is given by $y = \frac{1}{(1+x^2)}$ at time $t = 0$ and by $y = \frac{1}{[1+(x-1)^2]}$ at $t = 2$ seconds, where *x* and *y* are in *metres*. The velocity of the wave in *m/s* is

(a) 0.5 (b) 1

(c) 2 (d) 4

40. A person speaking normally produces a sound intensity of 40 *dB* at a distance of 1 *m*. If the threshold intensity for reasonable audibility is 20 *dB*, the maximum distance at which he can be heard clearly is

(a) 4 *m* (b) 5 *m*

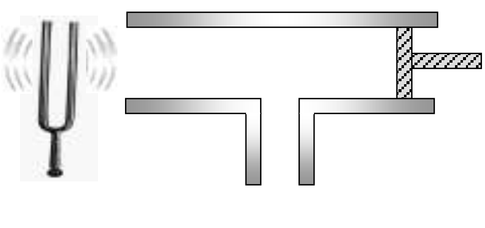
(c) 10 *m* (d) 20 *m*

41. A string of length *L* and mass *M* hangs freely from a fixed point. Then the velocity of transverse waves along the string at a distance *x* from the free end is

(a) $\sqrt{gL}$ (b) $\sqrt{gx}$

(c) gL (d) gx

42. Vibrating tuning fork of frequency *n* is placed near the open end of a long cylindrical tube. The tube has a side opening and is fitted with a movable reflecting piston. As the piston is moved through 8.75 *cm*, the intensity of sound changes from a maximum to minimum. If the speed of sound is 350 *m/s*. Then *n* is



(a) 500 *Hz* (b) 1000 *Hz*

(c) 2000 *Hz* (d) 4000 *Hz*

43. A stone is hung in air from a wire which is stretched over a sonometer. The bridges of the sonometer are *L cm* apart when the wire is in unison with a tuning fork of frequency *N*. When the stone is completely immersed in water, the length between the bridges is *l cm* for re-establishing unison, the specific gravity of the material of the stone is

(a) $\frac{L^2}{L^2 + l^2}$ (b) $\frac{L^2 - l^2}{L^2}$

(c) $\frac{L^2}{L^2 - l^2}$ (d) $\frac{L^2 - l^2}{L^2}$

44. The displacement of a particle in string stretched in *X* direction is represented by *y*. Among the following expressions for *y*, those describing wave motions are

[IIT 1987]

(a) $\cos kx \sin \omega t$ (b) $k^2x^2 - \omega^2t^2$

(c) $\cos(kx + \omega t)$ (d) $\cos(k^2x^2 - \omega^2t^2)$

45. Three waves of equal frequency having amplitudes 10 μm, 4 μm and 7 μm arrive at a given point with successive phase difference of $\frac{\pi}{2}$. The amplitude of the resulting wave in μm is given by

(a) 7 (b) 6

(c) 5 (d) 4

46. There are three sources of sound of equal intensity with frequencies 400, 401 and 402 *vib/sec*. The number of beats heard per second is

[MNR 1980; J & K CET 2005]

(a) 0 (b) 1

(c) 2 (d) 3

47. A tuning fork of frequency 340*Hz* is vibrated just above the tube of 120 *cm* height. Water is poured slowly in the tube. What is the minimum height of water necessary for the resonance (speed of sound in the air = 340 *m/sec*)

[CBSE PMT 1999; UPSEAT 1999]

(a) 15 *cm* (b) 25 *cm*

(c) 30 *cm* (d) 45 *cm*

48. An organ pipe is closed at one end has fundamental frequency of 1500 *Hz*. The maximum number of overtones generated by this pipe which a normal person can hear is :

[AIIMS 2004]

(a) 14 (b) 13

(c) 6 (d) 9

49. In Melde's experiment, the string vibrates in 4 loops when a 50 *gram* weight is placed in the pan of weight 15 *gram*. To make the string to vibrates in 6 loops the weight that has to be removed from the pan is [MH CET 2004]

(a) 0.0007 *kg wt* (b) 0.0021 *kg wt*

(c) 0.036 *kg wt* (d) 0.0029 *kg wt*

50. A racing car moving towards a cliff, sounds its horn. The driver observes that the sound reflected from the cliff has a pitch one octave higher than the actual sound of the horn. If v is the velocity of sound, then the velocity of the car is

[KCET 2002; CBSE PMT 2004]

(a) $v/\sqrt{2}$ (b) $v/2$

(c) $v/3$ (d) $v/4$

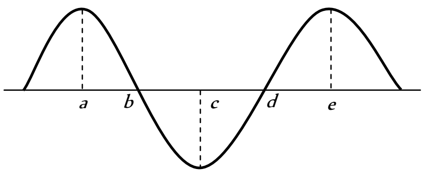
51. An earthquake generates both transverse (*S*) and longitudinal (*P*) sound waves in the earth. The speed of *S* waves is about 4.5 *km*/s and that of *P* waves is about 8.0 *km/s*. A seismograph records *P* and *S* waves from an earthquake. The first *P* wave arrives 4.0 *min* before the first *S* wave. The epicenter of the earthquake is located at a distance about [AIIMS 2003]

(a) 25 *km* (b) 250 *km*

(c) 2500 *km* (d) 5000 *km*

GQ Graphical Questions

1. The rope shown at an instant is carrying a wave travelling towards right, created by a source vibrating at a frequency n. Consider the following statements



I. The speed of the wave is $4n \times ab$

II. The medium at a will be in the same phase as d after $\frac{4}{3n}s$

III. The phase difference between b and e is $\frac{3\pi}{2}$

Which of these statements are correct [AMU 2001]

(a) I, II and III (b) II only

(c) I and III (d) III only

2. Two pulses in a stretched string whose centres are initially 8 *cm* apart are moving towards each other as shown in the figure. The speed of each pulse is 2 *cm/s*. After 2 seconds, the total energy of the pulses will be

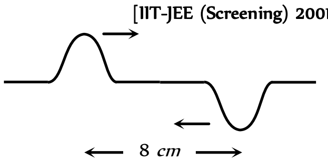
[IIT-JEE (Screening) 2001]

(a) Zero

(b) Purely kinetic

(c) Purely potential

(d) Partly kinetic and partly potential



Assertion & Reason

For AIIMS Aspirants

Read the assertion and reason carefully to mark the correct option out of the options given below:

(a) *If both assertion and reason are true and the reason is the correct explanation of the assertion.*
(b) *If both assertion and reason are true but reason is not the correct explanation of the assertion.*
(c) *If assertion is true but reason is false.*
(d) *If the assertion and reason both are false.*
(e) *If assertion is false but reason is true.*

1. Assertion : Two persons on the surface of moon cannot talk to each other.
Reason : There is no atmosphere on moon.

2. Assertion : Transverse waves are not produced in liquids and gases.
Reason : Light waves are transverse waves.

3. Assertion : Sound waves cannot propagate through vacuum but light waves can.
Reason : Sound waves cannot be polarised but light waves can be polarised. [AIIMS 1998]

4. Assertion : The velocity of sound increases with increase in humidity.
Reason : Velocity of sound does not depend upon the medium.

5. Assertion : Ocean waves hitting a beach are always found to be nearly normal to the shore.
Reason : Ocean waves are longitudinal waves.

6. Assertion : Compression and rarefaction involve changes in density and pressure.
Reason : When particles are compressed, density of medium increases and when they are rarefied, density of medium decreases.

7. Assertion : Transverse waves travel through air in an organ pipe.
Reason : Air possesses only volume elasticity.

8. Assertion : Sound would travel faster on a hot summer day than on a cold winter day.
Reason : Velocity of sound is directly proportional to the square of its absolute temperature.

9. Assertion : The basic of Laplace correction was that, exchange of heat between the region of compression and rarefaction in air is not possible.
Reason : Air is a bad conductor of heat and velocity of sound in air is large.

10. Assertion : Particle velocity and wave velocity both are independent of time.
Reason : For the propagation of wave motion, the medium must have the properties of elasticity and inertia.

11. Assertion : When we start filling an empty bucket with water, the pitch of sound produced goes on decreasing.
Reason : The frequency of man voice is usually higher than that of woman.

12. Assertion : A tuning fork is made of an alloy of steel, nickel and chromium.
Reason : The alloy of steel, nickel and chromium is called elinvar.

13. Assertion : The change in air pressure effect the speed of sound.
Reason : The speed of sound in a gas is proportional to square root of pressure.

14. Assertion : Solids can support both longitudinal and transverse waves but only longitudinal waves can propagate in gases.
Reason : For the propagation of transverse waves, medium must also neccessarly have the property of rigidity.

15. Assertion : Under given conditions of pressure and temperature, sound travels faster in a monoatomic gas than in diatomic gas.
Reason : Opposition for wave to travel is more in diatomic gas than monoatomic gas.

16. Assertion : The speed of sound in solids is maximum though their density is large.
Reason : The coefficient of elasticity of solid is large.

17. Assertion : On a rainy day sound travel slower than on a dry day.
Reason : When moisture is present in air the density of air increases.

18. Assertion : To hear distinct beats, difference in frequencies of two sources should be less than 10.
Reason : More the number of beats per sec more difficult to hear them.

19. Assertion : Sound produced by an open organ pipe is richer than the sound produced by a closed organ pipe.
Reason : Outside air can enter the pipe from both ends, in case of open organ pipe.

20. Assertion : It is not possible to have interference between the waves produced by two violins.
Reason : For interference of two waves the phase difference between the waves must remain constant.

21. Assertion : Beats can also be observed by two light sources as in sound.
Reason : Light sources have constant phase deference.

22. Assertion : In the case of a stationary wave, a person hear a loud sound at the nodes as compared to the antinodes.
Reason : In a stationary wave all the particles of the medium vibrate in phase.

23. Assertion : Velocity of particles, while crossing mean position (in stationary waves) varies from maximum at antinodes to zero at nodes.
Reason : Amplitude of vibration at antinodes is maximum and at nodes, the amplitude is zero, And all particles between two successive nodes cross the mean position together.

24. Assertion : Where two vibrating tuning forks having frequencies 256 *Hz* and 512 *Hz* are held near each other, beats cannot be heard.
Reason : The principle of superposition is valid only if the frequencies of the oscillators are nearly equal.

25. Assertion : The fundamental frequency of an open organ pipe increases as the temperature is increased.
Reason : As the temperature increases, the velocity of sound increases more rapidly than length of the pipe.

26. Assertion : Sound travel faster in solids than gases.
Reason : Solid possess greater density than gases. [AIIMS 2000]

27. Assertion : Like sound, light can not propagate in vacuum.
Reason : Sound is a square wave. It propagates in a medium by a virtue of damping oscillation . [AIIMS 2000]

28. Assertion : Speed of wave $= \frac{\text{Wave length}}{\text{Time period}}$
Reason : Wavelength is the distance between two nearest particles in phase. [AIIMS 2002]

29. Assertion : The flash of lightening is seen before the sound of thunder is heard.
Reason : Speed of sound is greater than speed of light [AIIMS 2002]

30. Assertion : When a beetle moves along the sand with in a few tens of centimeters of a sand scorpion the scorpion immediately turn towards the beetle and dashes to it
Reason : When a beetle disturbs the sand, it sends pulses along the sands surface one set of pulses is longitudinal while other set is transverse. [AIIMS 2003]

31. Assertion : The reverberation time dependent on the the shape of enclosure, position of source and observer.
Reason : The unit of absorption coefficient in *mks* system is metric sabine. [EAMCET 2004]

Answers

Basics of Mechanical Waves

1	d	2	c	3	a	4	a	5	d
6	d	7	a	8	c	9	c	10	a
11	a	12	a	13	d	14	c	15	a
16	b	17	c	18	b	19	d	20	a
21	b	22	b	23	b	24	d	25	b
26	a	27	d	28	c	29	b	30	d
31	c	32	a	33	b	34	d	35	b
36	b	37	b	38	a	39	c	40	d
41	d	42	d	43	c	44	a	45	d
46	c	47	b	48	d	49	b	50	a
51	d	52	c	53	c	54	c	55	b
56	a	57	a	58	a	59	a	60	a
61	d	62	c	63	a	64	c	65	d
66	c	67	c	68	a	69	d	70	a
71	b	72	b	73	b	74	d	75	c
76	b	77	d	78	b	79	b	80	b
81	d	82	b	83	b	84	b	85	d
86	d	87	a	88	c	89	a	90	a
91	a	92	d	93	d	94	d		

Progressive Waves

1	d	2	c	3	b	4	c	5	d
6	d	7	c	8	d	9	c	10	c
11	c	12	c	13	c	14	b	15	b
16	abcd	17	b	18	b	19	d	20	bc
21	a	22	b	23	a	24	a	25	a
26	a	27	acd	28	d	29	a	30	a
31	b	32	d	33	b	34	d	35	d
36	d	37	a	38	a	39	b	40	b
41	d	42	c	43	b	44	c	45	a
46	a	47	d	48	a	49	b	50	d
51	d	52	abc	53	a	54	a	55	b
56	d	57	b	58	d	59	c	60	a
61	b	62	a	63	d	64	a	65	b
66	b	67	b	68	b	69	d	70	b
71	a	72	b	73	d	74	ac	75	c
76	b	77	b	78	c	79	b	80	a

Interference and Superposition of Waves

1	b	2	d	3	a	4	d	5	b
6	d	7	d	8	bc	9	c	10	c
11	a	12	b	13	c	14	d	15	b
16	c	17	a	18	a	19	b	20	c
21	a	22	b	23	a	24	c	25	d
26	b								

Beats

1	c	2	d	3	c	4	a	5	d
6	b	7	c	8	a	9	d	10	b
11	c	12	b	13	a	14	c	15	c
16	c	17	c	18	b	19	c	20	a
21	d	22	c	23	d	24	c	25	c
26	d	27	a	28	c	29	b	30	a
31	c	32	a	33	a	34	a	35	d
36	b	37	a	38	a	39	a	40	b
41	a	42	c	43	d	44	b	45	a
46	c	47	a	48	b	49	b	50	b
51	b								

Stationary Waves

1	c	2	c	3	c	4	c	5	b
6	a	7	b	8	d	9	a	10	a
11	b	12	d	13	b	14	d	15	d
16	abc	17	a	18	d	19	a	20	a
21	a	22	b	23	c	24	b	25	a
26	c	27	d	28	c	29	b	30	d
31	b	32	a	33	b	34	a	35	a
36	a	37	a	38	d	39	d		

Vibration of String

1	c	2	d	3	c	4	c	5	c
6	b	7	b	8	d	9	a	10	c
11	d	12	c	13	c	14	a	15	a
16	d	17	a	18	a	19	c	20	b
21	d	22	c	23	a	24	b	25	a
26	b	27	b	28	b	29	c	30	c
31	b	32	a	33	d	34	b	35	d
36	c	37	d	38	a	39	d	40	b
41	a	42	a	43	d	44	d	45	d
46	c	47	a	48	b	49	d	50	c
51	d	52	b						

Organ Pipe (Vibration of Air Column)

1	c	2	a	3	c	4	d	5	c
6	acd	7	d	8	a	9	b	10	c
11	b	12	c	13	b	14	b	15	b
16	a	17	b	18	a	19	c	20	a
21	b	22	a	23	a	24	b	25	c
26	a	27	a	28	b	29	a	30	d
31	c	32	a	33	b	34	b	35	b
36	b	37	b	38	c	39	b	40	b
41	b	42	b	43	a	44	c	45	a
46	c	47	a	48	d	49	b	50	c
51	a	52	a	53	b				

Doppler's Effect

1	d	2	b	3	a	4	b	5	c
6	b	7	c	8	b	9	a	10	a
11	b	12	a	13	d	14	c	15	b
16	a	17	a	18	c	19	d	20	a
21	d	22	a	23	a	24	b	25	c
26	b	27	c	28	d	29	b	30	d
31	a	32	c	33	d	34	d	35	a
36	b	37	c	38	d	39	a	40	c
41	a	42	c	43	a	44	d	45	d
46	b	47	b	48	b	49	b	50	a
51	a	52	c	53	d	54	b	55	a
56	c	57	c	58	d	59	c	60	a
61	c	62	b	63	a	64	a	65	b

Musical Sound

1	d	2	a	3	a	4	c	5	b
6	c	7	a	8	d	9	d	10	d
11	d	12	c	13	d	14	c	15	b
16	c	17	b	18	a	19	d	20	b
21	c	22	d	23	b	24	a	25	b
26	d	27	d	28	b	29	b	30	a
31	d	32	a						

Critical Thinking Questions

1	abcd	2	bc	3	c	4	a	5	c
6	b	7	b	8	c	9	b	10	d
11	b	12	abc	13	b	14	b	15	a
16	b	17	a	18	d	19	a	20	c
21	a	22	abcd	23	b	24	d	25	a
26	a	27	c	28	a	29	b	30	a
31	b	32	b	33	a	34	c	35	b
36	a	37	d	38	b	39	a	40	c
41	b	42	b	43	c	44	ac	45	c
46	b	47	d	48	c	49	c	50	c
51	c								

Graphical Questions

1	c	2	b	3	a	4	b	5	d
6	c	7	d	8	d	9	c	10	c
11	c	12	c	13	c	14	b	15	bd
16	d	17	b	18	d				

Assertion and Reason

1	a	2	b	3	b	4	c	5	c
6	a	7	e	8	c	9	c	10	e
11	d	12	b	13	e	14	a	15	c
16	a	17	d	18	b	19	b	20	a
21	d	22	c	23	a	24	c	25	a
26	b	27	d	28	b	29	c	30	a
31	e								

AS Answers and Solutions

Basics of Mechanical Waves

1. (d) Air is more rarer for sound to travel as compared to vacuum.

2. (c)

3. (a)

4. (a) $v = n\lambda = 2\times 5 = 10$ *cm/sec*

5. (d) $v = n\lambda \Rightarrow \lambda = \frac{v}{n} = \frac{330}{256} = 1.29m$

6. (d) Time lost in covering the distance of 2 km by the sound waves $t = \frac{d}{v} = \frac{2000}{330} = 6.06$ *sec* ≈ 6 *sec*

7. (a) $v_{\max} = a\omega = a\times 2\pi n = 0.1\times 2\pi\times 300 = 60\pi\ cm/\sec$

8. (c) Audiable range of frequency is 20Hz to 20kHz

9. (c) Phase difference $= \frac{2\pi}{\lambda}\times$ path difference

$$\Rightarrow 1.6\pi = \frac{2\pi}{\lambda}\times 40 \Rightarrow \lambda = 50\ cm = 0.5m$$

$$\Rightarrow v = n\lambda \Rightarrow 330 = 0.5\times n \Rightarrow n = 660\ Hz$$

10. (a) $\lambda = \frac{v}{n}; n \approx 50{,}000\ Hz$, $v = 330$ *m/sec* $\Rightarrow \lambda = \frac{330}{50000} m$

$$= 6.6\times 10^{-5} cm \approx 5\times 10^{-5} cm$$

11. (a)

12. (a) $\lambda = \frac{v}{n} = \frac{1.7\times 1000}{4.2\times 10^{6}} = 4\times 10^{-4}\ m$

13. (d) Since maximum audible frequency is 20,000 Hz, hence $\lambda_{\min} = \frac{v}{n_{\max}} = \frac{340}{20{,}000} \approx 20\ mm$

14. (c) Velocity of sound in gas $v = \sqrt{\frac{\gamma RT}{M}} \Rightarrow v \propto \sqrt{\frac{\gamma T}{M}}$

$$\Rightarrow \frac{v_{N_2}}{v_{He}} = \sqrt{\frac{\gamma_{N_2}}{\gamma_{He}}\times\frac{M_{He}}{M_{H_2}}} = \sqrt{\frac{\frac{7}{5}R\times 4}{\frac{5}{3}R\times 28}} = \frac{\sqrt{3}}{5}$$

15. (a) Time required for a point to move from maximum displacement to zero displacement is $t = \frac{T}{4} = \frac{1}{4n}$

$$\Rightarrow n = \frac{1}{4t} = \frac{1}{4\times 0.170} = 1.47\ Hz$$

16. (b) Wave number is the reciprocal of wavelength and is written as $\bar{n} = \frac{1}{\lambda}$.

17. (c) $\lambda = \frac{v}{n} = \frac{340}{200} = 1.7\ m$

18. (b)

19. (d) $v \propto \lambda \Rightarrow \frac{\lambda_1}{\lambda_2} = \frac{v_1}{v_2} = \frac{2/3}{3/10} = \frac{20}{9}$

20. (a) The time taken by the stone to reach the lake

$$t_1 = \sqrt{\left(\frac{2h}{g}\right)} = \sqrt{\left(\frac{2\times 500}{10}\right)} = 10\,sec \text{ (Using } h = ut + \frac{1}{2}gt^2\text{)}$$

Now time taken by sound from lake to the man

$$t_2 = \frac{h}{v} = \frac{500}{340} \approx 1.5 \sec$$

$\Rightarrow$ Total time $= t_1 + t_2 = 10 + 1.5 = 11.5 \sec$.

21. (b) When medium changes, velocity and wavelength changes but frequency remains constant.

22. (b) $t = \sqrt{\frac{2h}{g}} + \frac{h}{v} = \sqrt{\frac{2\times 19.6}{9.8}} + \frac{19.6}{v} = 2.06$

$$\Rightarrow v = 326.7\ m/s$$

23. (b) $v \propto \sqrt{T} \Rightarrow \frac{v_2}{v_1} = \sqrt{\frac{T_2}{T_1}} \Rightarrow 2 = \sqrt{\frac{T_2}{(273+0)}}$

$$\Rightarrow T_2 = 273\times 4 = 1092\,K = 819^{o}C$$

24. (d) Velocity of sound in steel is maximum out of the given materials water and air. In vacuum sound cannot travel, it's speed is zero.

25. b) Distance between a compression and the nearest rarefaction is $\frac{\lambda}{2}=1m$. Hence $n=\frac{v}{\lambda}=\frac{360}{2}=180\,Hz$.

26. (a) $v=\sqrt{\frac{\gamma P}{\rho}}\Rightarrow\frac{v_{O_2}}{v_{H_2}}=\sqrt{\frac{\rho_{H_2}}{\rho_{o_2}}}=\sqrt{\frac{1}{16}}=\frac{1}{4}$

27. (d) Speed of sound in gases is $v=\sqrt{\frac{\gamma RT}{M}}\Rightarrow T\propto M$

(Because v, γ-constant). Hence $\frac{T_{H_2}}{T_{O_2}}=\frac{M_{H_2}}{M_{O_2}}$

$\Rightarrow\frac{T_{H_2}}{(273+100)}=\frac{2}{32}\Rightarrow T_{H_2}=23.2K=-249.7°C$

28. (c) If the temperature changes then velocity of wave and its wavelength changes. Frequency amplitude and time period remains constant.

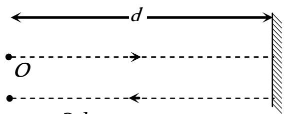
29. (b)

30. (d)

31. (c) Path difference $\Delta=\frac{\lambda}{2\pi}\times\phi\Rightarrow 1=\frac{\lambda}{2\pi}\times\frac{\pi}{2}\Rightarrow\lambda=4m$

Hence $v=n\lambda=120\times4=480\;\;m/s$

32. (a) Suppose the distance between shooter and reflecting surface is d. Hence time interval for hearing echo is



$t=\frac{2d}{v}\Rightarrow 8=\frac{2d}{350}\Rightarrow d=1400\,m$.

33. (b) Time $=\frac{\text{Distance}}{\text{Velocity}}=\frac{1000}{330}=3.03\text{ sec}$.

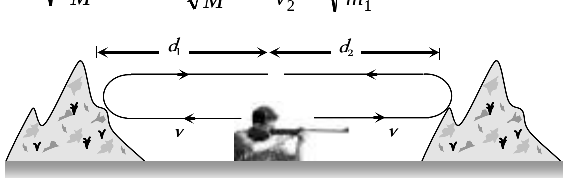
Sound will be heard after 3.03 sec. So his watch is set 3*sec*, slower.

34. (d) $v=\sqrt{\frac{\gamma P}{\rho}}$; as P changes, ρ also changes. Hence $\frac{P}{\rho}$ remains constant so speed remains constant.

35. (b) Speed of sound in gases is given by

$v=\sqrt{\frac{\gamma RT}{M}}\Rightarrow v\propto\frac{1}{\sqrt{M}}\Rightarrow\frac{v_1}{v_2}=\sqrt{\frac{m_2}{m_1}}$

36. (b)



$2d_1+2d_2=v\times t_1+v\times t_2\Rightarrow 2(d_1+d_2)=v(t_1+t_2)$

$d_1+d_2=\frac{v(t_1+t_2)}{2}=\frac{340\times(1.5+3.5)}{2}=850\;\;m.$

37. (b) By using $v=\sqrt{\frac{\gamma RT}{M}}\Rightarrow v\propto\sqrt{T}$

$\frac{v_2}{v_1}=\sqrt{\frac{T_2}{T_1}}=\sqrt{\frac{T+600}{T}}=\sqrt{3}\Rightarrow T=300\,K=27^{o}\,C$

38. (a) Velocity of sound is independent of frequency. Therefore it is same (v) for frequency n and $4n$.

39. (c) $v=\sqrt{\frac{\gamma RT}{M}}\Rightarrow v\propto\sqrt{T}$

i.e. if v is doubled then T becomes four times,

hence $T_2=4T_1=4(273+27)=1200K=927°C$

40. (d) $n=\frac{3600}{60}=60\;Hz\Rightarrow\lambda=\frac{v}{n}=\frac{960}{60}=16\,m$

41. (d) Speed do sound, doesn't depend up on pressure and density medium.

42. (d) If d is the distance between man and reflecting surface of sound then for hearing echo

$2d=v\times t\Rightarrow d=\frac{340\times1}{2}=170\,m$

43. (c) $n=\frac{54}{60}\,Hz,\lambda=10\,m\Rightarrow v=n\lambda=9\,m/s$.

44. (a) $v=\sqrt{\frac{\gamma RT}{M}}\Rightarrow v\propto\frac{1}{\sqrt{M}}$. Since M is minimum for H_2 so sound velocity is maximum in H_2.

45. (d) $2d=v\times t$, where $v=$ velocity of sound = 332 m/s

t = Persistence of hearing = $\frac{1}{10}$ sec.

$\Rightarrow d=\frac{v\times t}{2}=\frac{332\times\frac{1}{10}}{2}=16.5\;\;m$

46. (c) Since solid has both the properties (rigidity and elasticity)

47. (b) If d is the distance between man and reflecting surface of sound then for hearing echo

$2d=v\times t\Rightarrow d=\frac{330\times1.5}{2}=247.5\;\;m$

48. (d) Speed of sound $v\propto\sqrt{T}$ and it is independent of pressure.

49. (b) Frequency of wave is

$n=\frac{3600}{2\times60}\,Hz\Rightarrow\lambda=\frac{v}{n}=\frac{760}{30}=25.3\;m.$

50. (a) Speed of sound $v=\sqrt{\frac{\gamma P}{d}}\Rightarrow\frac{v_1}{v_2}=\sqrt{\frac{d_2}{d_1}}$ ($\because P$ - constant)

51. (d) $\lambda=\frac{v}{n}=\frac{352}{384}$; during 1 vibration of fork sound will travel $\frac{352}{384}\,m$ during 36 vibration of fork sound will travel $\frac{352}{384}\times36=33\;m$

52. (c) At given temperature and pressure

$v\propto\frac{1}{\sqrt{\rho}}\Rightarrow\frac{v_1}{v_2}=\sqrt{\frac{\rho_2}{\rho_1}}=\sqrt{\frac{4}{1}}=2:1$

53. (c) $v\propto\sqrt{T}\Rightarrow\sqrt{\frac{T_2}{T_1}}=\frac{v_2}{v_1}\Rightarrow T_2=T_1\left(\frac{v_2}{v_1}\right)^2$

$\Rightarrow T_2=273\times4=1092K$

54. (c) $\bar{n} = \frac{1}{\lambda} = \frac{1}{6000\times10^{-10}} = 1.66\times10^{6} m^{-1}$

55. (b) $v \propto \frac{1}{\sqrt{M}} \Rightarrow \frac{v_{H_2}}{v_{O_2}} = \sqrt{\frac{M_{O_2}}{M_{H_2}}} = \sqrt{\frac{32}{2}} \Rightarrow \frac{v_{H_2}}{v_{O_2}} = \frac{4}{1}$

56. (a) The minimum distance between compression and rarefaction of the wire $l = \frac{\lambda}{4}$ $\therefore$ Wave length $\lambda = 4l$

Now by $v = n\lambda \Rightarrow n = \frac{360}{4\times1} = 90\ sec^{-1}$.

57. (a) $v_{sound} \propto \frac{1}{\sqrt{\rho}} \Rightarrow \frac{v_1}{v_2} = \sqrt{\frac{\rho_2}{\rho_1}} = \sqrt{\frac{4}{1}} = 2 \Rightarrow v_2 = \frac{v_1}{2} = \frac{v_s}{2}$

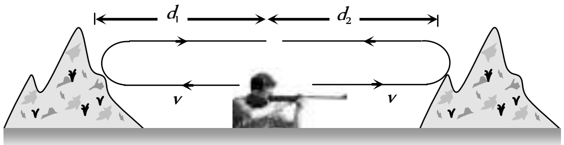
58. (a) Suppose the distance between two fixed points is d then $t = \frac{d}{v}$ also $v \propto \sqrt{T} \Rightarrow \frac{t_1}{t_2} = \frac{v_2}{v_1} = \sqrt{\frac{T_2}{T_1}}$

$\Rightarrow \frac{2}{t_2} = \sqrt{\frac{303}{283}} \Rightarrow t_2 = 1.9\ sec.$

59. (a) The density of moist air (*i.e.* air mixed with water vapours) is less than the density of dry air

Hence from $v = \sqrt{\frac{\gamma P}{\rho}} \Rightarrow v_{moist\ air} > v_{dry\ air}$

60. (a) Total time taken for both the echoes $t = t_1 + t_2 = 2\ sec$



but $t = \frac{2d_1}{v} + \frac{2d_2}{v} \Rightarrow t = \frac{2}{v}(d_1 + d_2)$

$\Rightarrow (d_1 + d_2) = \frac{v\times t}{2} = \frac{340\times2}{2} = 340 m.$

61. (d) Frequency of sound does not change with medium, because it is characteristics of source.

62. (c) Since $v = \sqrt{\frac{\gamma RT}{M}}$ *i.e.,* $v \propto \sqrt{T}$

63. (a) Frequency of waves remains same, *i.e.* 60 *Hz*

and wavelength $\lambda = \frac{v}{n} = \frac{330}{60\times10^3} = 5.5\ mm.$

64. (c) Path difference $\Delta = \frac{\lambda}{2\pi}\times\phi = \frac{\lambda}{2\pi}\times\frac{\pi}{3} = \frac{\lambda}{6}$

65. (d) Interference, diffraction and reflection occurs in both transverse and longitudinal waves. Polarisation occurs only in transverse waves.

66. (c) Water waves are transverse as well as longitudinal in nature.

67. (c)

68. (a) In transverse waves medium particles vibrate perpendicular to the direction of propagation of wave.

69. (d)

70. (a) Wave on a plucked string is stationary wave. Light waves are EM waves. Water waves are transverse as well as longitudinal.

71. (b)

72. (b) Transverse wave can propagate in solids but not in liquids and gases.

73. (b) Because sound waves in gases are longitudinal.

74. (d)

75. (c) Since distance between two consecutive crests is λ, so

$\phi = \frac{2\pi}{\lambda}\times\lambda = 2\pi.$

76. (b) The distance between two points *i.e.* path difference between them $\Delta = \frac{\lambda}{2\pi}\times\phi = \frac{\lambda}{2\pi}\times\frac{\pi}{3} = \frac{\lambda}{6} = \frac{v}{6n}$ $(\because v = n\lambda) \Rightarrow$

$\Delta = \frac{360}{6\times500} = 0.12\,m = 12\,cm$

77. (d) Sound waves are longitudinal in nature so they can not be polarised

78. (b)

79. (b) Ultrasonic waves are those of higher frequencies than maximum audible range frequencies (audible range of frequencies is 20 *Hz* to 20000 *Hz*)

80. (b)

81. (d) Infrasonic waves have frequency less than (20 *Hz*) audible sound and wavelength more than audible sound.

82. (b) SONAR emits ultrasonic waves.

83. (b) EM waves do not requires medium for their propagation.

84. (b)

85. (d)

86. (d) $v = \sqrt{\frac{\gamma RT}{M}} \Rightarrow \frac{T_N}{T_0} = \frac{M_N}{M_0} \Rightarrow \frac{T_N}{273+55} = \frac{14}{16} = \frac{7}{8}$

$\Rightarrow T_N = 287K = 14°C$

87. (a) We know that at night amount of carbon dioxide in atmosphere increases which raises the density of atmosphere. Since intensity is directly proportional to density, intensity of sound is more at night.

88. (c) $n = \frac{v}{\lambda} = \frac{300}{0.6\times10^{-2}} Hz = \frac{3}{6}\times10^4 Hz = 50{,}000 Hz$

$\Rightarrow$ Wave is ultrasonic.

89. (a) $v = \sqrt{\frac{K}{\rho}}$ $\therefore$ $K = v^2\rho = 2.86\times10^{10} N/m^3$

90. (a) $n = \frac{v}{\lambda} \propto v \Rightarrow \frac{n_{MW}}{n_{US}} \approx \frac{3\times10^8}{3\times10^2} \approx 10^6 : 1$

91. (a) Intensity $\propto \frac{1}{(\text{Distance})^2} \Rightarrow \frac{I_1}{I_2} = \left(\frac{d_2}{d_1}\right)^2 = \left(\frac{3}{2}\right)^2 = \frac{9}{4}$

92. (d) $v = \frac{\sin i}{\sin r} = \frac{v_1}{v_2}$

$\Rightarrow \sin r = \sin 30°\times\frac{2u}{u} \Rightarrow \sin r = \frac{1}{2}\times2\times1 \Rightarrow r = 90°$

93. (d) Number of waves per minute = 54

$\therefore$ Number of waves per second = 54/60

Now $v = n\lambda \Rightarrow n = \frac{54}{60}\times10 = 9\,m/s.$

94. (d) If d is the distance of rock from SONAR then

$$2d = vt \Rightarrow d = \frac{v \times t}{2} = \frac{1600 \times 1}{2} = 800m$$

Progressive Waves

1. (d) Comparing given equation with standard equation of progressive wave. The velocity of wave

$$v = \frac{\omega(\text{Co - efficient of } t)}{k\,(\text{Co - efficient of } x)} = \frac{200\pi}{0.5\pi} = 400\ cm/s$$

2. (c) Comparing with $y = a\cos(\omega t + kx - \phi)$,

We get $k = \frac{2\pi}{\lambda} = 0.02 \Rightarrow \lambda = 100\ cm$

Also, it is given that phase difference between particles $\Delta\phi = \frac{\pi}{2}$. Hence path difference between them

$$\Delta = \frac{\lambda}{2\pi} \times \Delta\phi = \frac{\lambda}{2\pi} \times \frac{\pi}{2} = \frac{\lambda}{4} = \frac{100}{4} = 25\ cm$$

3. (b) Phase difference between two successive crest is 2π. Also, phase difference $(\Delta\phi) = \frac{2\pi}{T}$ time interval (Δt)

$$\Rightarrow 2\pi = \frac{2\pi}{T} \times 0.2 \Rightarrow \frac{1}{T} = 5\sec^{-1} \Rightarrow n = 5\ Hz$$

4. (c) Comparing with the standard equation,

$y = A\sin\frac{2\pi}{\lambda}(vt - x)$, we have

$v = 200\ cm/\sec$, $\lambda = 200\ cm$; $\therefore n = \frac{v}{\lambda} = 1\ \sec^{-1}$

5. (d) Let the phase of second particle be ϕ. Hence phase difference between two particles is $\Delta\phi = \frac{2\pi}{\lambda}\Delta x$

$$\Rightarrow \left(\phi - \frac{\pi}{3}\right) = \frac{2\pi}{60} \times 15 \Rightarrow \phi - \frac{\pi}{3} = \frac{\pi}{2} \Rightarrow \phi = \frac{5\pi}{6}$$

6. (d) The given equation can be written as $y = 4\sin\left(4\pi t - \frac{\pi x}{16}\right)$

$$\Rightarrow (v) = \frac{\text{Co - efficient of } t(\omega)}{\text{Co - efficient of } x(K)}$$

$\Rightarrow v = \frac{4\pi}{\pi/16} = 64\ cm/sec$ along $+x$ direction.

7. (c) $v = \frac{\text{Co - efficient of } t}{\text{Co - efficient of } x} = \frac{628}{31.4} = 20\ cm/sec$

8. (d) $y_1 = a\sin(\omega t - kx)$

and $y_2 = a\cos(\omega t - kx) = a\sin\left(\omega t - kx + \frac{\pi}{2}\right)$

Hence phase difference between these two is $\frac{\pi}{2}$.

9. (c) $I \propto a^2 \propto \frac{1}{d^2} \Rightarrow a \propto \frac{1}{d}$

10. (c) $\frac{I_1}{I_2} = \frac{a_1^2}{a_2^2} = \left(\frac{0.06}{0.03}\right)^2 = \frac{4}{1}$

11. (c) After reflection from rigid support, a wave suffers a phase change of π.

12. (c) The given equation representing a wave travelling along $-y$ direction (because '+' sign is given between t term and x term). On comparing it with $x = A\sin(\omega t + ky)$

We get $k = \frac{2\pi}{\lambda} = 12.56 \Rightarrow \lambda = \frac{2 \times 3.14}{12.56} = 0.5\ m$

13. (c) Comparing with $y = a\sin(\omega t - kx) \Rightarrow a = \frac{10}{\pi}, \omega = 200\pi$

$\therefore v_{max} = a\omega = \frac{10}{\pi} \times 2000\pi = 200m/\sec$

and $\omega = \frac{2\pi}{T} \Rightarrow 200\pi = \frac{2\pi}{T} \Rightarrow T = 10^{-3}\ sec$

14. (b) Comparing the given equation with $y = a\cos(\omega t - kx)$

We get $k = \frac{2\pi}{\lambda} = \pi \Rightarrow \lambda = 2cm$

15. (b) Comparing the given equation with $y = a\sin(\omega t - kx)$, We get $a = Y$, $\omega = 2\pi f$, $k = \frac{2\pi}{\lambda}$. Hence maximum particle velocity $(v_{max})_{particle} = a\omega = Y_0 \times 2\pi f$ and wave velocity $(v)_{wave} = \frac{\omega}{k} = \frac{2\pi f}{2\pi/\lambda} = f\lambda$

$\because (v_{max})_{Particle} = 4v_{Wave} \Rightarrow Y_0 \times 2\pi f = 4f\lambda \Rightarrow \lambda = \frac{\pi Y_0}{2}$.

16. (a,b,c,d) On comparing the given equation with $y = a\sin(\omega t + kx)$, it is clear that wave is travelling in negative x-direction.

It's amplitude $a = 10^{\cdot}\ m$ and $\omega = 60$, $k = 2$. Hence frequency $n = \frac{\omega}{2\pi} = \frac{60}{2\pi} = \frac{30}{\pi}\ Hz$

$k = \frac{2\pi}{\lambda} = 2 \Rightarrow \lambda = \pi\ m$ and $v = \frac{\omega}{k} = \frac{60}{2} = 30\ m/s$

17. (b) $\because y = a\cos\left(\frac{2\pi}{\lambda}vt + \frac{2\pi x}{\lambda}\right) = 0.5\cos(4\pi t + 2\pi x)$

18. (b) $v = \frac{\text{Co - efficient of } t}{\text{Co - efficient of } x} = \frac{100}{50} = 2\ m/\sec$.

19. (d) $y = f(x^2 - vt^2)$ doesn't follows the standard wave equation.

20. (b,c) Standard wave equation which travel in negative x-direction is $y = A\sin(\omega t + kx + \phi_0)$

For the given wave $\omega = 2\pi n = 15\pi$, $k = \frac{2\pi}{\lambda} = 10\pi$

Now $v = \frac{\text{Co - efficient of } t}{\text{Co - efficient of } x} = \frac{\omega}{k} = \frac{15\pi}{10\pi} = 1.5\ m/sec$

and $\lambda = \frac{2\pi}{k} = \frac{2\pi}{10\pi} = 0.2\ m$.

21. (a) $v_{max} = a\omega = 3 \times 10 = 30$

22. (b) $y_1 = a_1\sin\left(\omega t - \frac{2\pi x}{\lambda}\right)$ and

$$y_2 = a_2 \cos\left(\omega t - \frac{2\pi x}{\lambda} + \phi\right) = a_2 \sin\left(\omega t - \frac{2\pi x}{\lambda} + \phi + \frac{\pi}{2}\right)$$

So phase difference $= \phi + \frac{\pi}{2}$ and $\Delta = \frac{\lambda}{2\pi}\left(\phi + \frac{\pi}{2}\right)$

23. (a) Both waves are moving opposite to each other .

24. (a) The velocity of wave

$$v = \frac{\omega\,(\text{Co - efficient of } t)}{k\,(\text{Co - efficient of } x)} = \frac{10}{1} = 10\ m/s$$

25. (a) $v = \frac{\text{Co - efficient of } t}{\text{Co - efficient of } x} = \frac{7\pi}{0.04} = 175\ m/s$.

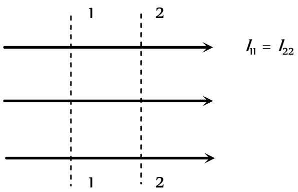
26. (a) The given equation is $y = 10\sin(0.01\pi x - 2\pi t)$

Hence $\omega =$ coefficient of $t = 2\pi$

$\Rightarrow$ Maximum speed of the particle $v_{\max} = a\omega = 10 \times 2\pi$

$= 10 \times 2 \times 3.14 = 62.8 \approx 63$ *cm/s*

27. (a,c,d) For a travelling wave, the intensity of wave remains constant if it is a plane wave.



Intensity of wave is inversely proportional to the square of the distance from the source if the wave is spherical

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

Intensity of spherical wave on the spherical surface centred at source always remains same. Here total intensity means power P .

28. (d) On comparing the given equation with standard equation $y = a\sin\frac{2\pi}{\lambda}(vt - x)$. It is clear that wave speed $(v)_{wave} = v$ and maximum particle velocity $(v_{\max})_{particle} = a\omega = y_0 \times$ co-efficient of $t = y_0 \times \frac{2\pi v}{\lambda}$

$$\because\ (v_{\max})_{particle} = 2(\omega)_{wave} \Rightarrow \frac{a \times 2\pi v}{\lambda} = 2v \Rightarrow \lambda = \pi y_0$$

29. (a) Given $y = A\sin(kx - \omega t)$

$$\Rightarrow\ v = \frac{dy}{dt} = -A\omega\cos(kx - \omega t);\ \Rightarrow v_{\max} = A\omega$$

30. (a) Comparing with $y = (x, t) = a\sin(\omega t - kx)$

$$k = \frac{2\pi}{\lambda} = 0.01\pi \Rightarrow \lambda = 200\ m.$$

31. (b)

32. (d) Comparing the given equation with standard equation $y = a\sin 2\pi\left(\frac{t}{T} - \frac{x}{\lambda}\right) \Rightarrow T = 0.04$ *sec* $\Rightarrow v = \frac{1}{T} = 25Hz$

Also $(A)_{\max} = \omega^2 a = \left(\frac{2\pi}{T}\right)^2 \times a = \left(\frac{2\pi}{0.04}\right)^2 \times 3$

$= 7.4 \times 10^4$ *cm/sec*.

33. (b) From the given equation amplitude $a = 0.04m$

Frequency $= \frac{\text{Co–efficient of t}}{2\pi} = \frac{\pi/5}{2\pi} = \frac{1}{10}Hz$

Wave length $\lambda = \frac{2\pi}{\text{Co–efficient of } x} = \frac{2\pi}{\pi/9} = 18m.$

Wave speed $v = \frac{\text{Co - efficient of } t}{\text{Co - efficient of } x} = \frac{\pi/5}{\pi/9} = 1.8 m/s.$

34. (d)

35. (d) Compare the given equation with $y = a\cos(\omega t + k\phi)$

$$\Rightarrow\ \omega = 2\pi n = 2000 \Rightarrow n = \frac{1000}{\pi}Hz$$

36. (d) $y = A\sin(at - bx + c)$ represents equation of simple harmonic progressive wave as it describes displacement of any particle (x) at any time (t). or It represents a wave because it satisfies wave equation $\frac{\partial^2 y}{\partial t^2} = v^2\frac{\partial^2 y}{\partial x^2}$.

37. (a) Here $\omega = 2\pi n = 2\pi \Rightarrow n = 1$

38. (a) Compare the given equation with $y = a\sin(\omega t + kx)$. We get

$$\omega = 2\pi n = 100 \Rightarrow n = \frac{50}{\pi}Hz$$

39. (b) Compare with $y = a\sin(\omega t - kx)$

We have $k = \frac{2\pi}{\lambda} = 62.4 \Rightarrow \lambda = \frac{2\pi}{62.4} = 0.1$

40. (b) Maximum velocity of the particle

$$v_{\max} = a\omega = 0.5 \times 10\pi = 5\pi\ cm/sec$$

41. (d) On reflection from fixed end (denser medium) a phase difference of π is introduced.

42. (c) Maximum particle velocity $v_{\max} = \omega a$ and wave velocity

$v = \frac{\omega}{k} \Rightarrow \frac{v_{\max}}{v} = \frac{\omega a}{\omega/k} = ka$. From the given equation $k = \text{Co - efficient of } x = 6\,micron = 6 \times 10^{-6} m$

$$\Rightarrow \frac{v_{\max}}{v} = ka = 6 \times 10^{-6} \times 60 = 3.6 \times 10^{-4}$$

43. (b) $\omega = 314$, $k = 1.57$ and $v = \frac{\omega}{k} = \frac{314}{1.57} = 200$ *m/s.*

44. (c) $v = \frac{\text{Co - efficient of } t}{\text{Co - efficient of } x} = \frac{40}{1} = 40\ m/s$

45. (a) $n = \frac{\omega}{2\pi} = \frac{400\pi}{2\pi} = 200\ Hz$ (As $\omega = 400\pi$)

46. (a) Beats period $= \frac{1}{30 - 20} = 0.1$ *sec*

$\Delta\phi = \frac{2\pi}{T}\Delta t = \frac{2\pi}{0.1} \times 0.6 = 2\pi \times 6 = 12\ \pi$ or Zero.

47. (d) Path difference $\Delta = \frac{\lambda}{2\pi} \times \phi = \frac{\lambda}{2\pi} \times \frac{\pi}{2} = \frac{\lambda}{4}$

$\because \Delta = 0.8\ m \Rightarrow \frac{\lambda}{4} = 0.8 \Rightarrow \lambda = 3.2\ m.$

$\therefore\ v = n\lambda = 120 \times 3.2 = 384$ *m/s*

48. (a) $v = \frac{\text{co - efficient of } t}{\text{co - efficient of } x} = \frac{2\pi / 0.01}{2\pi / 0.3} = 30\, m/s$

49. (b) Comparing with $y = a\sin 2\pi\left[\frac{t}{T} - \frac{x}{\lambda}\right] \Rightarrow \lambda = 40\ cm$

50. (d) $v = \frac{\omega}{k} = \frac{\text{Co} - \text{efficient of } t}{\text{Co} - \text{efficient of } x} = \frac{2}{0.01} = 200\ cm/\sec$.

51. (d) From the given equation $k = 0.2\pi$

$\Rightarrow \frac{2\pi}{\lambda} = 0.2\pi \Rightarrow \lambda = 10\ cm$

$\Delta\phi = \frac{2\pi}{\lambda}\Delta x = \frac{2\pi}{10} \times 2 = \frac{2\pi}{5} = 72^o$

52. (a,b,c) $I = 2\pi n^2 a^2 \rho v \Rightarrow I \propto n^2 a^2 v$

53. (a) comparing the given equation with $y = a\sin(\omega t - kx)$

$\omega = 200,\ k = 1$ so $v = \frac{\omega}{k} = 200\ m/s$

54. (a) $v = \frac{\omega}{k} = \frac{2\pi}{2\pi} = 1\ m/s$

55. (b) By comparing it with standard equation

$y = a\cos(\omega t - kx) \Rightarrow k = \frac{2\pi}{\lambda} = \pi \Rightarrow \lambda = 2cm$

56. (d) Compare the given equation with

$y = a\sin(\omega t + kx) \Rightarrow \omega = 2\pi n = 100 \Rightarrow n = \frac{50}{\pi} Hz$

$k = \frac{2\pi}{\lambda} = 1 \Rightarrow \lambda = 2\pi$ and $v = \omega / k = 100\ m/s$

Since '+' is given between t terms and x term, so wave is travelling in negative x-direction.

57. (b) Given $A\omega = 4v \Rightarrow A2\pi n = 4n\lambda \Rightarrow \lambda = \frac{\pi A}{2}$

58. (d) $v = \frac{\omega}{k} = \frac{100}{1/10} = 1000\ m/s$

59. (c) A wave travelling in positive x-direction may be represented as $y = A\sin\frac{2\pi}{\lambda}(vt - x)$. On putting values

$y = 0.2\sin\frac{2\pi}{60}(360\,t - x) \Rightarrow y = 0.2\sin 2\pi\left(6\,t - \frac{x}{60}\right)$

60. (a) $v = \frac{\omega}{k} = \frac{7\pi}{0.4\pi} = 17.5\ m/s$

61. (b) $\frac{I_1}{I_2} = \frac{a_1^2}{a_2^2} \Rightarrow \frac{I_1}{I_2} = \frac{25}{100} = \frac{1}{4}$

62. (a) From the given equation $k = \frac{2\pi}{\lambda}$ = Co-efficient of x

$= \frac{\pi}{4} \Rightarrow \lambda = 8m$

63. (d) $y = 4\sin 2\pi\left(\frac{t}{0.02} - \frac{x}{100}\right)$.

Comparing this equation with $y = a\sin 2\pi\left(\frac{t}{T} - \frac{x}{\lambda}\right)$

$v = \frac{\text{Co - efficient of } t}{\text{Co - efficient of } x} = \frac{1/0.02}{1/100}$

64. (a) Comparing the given equation with $y = a\sin(\omega t - kx)$

We get $\omega = 3000\,\pi \Rightarrow n = \frac{\omega}{2\pi} = 1500\,Hz$

and $k = \frac{2\pi}{\lambda} = 12\pi \Rightarrow \lambda = \frac{1}{6}m$

So, $v = n\lambda \Rightarrow v = 1500 \times \frac{1}{6} = 250\ m/s$

65. (b) Positive sign in the argument of sin indicating that wave is travelling in negative x-direction.

66. (b) Comparing the given equation with $y = a\cos(\omega t - kx)$

$a = 25,\ \omega = 2\pi n = 2\pi \Rightarrow n = 1Hz$

67. (b) $v = \frac{\omega}{k} = \frac{600}{2} = 300 m/\sec$.

68. (b) $v = \frac{\text{Co–efficent of } t}{\text{Co–efficent of } x} = \frac{\omega}{k} = \frac{100}{20} = 5\,m/s$.

69. (d) Comparing with standard wave equation

$y = a\sin\frac{2\pi}{\lambda}(vt - x)$, we get, $v = 200\,m/s$.

70. (b) Phase difference $= \frac{2\pi}{\lambda} \times$ path difference

$\Rightarrow \frac{\pi}{2} = \frac{2\pi}{\lambda} \times 0.8 \Rightarrow \lambda = 4 \times 0.8 = 3.2\,m$

Velocity $v = n\lambda = 120 \times 3.2 = 384\,m/s$.

71. (a) Comparing the given equation with standard equation

We get $\omega = 2\pi n = 200\pi \Rightarrow n = 100\ Hz$

$k = \frac{20\pi}{17} \Rightarrow \lambda = \frac{2\pi}{k} = \frac{2\pi}{20\pi/17} = 1.7\,m$

and $v = \frac{\omega}{k} = \frac{200\,\pi}{20\pi/17} = 170\,m/s$.

72. (b) Given, $y = 0.5\sin(20x - 400\,t)$

Comparing with $y = a\sin(\omega t - kx)$

Gives velocity of wave $v = \frac{\omega}{k} = \frac{400}{20} = 20\,m/s$.

73. (d) $v = n\lambda \Rightarrow \lambda = 10\ cm$

Phase difference $\frac{2\pi}{\lambda} \times$ Path difference $\frac{2\pi}{10} \times 2.5 = \frac{\pi}{2}$

74. (a, c) $v_{max} = a\omega = \frac{v}{10} = \frac{10}{10} =$ m/sec

$\Rightarrow a\omega = a \times 2\pi n = 1 \Rightarrow n = \frac{10^3}{2\pi}$ $(\because a = 10^{-3}\ m)$

Since $v = n\lambda \Rightarrow \lambda = \frac{v}{n} = \frac{10}{10^3/2\pi} = 2\pi \times 10^{-2}\ m$

75. (c) Total energy is conserved.

76. (b) $v = \frac{\text{Co–efficent of } t}{\text{Co–efficent of } x} = \frac{1/2}{1/4} = 2\,m/s$

Hence $d = v\,t = 2 \times 8 = 16m$

77. (b) $y_1 = 10^{-6}\sin[100\,t + (x/50) + 0.5]$

$y_2 = 10^{-6} \sin\left[100\,t + \left(\frac{x}{50}\right) + \left(\frac{\pi}{2}\right)\right]$

Phase difference ϕ

$= [100t + (x/50) + 1.57] - [100t + (x/50) + 0.5]$

$= 1.07$ *radians.*

78. (c) Resultant amplitude

$A_R = 2A\cos\left(\frac{\theta}{2}\right) = 2 \times (2a)\cos\left(\frac{\theta}{2}\right) = 4a\cos\left(\frac{\theta}{2}\right)$

79. (b) The particle will come after a time $\frac{T}{4}$ to its mean position.

80. (a) Maximum particle velocity $= a\omega = 2 \times 2 = 4$ units.

Interference and Superposition of Waves

1. (b) With path difference $\frac{\lambda}{2}$, waves are out of phase at the point of observation.

2. (d) $A_{max} = \sqrt{A^2 + A^2} = A\sqrt{2}$, frequency will remain same *i.e.* ω.

3. (a) Phase difference is 2π means constrictive interference so resultant amplitude will be maximum.

4. (d) Resultant amplitude

$A = \sqrt{a^2 + a^2 + 2aa\cos\phi} = \sqrt{4a^2\cos^2\left(\frac{\phi}{2}\right)}$

$\because\ I \propto A^2 \Rightarrow I \propto 4a^2$

5. (b) $A^2 = a^2 = a^2 + a^2 + 2a^2\cos\theta \Rightarrow \cos\theta = -\frac{1}{2} \Rightarrow \theta = \frac{2\pi}{3}$

6. (d) $\lambda = \frac{v}{n} = \frac{350}{350} = 1\,m$ =100 cm

Also path difference (Δx) between the waves at the point of observation is $AP - BP = 25cm$. Hence

$\Rightarrow \Delta\phi = \frac{2\pi}{\lambda}(\Delta x) = \frac{2\pi}{1} \times \left(\frac{25}{100}\right) = \frac{\pi}{2}$

$\Rightarrow A = \sqrt{(a_1)^2 + (a_2)^2} = \sqrt{(0.3)^2 + (0.4)^2}$ = 0.5 mm

7. (d) Path difference $(\Delta x) = 50\,cm = \frac{1}{2}m$

$\therefore$ Phase difference $\Delta\phi = \frac{2\pi}{\lambda} \times \Delta x \Rightarrow \phi = \frac{2\pi}{1} \times \frac{1}{2} = \pi$

Total phase difference = $\pi - \frac{\pi}{3} = \frac{2\pi}{3}$

$\Rightarrow A = \sqrt{a^2 + a^2 + 2a^2\cos(2\pi/3)} = a$

8. (b,c) Because in general phase velocity = wave velocity. But in case of complex waves (many waves together) phase velocity ≠ wave velocity.

$\therefore$ If two waves have same λ, v; then they have same frequency too

9. (c) If two waves of nearly equal frequency superpose, they give beats if they both travel in straight line and $I_{min} = 0$ if they have equal amplitudes.

10. (c) Resultant amplitude = $\sqrt{a_1^2 + a_2^2 + 2a_1a_2\cos\phi}$

= $\sqrt{0.3^2 + 0.4^2 + 2 \times 0.3 \times 0.4 \times \cos\frac{\pi}{2}}$ = 0.5 cm

11. (a) In the same phase ϕ = 0 so resultant amplitude = $a_1 + a_2 = 2A + A = 3A$

12. (b) $\frac{I_1}{I_2} = \left(\frac{a_1}{a_2}\right)^2 = \frac{1}{16} \Rightarrow \frac{a_1}{a_2} = \frac{1}{4}$

13. (c) For interference, two waves must have a constant phase relation ship. Equation '1' and '3' and '2' and '4' have a constant phase relationship of $\frac{\pi}{2}$ out of two choices. Only one S emitting '2' and S emitting '4' is given so only (c) option is correct.

14. (d) This is a case of destructive interference.

15. (b) $a_1 = 5,\ a_2 = 10 \Rightarrow \frac{I_{max}}{I_{min}} = \frac{(a_1 + a_2)^2}{(a_1 - a_2)^2} = \left(\frac{5+10}{5-10}\right)^2 = \frac{9}{1}$

16. (c) For the given super imposing waves

$a_1 = 3,\ a_2 = 4$ and phase difference $\phi = \frac{\pi}{2}$

$\Rightarrow A = \sqrt{a_1^2 + a_2^2 + 2a_1a_2\cos\pi/2} = \sqrt{(3)^2 + (4)^2} = 5$

17. (a) Phase difference between the two waves is

$\phi = (\omega t - \beta_2) = (\omega t - \beta_1) = (\beta_1 - \beta_2)$

$\therefore$ Resultant amplitude $A = \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos(\beta_1 - \beta_2)}$

18. (a) $\frac{I_{max}}{I_{min}} = \left(\frac{\frac{a_1}{a_2} + 1}{\frac{a_1}{a_2} - 1}\right)^2 = \left(\frac{2+1}{2-1}\right)^2 = 9/1$

19. (b) $\frac{I_{max}}{I_{min}} = \left(\frac{\sqrt{\frac{I_1}{I_2}} + 1}{\frac{\sqrt{I_1}}{\sqrt{I_2}} - 1}\right)^2 = \left(\frac{\sqrt{\frac{9}{4}} + 1}{\sqrt{\frac{9}{4}} - 2}\right)^2 = \frac{25}{1}$

20. (c) $\frac{I_{max}}{I_{min}} = \left(\frac{\frac{a_1}{a_2} + 1}{\frac{a_1}{a_2} - 1}\right)^2 = \left(\frac{\frac{4}{3} + 1}{\frac{4}{3} - 1}\right)^2 = \frac{49}{1}$

21. (a) The resultant amplitude is given by

$A_R = \sqrt{A^2 + A^2 + 2AA\cos\theta} = \sqrt{2A^2(1 + \cos\theta)}$

$= 2A\cos\theta/2 \qquad (\because H\cos\theta = 2\cos^2\theta/2)$

22. (b) $\frac{I_{max}}{I_{min}} = \frac{\left(\frac{\sqrt{I_1}}{\sqrt{I_2}} + 1\right)^2}{\left(\frac{\sqrt{I_1}}{\sqrt{I_2}} - 1\right)^2} = \frac{\left(\sqrt{\frac{9}{1}} + 1\right)^2}{\left(\sqrt{\frac{9}{1}} - 1\right)^2} = \frac{4}{1}$

23. (a) Since $\phi = \frac{\pi}{2} \Rightarrow A = \sqrt{a_1^2 + a_2^2} = \sqrt{(4)^2 + (3)^2} = 5$

24. (c) $A = \sqrt{(a_1^2 + a_2^2 + 2a_1 a_2 \cos\phi)}$

Putting $a_1 = a_2 = a$ and $\phi = \frac{\pi}{3}$, we get $A = \sqrt{3}a$

25. (d) $y = \frac{1}{\sqrt{a}}\sin\omega t \pm \frac{1}{\sqrt{b}}\sin\left(\omega t + \frac{\pi}{2}\right)$

Here phase difference = $\frac{\pi}{2}$ $\therefore$ The resultant amplitude

$= \sqrt{\left(\frac{1}{\sqrt{a}}\right)^2 + \left(\frac{1}{\sqrt{b}}\right)^2} = \sqrt{\frac{1}{a} + \frac{1}{b}} = \sqrt{\frac{a+b}{ab}}$

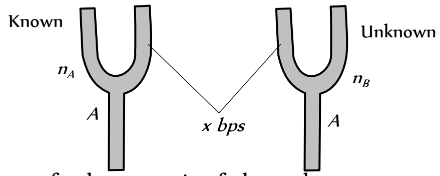
26. (b) Superposition of waves does not alter the frequency of resultant wave and resultant amplitude

$\Rightarrow a^2 = a^2 + a^2 + 2a^2\cos\phi = 2a^2(1 + \cos\phi)$

$\Rightarrow \cos\phi = -1/2 = \cos 2\pi/3 \therefore \phi = 2\pi/3$

Beats

1. (c) Suppose two tuning forks are named A and B with frequencies $n_A = 256\,Hz$ (known), n_B = ? (unknown), and beat frequency x = 4 *bps.*



Frequency of unknown tuning fork may be

$n_B = 256 + 4 = 260\,Hz$

or $= 256 - 4 = 252\,Hz$

It is given that on sounding waxed fork A (fork of frequency 256 *Hz*) and fork B, number of beats (beat frequency) increases. It means that with decrease in frequency of A, the difference in new frequency of A and the frequency of B has increased. This is possible only when the frequency of A while decreasing is moving away from the frequency of B.

This is possible only if n_B = 260 *Hz.*

Alternate method : It is given $n_A = 256\,Hz, n_B = ?$ and x = 4 *bps*

Also after loading A (*i.e.* $n_A\downarrow$), beat frequency (*i.e.* x) increases ($\uparrow$).

Apply these informations in two possibilities to known the frequency of unknown tuning fork.

$n_A\downarrow - n_B = x\uparrow$ ... (i)

$n_B - n_A\downarrow = x\uparrow$ ... (ii)

It is obvious that equation (i) is wrong (ii) is correct so

$n_B = n_A + x$ = 256 + 4 = 260 *Hz.*

2. (d)

3. (c)

4. (a) Suppose n_A = known frequency = 100 *Hz,* n_B = ?

x = 2 = Beat frequency, which is decreasing after loading (*i.e.* $x\downarrow$)

Unknown tuning fork is loaded so $n_B\downarrow$

Hence $n_A - n_B\downarrow = x\downarrow$ ... (i) ⟶ Wrong

$n_B\downarrow - n_A = x\downarrow$ ... (ii) ⟶ Correct

$\Rightarrow n_B = n_A + x$ = 100 + 2 = 102 *Hz.*

5. (d) n_A = Known frequency = 256, n_B = ?

x = 2 *bps*, which is decreasing after loading (*i.e.* $x\downarrow$) known tuning fork is loaded so $n_A\downarrow$

Hence $n_A\downarrow - n_B = x\downarrow$ ... (i) ⟶ Correct

$n_B - n_A\downarrow = x\downarrow$ ... (ii) ⟶ Wrong

$\Rightarrow n_B = n_A - x$ = 256 – 2 = 254 *Hz.*

6. (b) n_A = Known frequency = 256 *Hz,* n_B = ?

x = 4 *bps*, which is decreasing after loading (*i.e.* $x\downarrow$) also known tuning fork is loaded so $n_A\downarrow$

Hence $n_A\downarrow - n_B = x\downarrow$ ... (i) ⟶ Correct

$n_B - n_A\downarrow = x\downarrow$ ... (ii) ⟶ Wrong

$\Rightarrow n_B = n_A - x$ = 256 – 4 = 252 *Hz.*

7. (c) Time interval between two consecutive beats

$T = \frac{1}{n_1 - n_2} = \frac{1}{260 - 256} = \frac{1}{4}\sec$ so, $t = \frac{1}{16} = \frac{T}{4}$ sec

By using time difference = $\frac{T}{2\pi}$ × Phase difference

$\Rightarrow \frac{T}{4} = \frac{T}{2\pi} \times \phi \Rightarrow \phi = \frac{\pi}{2}$

8. (a) The time interval between successive maximum intensities will be $\frac{1}{n_1 \sim n_2} = \frac{1}{454 - 450} = \frac{1}{4}\sec$.

9. (d) n_A = Known frequency = 341 *Hz,* n_B = ?

x = 6 *bps*, which is decreasing (*i.e.* $x\downarrow$) after loading (from 6 to 1 *bps*)

Unknown tuning fork is loaded so $n_B\downarrow$

Hence $n_A - n_B\downarrow = x\downarrow$ ... (i) ⟶ Wrong

$n_B\downarrow - n_A = x\downarrow$ ... (ii) ⟶ Correct

$\Rightarrow n_B = n_A + x$ = 341 + 6 = 347 *Hz.*

10. (b) $T = \frac{1}{258 - 256} = 0.5\sec$

11. (c) Suppose n_A = known frequency = 100 *Hz,* n_B = ?

x = 5 *bps*, which remains unchanged after loading

Unknown tuning fork is loaded so $n_B\downarrow$

Hence $n_A - n_B\downarrow = x$ ... (i)

$n_B\downarrow - n_A = x$ ... (ii)

From equation (i), it is clear that as n_B decreases, beat frequency. (*i.e.* $n_A - (n_B)_{new}$) can never be x again.

From equation (ii), as $n_B\downarrow$, beat frequency (*i.e.* $(n_B)_{new} - n_A$) decreases as long as $(n_B)_{new}$ remains greater than n_A, If $(n_B)_{new}$ become lesser than n_A the beat frequency will increase again and will be x. Hence this is correct.

So, $n_B = n_A + x$ = 100 + 5 = 105 *Hz.*

12. (b) n_A = Known frequency = 256 *Hz,* n_B = ?

x = 6 *bps*, which remains the same after loading.

Unknown tuning fork F is loaded so $n_B\downarrow$

Hence $n_A - n_B\downarrow = x$ ... (i) ⟶ Wrong

$n_B\downarrow - n_A = x$ ... (ii) ⟶ Correct

$\Rightarrow n_B = n_A + x = 256 + 6 = 262$ *Hz.*

13. (a) Probable frequencies of tuning fork be $n+4$ or $n-4$

Frequency of sonometer wire $n \propto \dfrac{1}{l}$

$\therefore \dfrac{n+4}{n-4} = \dfrac{100}{95}$ or $95(n+4) = 100(n-4)$

or $95n + 380 = 100n - 400$ or $5n = 780$ or $n = 156$

14. (c) After filling frequency increases, so n_A decreases ($\downarrow$). Also it is given that beat frequency increases (*i.e.,* $x\uparrow$)

Hence $n_A\downarrow - n_B = x\uparrow$ ... (i) ⟶ Correct

$n_B - n_A\uparrow = x\uparrow$ ... (ii) ⟶ Wrong

$\Rightarrow n_A = n_B + x = 512 + 5 = 517$ *Hz.*

15. (c) Intensity $\propto$ (amplitude)^2

as $A_{\max} = 2a_o$ (a_o = amplitude of one source) so $I_{\max} = 4I_o$.

16. (c) Number of beats per second = $n_1 \sim n_2$

$\omega_1 = 2000\pi = 2\pi n_1 \Rightarrow n_1 = 1000$

and $\omega_2 = 2008\pi = 2\pi n_2 \Rightarrow n_2 = 1004$

Number of beats heard per sec $= 1004 - 1000 = 4$

17. (c) The tuning fork whose frequency is being tested produces 2 beats with oscillator at 514 *Hz*, therefore, frequency of tuning fork may either be 512 or 516. With oscillator frequency 510 it gives 6 *beats/sec*, therefore frequency of tuning fork may be either 516 or 504.

Therefore, the actual frequency is 516 *Hz* which gives 2 *beats/sec* with 514 *Hz* and 6 *beats/sec* with 510 *Hz.*

18. (b) If suppose n_s = frequency of string $= \dfrac{1}{2l}\sqrt{\dfrac{T}{m}}$

n_f = Frequency of tuning fork = 480 *Hz*

x = Beats heard per second = 10

as tension T increases, so n_s increases ($\uparrow$)

Also it is given that number of beats per sec decreases (*i.e.* $x\downarrow$)

Hence $n_s\uparrow - n_f = x\downarrow$ ... (i) ⟶ Wrong

$n_f - n_s\uparrow = x\downarrow$ ... (ii) ⟶ Correct

$\Rightarrow n_s = n_f - x = 480 - 10 = 470$ *Hz.*

19. (c) It is given that

n_A = Unknown frequency = ?

n_B = Known frequency = 256 *Hz*

x = 3 *bps*, which remains same after loading

Unknown tuning fork *A* is loaded so $n_A\downarrow$

Hence $n_A\downarrow - n_B = x$ ... (i) ⟶ Correct

$n_B - n_A\downarrow = x$ ... (ii) ⟶ Wrong

$\Rightarrow n_A = n_B + x = 256 + 3 = 259$ *Hz.*

20. (a) Frequency of the source = 100 ± 5 = 105 *Hz* or 95 *Hz.*

Second harmonic of the source = 210 *Hz* or 190 *Hz.*

As the second harmonic gives 5 *beats/sec* with sound of frequency 205 *Hz*, the second harmonic should be 210 *Hz.*

$\Rightarrow$ Frequency of the source = 105 *Hz.*

21. (d) For producing beats, their must be small difference in frequency.

22. (c) n_A = Known frequency = 256 *Hz*, n_B = ?

x = 4 *beats per sec* which is decreasing (4 *bps* to $\dfrac{5}{2}bps$) after loading (*i.e.* $x\downarrow$)

Unknown tuning fork *B*, is loaded so $n_B\downarrow$

Hence $n_A - n_B\downarrow = x\downarrow$ ... (i) ⟶ Wrong

$n_B\downarrow - n_A = x\downarrow$ ... (ii) ⟶ Correct

$\Rightarrow n_B = n_A + x = 256 + 4 = 260$ *Hz.*

23. (d) $n_A\downarrow - n_B = x\uparrow$ ... (i) ⟶ Wrong

$n_B - n_A\downarrow = x\uparrow$ ... (ii) ⟶ Correct

$\Rightarrow n_B = n_A + x = 200 + 5 = 205$ *Hz.*

24. (c) $n_A - n_B\downarrow = x$ (same) ... (i) ⟶ Wrong

$n_B\downarrow - n_A = x$ (same) ... (ii) ⟶ Correct

$\Rightarrow n_B = n_A + x = 320 + 4 = 324$ *Hz.*

25. (c) Beat period $T = \dfrac{1}{n_1 \sim n_2} = \dfrac{1}{384 - 380} = \dfrac{1}{4}\sec$. Hence minimum time interval between maxima and minima $t = \dfrac{T}{2} = \dfrac{1}{8}\sec$.

26. (d) $\dfrac{I_{\max}}{I_{\min}} = \left(\dfrac{a_1 + a_2}{a_1 - a_2}\right)^2 = \dfrac{(5+3)^2}{(5-3)^2} = \dfrac{16}{1}$

27. (a) $n_1 = \dfrac{v}{\lambda_1} = \dfrac{v}{0.50}$ and $n_2 = \dfrac{v}{\lambda_2} = \dfrac{v}{0.51}$

$\Delta n = n_1 - n_2 = v\left[\dfrac{1}{0.05} - \dfrac{1}{0.51}\right] = 12$

$\Rightarrow v = \dfrac{12 \times 0.51 \times 0.50}{0.01} = 306\ m/s$

28. (c) $n_1 = \dfrac{316}{2\pi}$ and $n_2 = \dfrac{310}{2\pi}$ Number of beats heard per second $= n_1 - n_2 = \dfrac{316}{2\pi} - \dfrac{310}{2\pi} = \dfrac{3}{\pi}$

29. (b) Beat frequency $= \dfrac{2}{0.4} = 5\,Hz$

30. (a) Since source of frequency x gives 8 beats per second with frequency 250 *Hz*, it's possible frequency are 258 or 242. As source of frequency x gives 12 beats per second with a frequency 270 *Hz*, it's possible frequencies 282 or 258 *Hz.* The only possible frequency of x which gives 8 beats with frequency 250 *Hz* also 12 beats per second with 258 *Hz.*

31. (c) $n_1 = \dfrac{1000\pi}{2\pi} = 500\,Hz$ and $n_2 = \dfrac{998\pi}{2\pi} = 499$ *Hz*

Hence beat frequency = $n_1 - n_2 = 1$

32. (a) $v_0 = 332$ *m/s.* Velocity sound at $t°C$ is $v_t = (v_0 + 0.61\,t)$

$\Rightarrow v_{20} = v_0 + 0.61 \times 20 = 344.2\ m/s$

$\Rightarrow \Delta n = v_{20}\left(\dfrac{1}{\lambda_1} - \dfrac{1}{\lambda_2}\right) = 344.2\left(\dfrac{100}{50} - \dfrac{100}{51}\right) = 14$

33. (a) Persistence of hearing is 10 *sec*.

34. (a)

35. (d) n_A = ?, n_B = 384 *Hz*

x = 6 *bps*, which is decreasing (from 6 to 4) *i.e.* $x\downarrow$

Tuning fork *A* is loaded so $n_A\downarrow$

Hence $n_A\downarrow - n_B = x\downarrow$ ⟶ Correct

$n_B - n_A\downarrow = x\downarrow$ ⟶ Wrong

$\Rightarrow n_A = n_B + x$ = 384 + 6 = 390 *Hz.*

36. (b) For hearing beats, difference of frequencies should be approximately 10 *Hz.*

37. (a) $n \propto \frac{1}{l} \Rightarrow n_1 l_1 = n_2 l_2 \Rightarrow (n+4)49 = (n-4)50 \Rightarrow n = 396$

38. (a) No of beats, $x = \Delta n = \frac{30}{3} = 10\ Hz$

$\Rightarrow$ Also $\Delta n = v\left[\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right] = v\left[\frac{1}{5} - \frac{1}{6}\right] = 10 \Rightarrow v = 300\ m/s$

39. (a) $\Delta n = v\left[\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right] = 396\left[\frac{1}{0.99} - \frac{1}{1}\right] = 3.96 \approx 4.$

40. (b) n_A = Known frequency = 288 *cps*, n_B = ?

x = 4 *bps*, which is decreasing (from 4 to 2) after loading *i.e.* $x\downarrow$

Unknown fork is loaded so $n_B\downarrow$

Hence $n_A - n_B\downarrow = x\downarrow$ ⟶ Wrong

$n_B\downarrow - n_A\downarrow = x\downarrow$ ⟶ Correct

$\Rightarrow n_B = n_A + x$ = 288 + 4 = 292 *Hz.*

41. (a) Frequency = $\frac{\text{Number of beats}}{\text{Time}} = \frac{2}{0.04} = 50\ Hz$

42. (c) No. of beats = frequency difference = $\frac{4}{0.25} = 16$

43. (d) Suppose n_P = frequency of piano = ? $(n_P \propto \sqrt{T})$

n_f = Frequency of tuning fork $= 256 Hz$

x = Beat frequency = 5 *bps*, which is decreasing (5→2) after clanging the tension of piano wire

Also, tension of piano wire is increasing so $n_P\downarrow$

Hence $n_P\uparrow - n_f = x\downarrow$ ⟶ Wrong

$n_f - n_P\uparrow = x\downarrow$ ⟶ Correct

$\Rightarrow n_P = n_f - x$ = 256 – 5 *Hz.*

44. (b) With temperature rise frequency of tuning fork decreases. Because, the elastic properties are modified when temperature is changed

also, $n_t = n_0(1 - 0.00011t)$

where n_t = frequency at $t°C$, n_0 = frequency at $0°C$

45. (a) $n_x = 300 Hz,\ n_y = ?$

x = beat frequency = 4 *Hz*, which is decreasing (4→2) after increasing the tension of the string *y*.

Also tension of wire *y* increasing so $n_y\uparrow$ $(\because n \propto \sqrt{T})$

Hence $n_x - n_y\uparrow = x\downarrow$ ⟶ Correct

$n_y\uparrow - n_x = x\downarrow$ ⟶ Wrong

$\Rightarrow n_y = n_x - x = 300 - 4 = 296 Hz$

46. (c) Let n be the frequency of fork *C* then

$n_A = n + \frac{3n}{100} = \frac{103n}{100}$ and $n_B = n - \frac{2n}{100} = \frac{98}{100}$

but $n_A - n_B = 5 \Rightarrow \frac{5n}{100} = 5 \Rightarrow n = 100\ Hz$

$\therefore n_A = \frac{(103)(100)}{100} = 103\ Hz$

47. (a)

48. (b) From the given equations of progressive waves $\omega_1 = 500\pi$ and $\omega_2 = 506\pi$ $\therefore n_1 = 250$ and $n_2 = 253$

So beat frequency $= n_2 - n_1 = 253 - 250 = 3$ *beats per sec*

$\therefore$ Number of beats per min = 180.

49. (b)

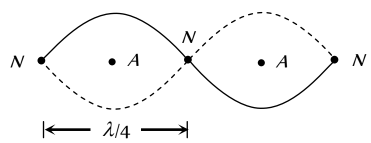
50. (b) Frequency $= \frac{360}{60} \times 60 = 360 Hz.$

51. (b) $v = n\lambda \Rightarrow \lambda = \frac{v}{n} = \frac{340}{170} \Rightarrow \lambda = 2$

Distance separating the position of minimum intensity = $\frac{\lambda}{2} = \frac{2}{2} = 1\ m$

Stationary Waves

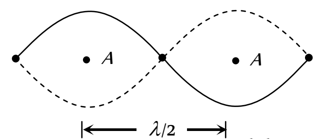
1. (c) The distance between the nearest node and antinode in a stationary wave is $\frac{\lambda}{4}$



2. (c) At nodes pressure change (strain) is maximum

3. (c) Both the sides of a node, two antinodes are present with separation $\frac{\lambda}{2}$

So phase difference between then $\phi = \frac{2\pi}{\lambda} \times \frac{\lambda}{2} = \pi$



4. (c) Progressive wave propagate energy while no propagation of energy takes place in stationary waves.

5. (b)

6. (a) Comparing given equation with standard equation

$y = 2a \sin\frac{2\pi x}{\lambda} \cos\frac{2\pi vt}{\lambda}$ gives us $\frac{2\pi}{\lambda} = \frac{\pi}{15} \Rightarrow \lambda = 30$

Distance between nearest node and antinodes = $\frac{\lambda}{4} = \frac{30}{4} = 7.5$

7. (b) On comparing the given equation with standard equation $y = 2a\sin\frac{2\pi x}{\lambda}\cos\frac{2\pi vt}{\lambda} \Rightarrow \frac{2\pi x}{\lambda} = \frac{\pi x}{3} \Rightarrow \lambda = 6$

Separation between two adjacent nodes = $\frac{\lambda}{2} = 3\ cm$

8. (d)

9. (a) On comparing the given equation with standard equation $y = 2a\sin\frac{2\pi x}{\lambda}\cos\frac{2\pi vt}{\lambda}$]

We get $\frac{2\pi}{\lambda} = \frac{\pi}{20} \Rightarrow \lambda = 40$

Separation between two consecutive nodes = $\frac{\lambda}{2} = \frac{40}{2} = 20\ cm$

10. (a)

11. (b) Since the point $x = 0$ is a node and reflection is taking place from point $x = 0$. This means that reflection must be taking place from the fixed end and hence the reflected ray must suffer an additional phase change of π or a path change of $\frac{\lambda}{2}$.

So, if $y_{\text{incident}} = a\cos(kx - \omega t)$

$\Rightarrow y_{\text{reflected}} = a\cos(-kx - \omega t + \pi) = -a\cos(\omega t + kx)$

12. (d) Particles have kinetic energy maximum at mean position.

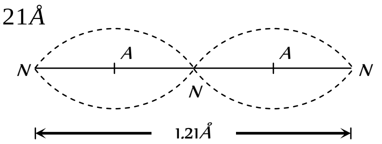
13. (b) On comparing the given equation with standard equation $\frac{2\pi}{\lambda} = 5 \Rightarrow \lambda = \frac{6.28}{5} = 1.256m$

14. (d)

15. (d)

16. (a,b,c) Standing waves can be produced only when two similar type of waves (same frequency and speed, but amplitude may be different) travel in opposite directions.

17. (a) $\lambda = 1.21Å$



18. (d) $\frac{\lambda}{4} = 20 \Rightarrow \lambda = 80\ cm$, also $\Delta\phi = \frac{\lambda}{2\pi}.\Delta x$

$\Rightarrow \Delta\phi = \frac{60}{80} \times 2\pi = \frac{3\pi}{2}$

19. (a) Required distance $= \frac{\lambda}{4} = \frac{v/n}{4} = \frac{1200}{4 \times 300} = 1\ m$

20. (a) Waves *A* and *B* satisfied the conditions required for a standing wave.

21. (a) By comparing given equation with $y = a\sin(\omega t)\cos kx$

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

22. (b) At fixed end node is formed and distance between two consecutive nodes $\frac{\lambda}{2} = 10\ cm \Rightarrow \lambda = 20\ cm$

$\Rightarrow v = n\lambda = 20\ m/sec$

23. (c) $a\cos(kx + \omega t)$

hence $y_{\text{reflected}} = a\cos(-kx + \omega t + \pi) = -a\cos(kx - \omega t)$

24. (b) Distance between the consecutive node $= \frac{\lambda}{2}$,

but $\lambda = \frac{v}{n} = \frac{20}{n}$ so $\frac{\lambda}{2} = \frac{10}{n}$

25. (a) Energy is not carried by stationary waves

26. (c) On comparing the given equation with standard equation $\Rightarrow \frac{2\pi}{\lambda} = \frac{\pi}{3} \Rightarrow \lambda = 6\ cm$. Hence, distance between two consecutive nodes $\Rightarrow \lambda = 3\ cm$

27. (d) Minimum time interval between two instants when the string is flat = $\frac{T}{2} = 0.5\sec \Rightarrow T = 1\sec$

Hence $\lambda = v \times T = 10 \times 1 = 10\ m$.

28. (c)

29. (b) Distance between two nodes = $\frac{\lambda}{2} = \frac{v}{2n} = \frac{16}{2n} = \frac{8}{n}$

30. (d)

31. (b) In stationary wave all the particles in one particular segment (*i.e.*, between two nodes) vibrates in the same phase.

32. (a) If $y_{incident} = a\sin(\omega t - kx)$ and $y_{stationary} = a\sin(\omega t)\cos kx$ then it is clear that frequency of both is same (ω)

33. (b)

34. (a) On comparing the given equation with standard equation $\frac{2\pi}{\lambda} = \frac{\pi}{4} \Rightarrow \lambda = 8$

Hence distance between two consecutive nodes $\frac{\lambda}{2} = 4$

35. (a)

36. (a) Waves $Z_1 = A\sin(kx - \omega t)$ is travelling towards positive *x*-direction.

Wave $Z_2 = A\sin(kx + \omega t)$, is travelling towards negative *x*-direction.

Wave $Z_3 = A\sin(ky - \omega t)$ is travelling towards positive *y* direction.

Since waves Z_1 and Z_2 are travelling along the same line so they will produce stationary wave.

37. (a) When two waves of equal frequency and travelling in opposite direction superimpose, then the stationary wave is produced. Hence Z_1 and Z_2 produces stationary wave.

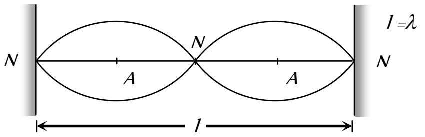
38. (d) The distance between adjacent nodes $x = \frac{\lambda}{2}$

Also $k = \frac{2\pi}{\lambda}$. Hence $x = \frac{\pi}{k}$.

39. (d) $y = 5\sin\left(\frac{2\pi x}{3}\right)\cos 20\pi t$, comparing with equation $y = 2a\sin\frac{2\pi x}{\lambda}\cos\frac{2\pi vt}{\lambda} \Rightarrow \lambda = 3$, distance between two adjacent nodes $= \lambda/2 = 1.5cm$.

Vibration of String

1. (c)



2. (d) $n \propto \frac{1}{l} \Rightarrow \frac{n_2}{n_1} = \frac{l_1}{l_2} \Rightarrow n_2 = \frac{l_1}{l_2} n_1 = \frac{1 \times 256}{1/4} = 1024 Hz$

3. (c) String vibrates in five segment so $\frac{5}{2}\lambda = l \Rightarrow \lambda = \frac{2l}{5}$

Hence $n = \frac{v}{\lambda} = 5 \times \frac{v}{2l} = 5 \times \frac{20}{2 \times 10} = 5\ Hz$

4. (c) Here $\frac{\lambda}{2} = 5.0\, cm \Rightarrow \lambda = 10\ cm$

Hence $n = \frac{v}{\lambda} = \frac{200}{10} = 20\ Hz$.

5. (c)

6. (b) As we know plucking distance from one end $= \frac{l}{2p}$

$\Rightarrow 25 = \frac{100}{2p} \Rightarrow p = 2$. Hence frequency of vibration

$n = \frac{p}{2l}\sqrt{\frac{T}{m}} = \frac{2}{2 \times 1}\sqrt{\frac{20}{5 \times 10^{-4}}} = 200 Hz.$

7. (b) To produce 5 *beats/sec.* Frequency of one wire should be increase up to 505 Hz. *i.e.* increment of 1% in basic frequency.

$n \propto \sqrt{T}$ or $T \propto n^2 \Rightarrow \frac{\Delta T}{T} = 2\frac{\Delta n}{n}$

$\Rightarrow$ percentage change in Tension = 2 (1%) = 2%

8. (d) $y = 0.021 \sin(x + 30t) \Rightarrow v = \frac{\omega}{k} = \frac{30}{1} = 30\, m/s$.

Using, $v = \sqrt{\frac{T}{m}} \Rightarrow 30 = \sqrt{\frac{T}{1.3 \times 10^{-4}}} \Rightarrow T = 0.117\ N$

9. (a) $n \propto \sqrt{T}$

10. (c) $n \propto \sqrt{T}$

11. (d) $n \propto \sqrt{T}$

$\Rightarrow n_1 : n_2 : n_3 : n_4 = \sqrt{1} : \sqrt{4} : \sqrt{9} : \sqrt{16} = 1 : 2 : 3 : 4$

12. (c) Let the frequency of tunning fork be N

As the frequency of vibration string $\propto \frac{1}{\text{length of string}}$

For sonometer wire of length 20 *cm*, frequency must be (N + 5) and that for the sonometer wire of length 21*cm*, the frequency must be (N – 5) as in each case the tunning fork produces 5 beats/sec with sonometer wire

Hence $n_1 l_1 = n_2 l_2 \Rightarrow (N + 5) \times 20 = (N - 5) \times 21$

$\Rightarrow N = 205 Hz.$

13. (c) $\lambda = \frac{2l}{p}$ (p = Number of loops)

14. (a) String will vibrate in 7 loops so it will have 8 nodes 7 antinodes.

Number of harmonics = Number of loops = Number of antinodes $\Rightarrow$ Number of antinodes = 7

Hence number of nodes = Number of antinodes + 1

$= 7 + 1 = 8$

15. (a)

16. (d) $n \propto \frac{1}{l}\sqrt{T} \Rightarrow \frac{n'}{n} = \sqrt{\frac{T'}{T}} \times \frac{l}{l'} = \sqrt{4} \times \frac{1}{2} = 1 \Rightarrow n' = n$

17. (a) Sonometer is used to produce resonance of sound source with stretched vibrating string.

18. (a) $n \propto \frac{1}{l} \Rightarrow \frac{l_2}{l_1} = \frac{n_1}{n_2} \Rightarrow l_2 = l_1\left(\frac{n_1}{n_2}\right) = 50 \times \frac{270}{1000} = 13.5 cm$

19. (c) $n \propto \sqrt{T} \Rightarrow \frac{n_1}{n_2} = \sqrt{\frac{T_1}{T_2}} \Rightarrow \frac{n}{2n} = \sqrt{\frac{10}{T_2}} \Rightarrow T_2 = 40 N$

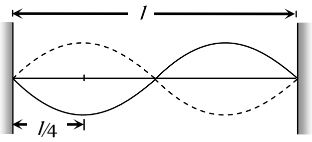
20. (b) $n \propto \sqrt{T}$

21. (d) $n = \frac{1}{2l}\sqrt{\frac{T}{m}} \Rightarrow n \propto \frac{\sqrt{T}}{l}$

$\Rightarrow \frac{T_2}{T_1} = \left(\frac{n_2}{n_1}\right)^2 \left(\frac{l_2}{l_1}\right)^2 = (2)^2 \left(\frac{3}{4}\right)^2 = \frac{9}{4}$

22. (c) $v = \sqrt{\frac{T}{m}} \Rightarrow v = \sqrt{\frac{60.5}{(0.035/7)}} = 110\ m/s$

23. (a) Second harmonic means 2 loops in a total length



Hence plucking distance from one end $= \frac{l}{2p} = \frac{l}{2 \times 2} = \frac{l}{4}$.

24. (b) $v = \sqrt{\frac{T}{m}} = \sqrt{\frac{T}{\pi r^2 \rho}}$

$v \propto \frac{\sqrt{T}}{r} \Rightarrow \frac{v_A}{v_B} = \sqrt{\frac{T_A}{T_B}} . \frac{r_B}{r_A} = \sqrt{\frac{1}{2}} . \frac{1}{2} = \frac{1}{2\sqrt{2}}$

25. (a) The frequency of vibration of a string $n = \frac{p}{2l}\sqrt{\frac{T}{m}}$

Also number of loops = Number of antinodes.

Hence, with 5 antinodes and hanging mass of 9 *kg*.

We have p = 5 and T = 9g $\Rightarrow n_1 = \frac{5}{2l}\sqrt{\frac{9g}{m}}$

With 3 antinodes and hanging mass M

We have p = 3 and T = Mg $\Rightarrow n_2 = \frac{3}{2l}\sqrt{\frac{Mg}{m}}$

$\because n_1 = n_2 \Rightarrow \frac{5}{2l}\sqrt{\frac{9g}{m}} = \frac{3}{2l}\sqrt{\frac{Mg}{m}} \Rightarrow M = 25\ kg.$

26. (b) $n \propto \frac{\sqrt{T}}{l} \Rightarrow l \propto \sqrt{T}$ (As n = constant)

$\Rightarrow \frac{l_2}{l_1} = \sqrt{\frac{T_2}{T_1}} = l_1\sqrt{\frac{169}{100}} \Rightarrow l_2 = 1.3 l_1 = l_1 + 30\%$ of l_1

27. (b) $n_1 l_1 = n_2 l_2 \Rightarrow 250 \times 0.6 = n_2 \times 0.4 \Rightarrow n_2 = 375 Hz$

28. (b) In fundamental mode of vibration wavelength is maximum $\Rightarrow$ $l = \frac{\lambda}{2} = 40\, cm \Rightarrow \lambda = 80\, cm$

29. (c) $n_1 l_1 = n_2 l_2 \Rightarrow 800 \times 50 = 1000 \times l_2 \Rightarrow l_2 = 40\ cm$

30. (c) $n \propto \sqrt{T} \Rightarrow \frac{\Delta n}{n} = \frac{\Delta T}{2T}$

If tension increases by 2%, then frequency must increases by 1%.

If initial frequency $n_1 = n$ then final frequency $n' - n = 5$

$\Rightarrow \frac{101}{100} n - n = 5 \Rightarrow n = 500 Hz.$

Short trick : If you can remember then apply following formula to solve such type of problems.

Initial frequency of each wire (n)

$= \frac{\text{(Number of beats heard per sec)} \times 200}{\text{(per centage change in tension of the wire)}}$

Here $n = \frac{5 \times 200}{2} = 500 Hz$

31. (b) First overtone of string A = Second overtone of string B.

$\Rightarrow$ Second harmonic of A = Third harmonic of B

$\Rightarrow n_2 = n_3 \Rightarrow [2(n_1)]_A = [3(n_1)]_B$ ($\because n_1 = \frac{1}{2l}\sqrt{\frac{T}{\pi r^2 \rho}}$)

$\Rightarrow 2\left[\frac{1}{2 l_A r_A}\sqrt{\frac{T}{\pi\rho}}\right] = 3\left[\frac{1}{2 l_B r_B}\sqrt{\frac{T}{\pi\rho}}\right]$

$\frac{l_A}{l_B} = \frac{2}{3}\frac{r_B}{r_A} \Rightarrow \frac{l_A}{l_B} = \frac{2}{3} \times \frac{r_B}{(2r_B)} = \frac{1}{3}$

32. (a) Fundamental frequency in case of string is

$n = \frac{1}{2l}\sqrt{\frac{T}{m}} \Rightarrow n \propto \frac{\sqrt{T}}{l} \Rightarrow \frac{n'}{n} = \sqrt{\frac{T'}{T}} \times \frac{l}{l'}$

putting $T' = T + 0.44T = \frac{144}{100}T$ and $l' = l - 0.4l = \frac{3}{5}l$

We get $\frac{n'}{n} = \frac{2}{1}$.

33. (d) Frequency in a stretched string is given by

$n = \frac{1}{2l}\sqrt{\frac{T}{\pi r^2 \rho}} = \frac{1}{l}\sqrt{\frac{T}{\pi d^2 \rho}}$ (d = Diameter of string)

$\Rightarrow \frac{n_1}{n_2} = \frac{l_2}{l_1}\sqrt{\frac{T_1}{T_2} \times \left(\frac{d_2}{d_1}\right)^2 \times \left(\frac{\rho_2}{\rho_1}\right)}$

$= \frac{35}{36}\sqrt{\frac{8}{1} \times \left(\frac{1}{4}\right)^2 \times \frac{2}{1}} = \frac{35}{36} \Rightarrow n_2 = \frac{36}{35} \times 360 = 370$

Hence beat frequency = $n_2 - n_1 = 10$

34. (b) Frequency of first overtone or second harmonic (n_2) $= 320\, Hz$. So, frequency of first harmonic

$n_1 = \frac{n_2}{2} = \frac{320}{2} = 160 Hz$

35. (d) Similar to Q. 30

Initial frequency of each wire (n)

$= \frac{\text{(Number of beats heared per sec)} \times 200}{\text{(per centage change in tension of the wire)}}$

$= \frac{(3/2) \times 200}{1} = 300\, sec^{-1}$

36. (c) $n \propto \frac{1}{l} \Rightarrow \frac{\Delta n}{n} = -\frac{\Delta l}{l}$

If length is decreased by 2% then frequency increases by 2%

i.e., $\frac{n_2 - n_1}{n_1} = \frac{2}{100}$

$\Rightarrow n_2 - n_1 = \frac{2}{100} \times n_1 = \frac{2}{100} \times 392 = 7.8 \approx 8.$

37. (d) Observer receives sound waves (music) which are longitudinal progressive waves.

38. (a) Because both tuning fork and string are in resonance condition.

39. (d) $n = \frac{1}{2l}\sqrt{\frac{T}{m}} \Rightarrow \frac{n_1}{n_2} = \frac{l_2}{l_1}\sqrt{\frac{T_1}{T_2}} = \frac{1}{4}\sqrt{\frac{1}{4}} = \frac{1}{8}$

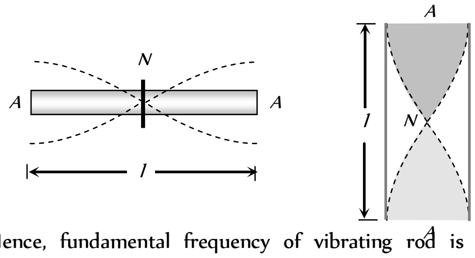
$\Rightarrow n_2 = 8n_1 = 8 \times 200 = 1600 Hz$

40. (b) $n = \frac{1}{2l}\sqrt{\frac{T}{m}} \Rightarrow n_1 l_1 = n_2 l_2 = n_3 l_3 = k$

$l_1 + l_2 + l_3 = l \Rightarrow \frac{k}{n_1} + \frac{k}{n_2} + \frac{k}{n_3} = \frac{k}{n}$

$\Rightarrow \frac{1}{n} = \frac{1}{n_1} + \frac{1}{n_2} + \frac{1}{n_3} + ...$

41. (a) If a rod clamped at middle, then it vibrates with similar fashion as open organ pipe vibrates as shown.



Hence, fundamental frequency of vibrating rod is given by

$n_1 = \frac{v}{2l} \Rightarrow 2.53 = \frac{v}{4 \times 1} \Rightarrow v = 5.06\ km/sec.$

42. (a) Change in amplitude does not produce change in frequency, $\left(n = \frac{1}{2l}\sqrt{\frac{T}{\pi r^2 \rho}}\right)$.

43. (d) Mass per unit length $m = \frac{2 \times 10^{-4}}{0.5} kg/m = 4 \times 10^{-4} kg/m$

Frequency of 2nd harmonic $n_2 = 2n_1$

$= 2 \times \frac{1}{2l}\sqrt{\frac{T}{m}} = \frac{1}{0.5}\sqrt{\frac{20}{4 \times 10^{-4}}} = 447.2 Hz$

44. (d) $n = \frac{1}{2l}\sqrt{\frac{T}{m}} \Rightarrow n \propto \sqrt{T}$ For octave, $n' = 2n$

$\Rightarrow \frac{n'}{n} = \sqrt{\frac{T'}{T}} = 2 \Rightarrow T' = 4T = 16 kg\text{-}wt$

45. (d) Fundamental frequency $n = \frac{1}{2l}\sqrt{\frac{T}{\pi r^2 \rho}}$

where m = Mass per unit length of wire

$\Rightarrow n \propto = \frac{1}{lr} \Rightarrow \frac{n_1}{n_2} = \frac{r_2}{r_1} \times \frac{l_2}{l_1} = \frac{r}{2r} \times \frac{2L}{L} = \frac{1}{1}$

46. (c) $n = \frac{1}{2l}\sqrt{\frac{T}{\pi r^2 \rho}} \propto \sqrt{\frac{T}{r^2 \rho}}$

$\Rightarrow \frac{n_1}{n_2} = \sqrt{\left(\frac{T_1}{T_2}\right)\left(\frac{r_2}{r_1}\right)^2\left(\frac{\rho_2}{\rho_1}\right)} = \sqrt{\left(\frac{1}{2}\right)\left(\frac{2}{1}\right)^2\left(\frac{1}{2}\right)} = 1$

$\therefore n_1 = n_2$

47. (a) $n = \frac{p}{2l}\sqrt{\frac{T}{m}} \propto \sqrt{T} \Rightarrow \frac{n_1}{n_2} = \sqrt{\frac{T_1}{T_2}}$

$\Rightarrow \frac{260}{n_2} = \sqrt{\frac{50.7g}{(50.7 - 0.0075 \times 10^3)g}} \Rightarrow n_2 \approx 240$

48. (b) Given equation of stationary wave is

$y = \sin 2\pi x \cos 2\pi t$, comparing it with standard equation $y = 2A \sin\frac{2\pi x}{\lambda}\cos\frac{2\pi x}{\lambda}$

We have $\frac{2\pi x}{\lambda} = 2\pi x \Rightarrow \lambda = 1m$

Minimum distance of string (first mode) $L_{\min} = \frac{\lambda}{2} = \frac{1}{2}m$

49. (d) $n = \frac{1}{2l}\sqrt{\frac{T}{\pi r^2 \rho}} \Rightarrow n \propto \frac{\sqrt{T}}{lr} \Rightarrow \frac{n_1}{n_2} = \sqrt{\frac{T_1}{T_2}} \times \frac{l_2}{l_1} \times \frac{r_2}{r_1}$

$= \sqrt{\frac{T}{3T}} \times \frac{3l}{l} \times \frac{2r}{r} = 3\sqrt{3} \Rightarrow n_2 = \frac{n}{3\sqrt{3}}$

50. (c) For string $\lambda = \frac{2l}{p}$

where p = No. of loops = Order of vibration

Hence for forth mode $p = 4 \Rightarrow \lambda = \frac{l}{2}$

Hence $v = n\lambda = 500 \times \frac{2}{2} = 500\ Hz$

51. (d) $n = \frac{1}{2l}\sqrt{\frac{T}{\pi r^2 \rho}} \Rightarrow n \propto \frac{\sqrt{T}}{r}$

$\Rightarrow \frac{n_2}{n_1} = \frac{r_1}{r_2}\sqrt{\frac{T_2}{T_1}} = \frac{1}{2} \times \sqrt{\frac{1}{2}} = \frac{1}{2\sqrt{2}}$

52. (b) In case of sonometer frequency is given by

$n = \frac{p}{2l}\sqrt{\frac{T}{m}} \Rightarrow \frac{n_2}{n_1} = \frac{l_1}{l_2} \Rightarrow n_2 = \frac{25}{16} \times 256 = 400\ \ Hz$

Organ Pipe (Vibration of Air Column)

1. (c) $\lambda_1 = 2l, \lambda_2 = 2l + 2\Delta l \Rightarrow n_1 = \frac{v}{2l}$ and $n_2 = \frac{v}{2l + 2\Delta l}$

$\Rightarrow$ No. of beats $= n_1 - n_2 = \frac{v}{2}\left(\frac{1}{l} - \frac{1}{l + \Delta l}\right) = \frac{v\Delta l}{2l^2}$

2. (a) Fundamental frequency of open pipe is double that of the closed pipe.

3. (c) If is given that

First over tone of closed pipe = First over tone of open pipe $\Rightarrow$ $3\left(\frac{v}{4l_1}\right) = 2\left(\frac{v}{2l_2}\right)$; where l_1 and l_2 are the lengths of closed and open organ pipes hence $\frac{l_1}{l_2} = \frac{3}{4}$

4. (d) First overtone for closed pipe = $\frac{3v}{4l}$

Fundamental frequency for open pipe = $\frac{v}{2l}$

First overtone for open pipe = $\frac{2v}{2l}$.

5. (c) For closed pipe in general $n = \frac{v}{4l}(2N - 1) \Rightarrow n \propto \frac{1}{l}$

i.e. if length of air column decreases frequency increases.

6. (a,c,d) Fundamental frequency of closed pipe $n = \frac{v}{4l}$

where $v = \sqrt{\frac{\gamma RT}{M}} \Rightarrow v \propto \frac{1}{\sqrt{M}}$

$\because\ M_{H_2} < M_{air} \Rightarrow v_{H_2} > v_{air}$

Hence fundamental frequency with H_2 will be more as compared to air. So option (a) is correct.

Also $n \propto \frac{1}{l}$, hence if l decreases n increases so option (c) is correct.

It is well known that $(n)_{Open} = 2(n)_{Closed}$ hence option (d) is correct.

7. (d) For closed pipe $n_1 = \frac{v}{4l} \Rightarrow l = \frac{v}{4n} = \frac{332}{4 \times 166} = 0.5m$

8. (a) Fundamental frequency of open pipe

$n_1 = \frac{v}{2l} = \frac{350}{2 \times 0.5} = 350\ Hz$.

9. (b) For closed pipe $n_1 = \frac{v}{4l} = \frac{330}{4}\ Hz$

Second note = $3n_1 = \frac{3 \times 300}{4}\ Hz$.

10. (c) $n_{\text{closed}} = \frac{v}{4l}, n_{\text{open}} = \frac{v}{2l} \Rightarrow n_{\text{open}} = 2n_{\text{closed}} = 2f$

11. (b) Minimum audible frequency = 20 Hz.

$\Rightarrow \frac{v}{4l} = 20 \Rightarrow l = \frac{336}{4 \times 20} = 4.2\ m$

12. (c) First overtone of closed organ pipe $n_1 = \frac{3v}{4l_1}$

Third overtone of open organ pipe $n_2 = \frac{4v}{2l_2}$

$n_1 = n_2$ (Given) $\Rightarrow \frac{3v}{4l_1} = \frac{4v}{2l_2} \Rightarrow \frac{l_1}{l_2} = \frac{3}{8}$

13. (b) For closed pipe $n_1 = \frac{v}{4l} \Rightarrow 250 = \frac{v}{4 \times 0.2} \Rightarrow v = 200 m/s$

14. (b) $n_{\text{open}} = \frac{v}{2l_{\text{open}}}$

$n_{\text{closed}} = \frac{v}{4l_{\text{closed}}} = \frac{v}{4l_{\text{open}}/2} = \frac{v}{2l_{\text{open}}}$

$\left(As\ l_{closed} = \frac{l_{open}}{2} \right)$, *i.e.* frequency remains unchanged.

15. (b) For closed pipe second note = $\frac{3v}{4l} = \frac{3 \times 330}{4 \times 1.5} = 165\ Hz$.

16. (a) Fundamental frequency of open pipe

$n_1 = \frac{v}{2l} = \frac{330}{2 \times 0.3} = 550\ Hz$

First harmonic = $2 \times n_1 = 1100\ Hz$. = $1.1\ kHz$

17. (b) For first pipe $n_1 = \frac{v}{4l_1}$ and for second pipe $n_2 = \frac{v}{4l_2}$

So, number of beats = $n_2 - n_1 = 4$

$\Rightarrow 4 = \frac{v}{4}\left(\frac{1}{l_2} - \frac{1}{l_1}\right) \Rightarrow 16 = 300\left(\frac{1}{l_2} - \frac{1}{1}\right) \Rightarrow l_2 = 94.9\ cm$

18. (a) Maximum pressure at closed end will be atmospheric pressure adding with acoustic wave pressure

So $\rho_{\max} = \rho_A + \rho_0$ and $\rho_{\min} = \rho_A - \rho_0$

Thus $\frac{\rho_{\max}}{\rho_{\min}} = \frac{\rho_A + \rho_0}{\rho_A - \rho_0}$

19. (c) $n_1 - n_2 = 10$ .....(i)

Using $n_1, = \frac{v}{4l_1}$ and $n_2 = \frac{v}{4l_2}$

$\Rightarrow \frac{n_1}{n_2} = \frac{l_2}{l_1} = \frac{26}{25}$ .....(ii)

After solving these equation $n_1 = 260 Hz$, $n_2 = 250\ Hz$

20. (a) Let l_1 and l_2 be the length's of closed and open pipes respectively. (Neglecting end correction)

$l_1 = \frac{\lambda_1}{4} \Rightarrow \lambda_1 = 4l_1$ and $l_2 = \frac{\lambda_2}{2} \Rightarrow \lambda_2 = 2l_2$

Given $n_1 = n_2$ so $\frac{v}{\lambda_1} = \frac{v}{\lambda_2} \Rightarrow \frac{v}{4l_1} = \frac{v}{2l_2} = \frac{l_1}{l_2} = \frac{1}{2}$

21. (b) Distance between two consecutive nodes

$= \frac{\lambda}{2} = 46 - 16 = 30 \Rightarrow \lambda = 60\ cm = 0.6m$

$\therefore\ v = n\lambda = 500 \times 0.6 = 300\ m/s$.

22. (a) For closed pipe $n = \frac{v}{4l} \Rightarrow n = \frac{332}{4 \times 42} = 2Hz$.

23. (a) For shortest length of pipe mode of vibration must be fundamental *i.e.*, $n = \frac{v}{4l} \Rightarrow l = \frac{v}{4n}$.

24. (b) $n_{\text{Closed}} = \frac{1}{2}(n_{\text{Open}}) = \frac{1}{2} \times 320 = 160\ Hz$

25. (c) Frequency of 2^{nd} overtone $n_3 = 5n_1 = 5 \times 50 = 250\ Hz$.

26. (a) $\Delta n = n_1 - n_2 \Rightarrow 10 = \frac{v}{2l_1} - \frac{v}{2l_2} = \frac{v}{2}\left[\frac{1}{l_1} - \frac{1}{l_2}\right]$

$\Rightarrow 10 = \frac{v}{2}\left[\frac{1}{0.25} - \frac{1}{0.255}\right] \Rightarrow v = 255\ m/s.$

27. (a) Fundamental frequency $n = \frac{v}{2l}$

$\Rightarrow 350 = \frac{350}{2l} \Rightarrow l = \frac{1}{2}m = 50\ cm.$

28. (b) $\Delta n = n_1 - n_2 \Rightarrow 4 = \frac{v}{2l_1} - \frac{v}{2l_2} = \frac{v}{2}\left[\frac{1}{1.00} - \frac{1}{1.025}\right]$

$\Rightarrow 8 = [1 - 0.975] \Rightarrow v = \frac{8}{0.025} \approx 328\ m/s.$

29. (a) In closed pipe only odd harmonics are present

30. (d) Fundamental frequency of open organ pipe $= \frac{v}{2l}$

Frequency of third harmonic of closed pipe $= \frac{3v}{4l}$

$\therefore \frac{3v}{4l} = 100 + \frac{v}{2l} \Rightarrow \frac{3v}{4l} - \frac{2v}{4l} = \frac{v}{4l} = 100 \Rightarrow \frac{v}{2l} = 200\ Hz.$

31. (c) $n_A = \frac{v}{2l}; n_B = \frac{v}{4l} \Rightarrow n_A / n_B = 2:1$

32. (a) Due to rise in temperature, the speed of sound increases. Since $n = \frac{v}{\lambda}$ and λ remains unchanged, hence n increases.

33. (b)

34. (b)

35. (b) In closed organ pipe. If $y_{incident} = a\sin(\omega t - kx)$

then $y_{reflected} = a\sin(\omega t + kx + \pi) = -a\sin(\omega t + kx)$

Superimposition of these two waves give the required stationary wave.

36. (b) $v = 330\ m/s$; $n = 165\ Hz$. Distance between two successive nodes = $\frac{\lambda}{2} = \frac{v}{2n} = \frac{330}{2 \times 165} = 1m$

37. (b) At the middle of pipe, node is formed.

38. (c) For closed organ pipe $n_1 : n_2 : n_3 .... = 1:3:5:.....$

39. (b) First tone of open pipe = first overtone of closed pipe $\Rightarrow \frac{v}{2l_0} = \frac{3v}{4l_c} \Rightarrow l_c = \frac{3 \times 2 \times 0.5}{4} = 0.75m$

40. (b) Only odd harmonics are present.

41. (b) Distance between six successive node

$= \frac{5\lambda}{2} = 85cm \Rightarrow \lambda = \frac{2 \times 85}{5} = 34\ cm = 0.34\ m$

Therefore speed of sound in gas

$= n\lambda = 1000 \times 0.34 = 340\ m/s$

42. (b) Let the base frequency be n for closed pipe then notes are $n, 3n, 5n.....$

$\therefore$ note $3n = 255 \Rightarrow n = 85$, note $5n = 85 \times 5 = 425$

note $7n = 7 \times 85 = 595$

43. (a) $l_2 = 3l_1 = 3 \times 24.7 = 74.1\ cm$

44. (c) Frequency of $p\ th$ harmonic

$n = \frac{pv}{2l} \Rightarrow p = \frac{2ln}{v} = \frac{2 \times 0.33 \times 1000}{330} = 2$

45. (a) For closed pipe $l_1 = \frac{v}{4n}$; $l_2 = \frac{3v}{4n} \Rightarrow v = 2n(l_2 - l_1)$

$\Rightarrow n = \frac{v}{2(l_2 - l_1)} = \frac{330}{2 \times (0.49 - 0.16)} = 500\,Hz$

46. (c) Number of beats per second,

$n = \frac{16}{20} = \frac{4}{5} \Rightarrow n = n_1 - n_2 = \frac{v}{4}\left(\frac{1}{l_1} - \frac{1}{l_2}\right)$

$\Rightarrow \frac{4}{5} = \frac{v}{4}\left(\frac{1}{1} - \frac{1}{1.01}\right) = \frac{0.01v}{4 \times 1.01}$

$v = \frac{16 \times 101}{5} = 323.2\,ms^{-1}$

47. (a) In open organ pipe both even and odd harmonics are produced.

48. (d) Using $\lambda = 2(l_2 - l_1) \Rightarrow v = 2n(l_2 - l_1)$

$\Rightarrow 2 \times 512(63.2 - 30.7) = 33280\,cm/s$

Actual speed of sound $v_0 = 332\,m/s = 33200\,cm/s$

Hence error $= 33280 - 33200 = 80\,cm/s$

49. (b) Initially number of beats per second = 5

$\therefore$ Frequency of pipe = 200 ± 5 = 195 Hz or 205 Hz ....(i)

Frequency of second harmonics of the pipe = $2n$ and number of beats in this case = 10

$\therefore$ $2n = 420 \pm 10 \Rightarrow 410$ Hz or 430 Hz

$\Rightarrow n$ = 205 Hz or 215 Hz ... (ii)

From equation (i) and (ii) it is clear that n = 205 Hz

50. (c) In case of open pipe, $n = \frac{N}{2l}$ where N = order of harmonics = order of mode of vibration $\Rightarrow N = \frac{n \times 2l}{v}$

$= \frac{480}{330} \times 2 \times 1 = 3$ (Here v = 330 m/s)

51. (a) In first overtone of organ pipe open at one end,

end, $n_c = \frac{3v}{4l_c}$ .....(i)

Third harmonic or second overtone of organ pipe open at both

end, $n_0 = \frac{3v}{2l_0}$ .....(ii)

given $n_c = n_o \Rightarrow \frac{3v}{4l_c} = \frac{3v_0}{2l_0} \Rightarrow \frac{l_c}{l_o} = \frac{1}{2}$.

52. (a) For end correction x, $\frac{l_2 + x}{l_1 + x} = \frac{3\lambda/4}{\lambda/4} = 3$

$x = \frac{l_2 - 3l_1}{2} = \frac{70.2 - 3 \times 22.7}{2} = 1.05\,cm$

53. (b) For open tube, $n_0 = \frac{v}{2l}$

For closed tube length available for resonance is

$l' = l \times \frac{25}{100} = \frac{l}{4}$ $\therefore$ Fundamental frequency of water filled tube $n = \frac{v}{4l'} = \frac{v}{4 \times (l/4)} = \frac{v}{l} = 2n_0 \Rightarrow \frac{n}{n_0} = 2$

Doppler's Effect

1. (d)

2. (b) $n' = n\left(\frac{v}{v - v_O}\right) = 450\left(\frac{340}{340 - 34}\right) = 500$ $cycles/\sec$

3. (a) $n' = n\left(\frac{v}{v - v_s}\right) \Rightarrow \lambda' = \lambda\left(\frac{v - v_S}{v}\right)$

$\Rightarrow \lambda' = 120\left(\frac{330 - 60}{330}\right) = 98\,cm.$

4. (b) $n' = n\left(\frac{v}{v - v_S}\right) = 600\left(\frac{330}{300}\right) = 660$ cps

5. (c) Both listeners, hears the same frequencies.

6. (b)

7. (c) $n' = n\left(\frac{v + v_O}{v}\right) \Rightarrow 2n = n\left(\frac{v + v_0}{v}\right) \Rightarrow \frac{v + v_0}{v} = 2$

$\Rightarrow v_O = v = 332$ m/sec

8. (b) Apparent frequency in this case $n' = \frac{n(v + v_O)}{v}$

$\because \frac{v + v_0}{v} > 1 \Rightarrow \frac{n'}{n} > 1$ $i.e.$ $n' > n$.

9. (a) Wave number = $\frac{1}{\lambda}$ but $\frac{1}{\lambda'} = \frac{1}{\lambda}\left(\frac{v}{v - v_s}\right)$ and $v_S = \frac{v}{3}$

$\therefore$ (W.N.)' = (W.N.) $\left(\frac{v}{v - v/3}\right) = 256 \times \frac{v}{2v/3}$

$= \frac{3}{2} \times 256 = 384$

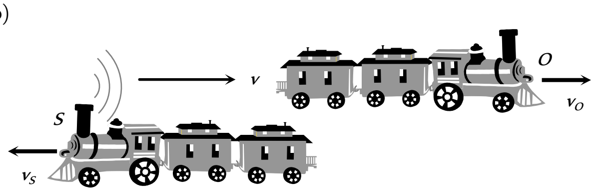
10. (a) By Doppler's formula $n' = \frac{nv}{(v - v_S)}$

Since, source is moving towards the listener so $n' > n$.

If n = 100 then n' = 102.5

$\Rightarrow 102.5 = \frac{100 \times 320}{(320 - v_S)} \Rightarrow v_s = 8$ $m/\sec$

11. (b)

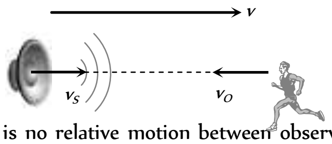


$$n' = n\left(\frac{v - v_O}{v + v_S}\right) = 750\left(\frac{330 - 180 \times \frac{5}{18}}{330 + 108 \times \frac{5}{18}}\right) = 625\ Hz$$

12. (a) By using $n' = n\left(\frac{v}{v - v_S}\right)$

$$2n = n\left(\frac{v - v_O}{v - 0}\right) \Rightarrow v_O = -v = -\text{(Speed of sound)}$$

Negative sign indicates that observer is moving opposite to the direction of velocity of sound, as shown



13. (d) Since there is no relative motion between observer and source, therefore there is no apparent change in frequency.

14. (c)

15. (b)

16. (a) $n' = n\left(\frac{v}{v - v_S}\right) \Rightarrow \frac{n'}{n} = \frac{v}{v - v_S} \Rightarrow \frac{v}{v - v_S} = 3 \Rightarrow v_s = \frac{2v}{3}$

17. (a) $n' = n\left(\frac{v}{v - v_S}\right) = n\left(\frac{v}{v - v/10}\right) \Rightarrow \frac{n'}{n} = \frac{10}{9}$

18. (c) $n' = n\left(\frac{v}{v - v_S}\right) = 1200 \times \left(\frac{350}{350 - 50}\right) = 1400\ cps$

19. (d) $n' = n\left(\frac{v}{v - v_S}\right) = 1200\left(\frac{400}{400 - 100}\right) = 1600\ Hz$

20. (a) $n' = \frac{v}{v - v_S} \times n = \left(\frac{330}{330 - 110}\right) \times 150 = 225\ Hz$

21. (d) Doppler's effect is applicable for both light and sound waves.

22. (a) When source is approaching the observer, the frequency heard

$$n_a = \left(\frac{v}{v - v_S}\right) \times n = \left(\frac{340}{340 - 20}\right) \times 1000 = 1063 Hz$$

When source is receding, the frequency heard

$$n_r = \left(\frac{v}{v + v_S}\right) \times n = \frac{340}{340 + 20} \times 1000 = 944$$

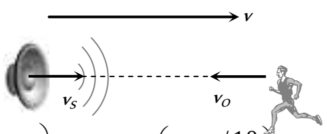
$$\Rightarrow n_a : n_r = 9 : 8$$

Short tricks : $\frac{n_a}{n_r} = \frac{v + v_S}{v - v_S} = \frac{340 + 20}{340 - 20} = \frac{9}{8}$.

23. (a) By using $\frac{n_{\text{approaching}}}{n_{\text{receding}}} = \frac{v + v_s}{v - v_s}$

$$\Rightarrow \frac{1000}{n_r} = \frac{350 + 50}{350 - 50} \Rightarrow n_r = 750 Hz.$$

24. (b) When source and listener both are moving towards each other then, the frequency heard



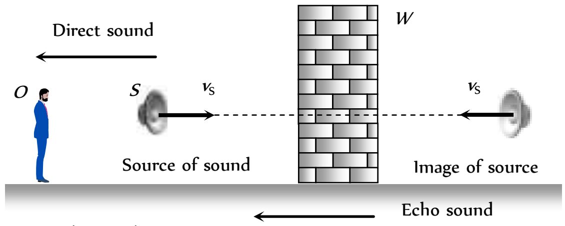
$$n' = n\left(\frac{v + v_O}{v - v_S}\right) \Rightarrow n' = f\left(\frac{v + v/10}{v - v/10}\right) = 1.22\, f.$$

25. (c) For source $v_s = r\omega = 0.70 \times 2\pi \times 5 = 22\ m/sec$

Minimum frequency is heard when the source is receding the man. It is given by $n_{\min} = n\frac{v}{v + v_S}$

$$= 1000 \times \frac{352}{352 + 22} = 941\ Hz$$

26. (b) For direct sound source is moving away from the observes so frequency heard in this case



$$n_1 = n\left(\frac{v}{v + v_s}\right) = 500\left(\frac{332}{332 + 2}\right) = 500\left(\frac{332}{334}\right) Hz$$

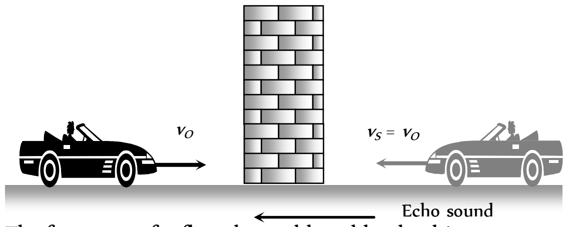
The other sound is echo, reaching the observer from the wall and can be regarded as coming from the image of source formed by reflection at the wall. This image is approaching the observer in the direction of sound.

Hence for reflected sound, frequency heard by the observer is

$$n_2 = n\left(\frac{v}{v - v_S}\right) = 500\left(\frac{332}{332 - 2}\right) = 500\left(\frac{332}{330}\right) Hz$$

Beats frequency $= n_2 - n_1 = 500 \times 332\left(\frac{1}{330} - \frac{1}{334}\right) = 6.$

27. (c) Similar to previous question



The frequency of reflected sound heard by the driver

$$n' = n\left(\frac{v - (-v_O)}{v - v_S}\right) = n\left(\frac{v + v_O}{v - v_S}\right)$$

$$= 124\left[\frac{330 + (72 \times 5/18)}{330 - (72 \times 5/18)}\right] = 140\ \text{vibration/sec.}$$

28. (d) By using $n' = n\frac{v}{v - v_S} \Rightarrow \frac{n_1}{n} = \left(\frac{V}{V - S}\right)$

29. (b) In this case Doppler's effect is not applicable.

30. (d) The apparent frequency heard by the observer is given by

$$n' = \frac{v}{v - v_S} n = \frac{330}{330 - 33} \times 450 = \frac{330}{297} \times 450 = 500\ Hz$$

31. (a) $n' = n\left(\frac{v - v_O}{v}\right) = \left(\frac{330 - 33}{330}\right) \times 100 = 90\ Hz$

32. (c) When train is approaching frequency heard by the observer is

$$n_a = n\left(\frac{v}{v - v_S}\right) \Rightarrow 219 = n\left(\frac{340}{340 - v_S}\right) \quad ...(i)$$

when train is receding (goes away), frequency heard by the observer is

$$n_r = n\left(\frac{v}{v+v_S}\right) \Rightarrow 184 = n\left(\frac{340}{340+v_S}\right) \quad ...(ii)$$

On solving equation (i) and (ii) we get $n = 200Hz$

and $v_S = 29.5 m/s$.

33. (d) Frequency is decreasing (becomes half), it means source is going away from the observes. In this case frequency observed by the observer is

$$n' = n\left(\frac{v}{v+v_S}\right) \Rightarrow \frac{n}{2} = n\left(\frac{v}{v+v_S}\right) \Rightarrow v_S = v$$

34. (d) Observer hears two frequencies

(i) n_1 which is coming from the source directly

(ii) n_2 which is coming from the reflection image of source

so, $n_1 = 680\left(\frac{340}{340-1}\right)$ and $n_2 = 680\left(\frac{340}{340+1}\right)$

$\Rightarrow n_1 - n_2 = 4$ *beats*

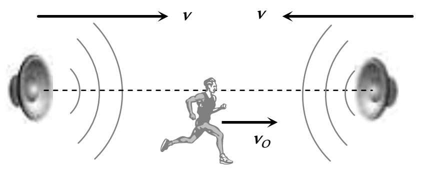
35. (a) From the figure, it is clear that

Frequency of reflected sound heard by the driver.

$$n' = n\left[\frac{v-(-v_o)}{v-v_s}\right] = n\left[\frac{v+v_o}{v-v_s}\right] = n\left[\frac{v+v_{car}}{v-v_{car}}\right]$$

$$= 600\left[\frac{330+30}{330-30}\right] = 720\ Hz.$$

36. (b) Observer is moving away from siren 1 and towards the siren 2.



Hearing frequency of sound emitted by siren 1

$$n_1 = n\left(\frac{v-v_0}{v}\right) = 330\left(\frac{330-2}{330}\right) = 328Hz$$

Hearing frequency of sound emitted by siren 2

$$n_2 = n\left(\frac{v+v_O}{v}\right) = 330\left(\frac{330+2}{330}\right) = 332Hz$$

Hence, beat frequency $= n_2 - n_1 = 332 - 328 = 4$.

37. (c) $n' = n\left(\frac{v}{v-v_S}\right) = \frac{2000\times1220}{(1220-40)} = 2068\ Hz$

38. (d) $n' = n\left(\frac{v+v_O}{v-v_S}\right)n \Rightarrow 400 = n\left(\frac{360+40}{360-40}\right) \Rightarrow n = 320\ cps$

39. (a) $n' = n\left(\frac{v}{v+v_S}\right) = 500\times\left(\frac{330}{300+50}\right) = 434.2Hz$

40. (c) Since there is no relative motion between the listener and source, hence actual frequency will be heard by listener.

41. (a) $n' = n\left(\frac{v}{v-v_S}\right) \Rightarrow n' = 500\left(\frac{330}{330-30}\right) = 550\ Hz$.

42. (c) $n' = n\left(\frac{v}{v-v_S}\right) = 90\left(\frac{v}{v-\frac{v}{10}}\right) = 100\frac{Vibration}{sec}$

43. (a) The linear velocity of Whistle

$$v_S = r\omega = 1.2\times2\pi\frac{400}{60} = 50\ m/s$$

When Whistle approaches the listener, heard frequency will be maximum and when listener recedes away, heard frequency will be minimum

So, $n_{max} = n\left(\frac{v}{v-v_S}\right) = 500\left(\frac{340}{290}\right) = 586Hz$

$n_{min} = n\left(\frac{v}{v+v_S}\right) = 500\left(\frac{340}{390}\right) = 436Hz$

44. (d) By using $n' = n\left(\frac{v}{v-v_S}\right)$

$$\Rightarrow f_1 = n\left(\frac{v}{v-v_S}\right) = n\left(\frac{340}{340-34}\right) = \frac{340}{306}n$$

and $f_2 = n\left(\frac{340}{340-17}\right) = n\left(\frac{340}{323}\right) \Rightarrow \frac{f_1}{f_2} = \frac{323}{306} = \frac{19}{18}$

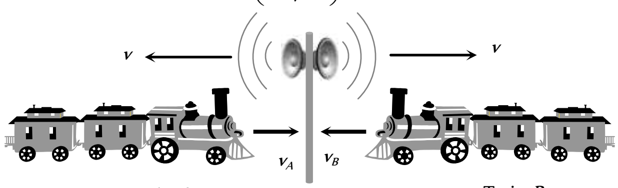
45. (d) No change in frequency.

46. (b) $n' = n\left(\frac{v-v_O}{v+v_S}\right) = n\left(\frac{340-10}{340+10}\right) = 1950 \Rightarrow n = 2068\ Hz$

47. (b) $n' = n\left(\frac{v+v_O}{v-v_S}\right) = 240\left(\frac{340+20}{340-20}\right) = 270\ Hz$.

48. (b) In both the cases observer is moving towards, the source.

Hence by using $n' = n\left(\frac{v+v_0}{v}\right)$



When passenger is sitting in train *A*, then

$$5.5 = 5\left(\frac{v+v_A}{v}\right) \quad ...(i)$$

when passenger is sitting in train *B*, then

$$6 = 5\left(\frac{v+v_B}{v}\right) \quad ...(ii)$$

On solving equation (i) and (ii) we get $\frac{v_B}{v_A} = 2$

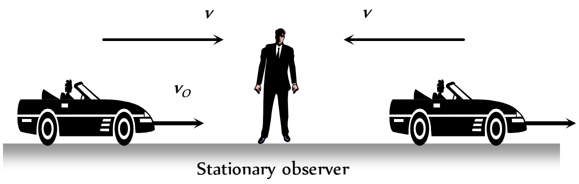
49. (b) Minimum frequency will be heard, when whistle moves away from the listener.

$n_{min} = n\left(\frac{v}{v+v_s}\right)$ where $v = r\omega = 0.5\times10 = 1\ m/s$

$$\Rightarrow n_{min} = 385\left(\frac{340}{340+10}\right) = 374Hz.$$

50. (a) $n' = n\left(\frac{v}{v+v_S}\right) = 800\left(\frac{330}{330+30}\right) = 733.33\ Hz$.

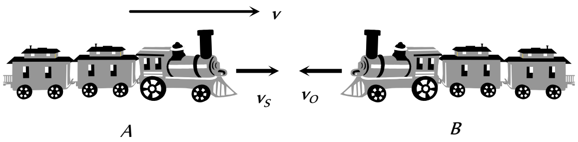
51. (a) $n_{Before} = \frac{v}{v-v_c}n$ and $n_{After} = \frac{v}{v+v_c}.n$



$\frac{n_{Before}}{n_{After}} = \frac{11}{9} = \left(\frac{v+v_c}{v-v_c}\right) \Rightarrow v_c \Rightarrow \frac{v}{10}$

52. (c) By using $n' = \left(\frac{v}{v-v_S}\right) \Rightarrow 2n = n\left(\frac{v}{v-v_S}\right) \Rightarrow v_S = \frac{v}{2}$

53. (d) The frequency of whistle heard by passenger in the train *B*, is



$n' = n\left(\frac{v+v_0}{v-v_s}\right) = 600\left(\frac{340+15}{340-20}\right) \approx 666\ Hz$

54. (b) At point *A*, source is moving away from observer so apparent frequency $n_1 < n$ (actual frequency) At point *B* source is coming towards observer so apparent frequency $n_2 > n$ and point *C* source is moving perpendicular to observer so $n_3 = n$

Hence $n_2 > n_3 > n_1$

55. (a) $n' = n\left[\frac{v+v_O}{v-v_S}\right]$; Here $v = 332$ *m/s* and $v_0 = v_s = 50$ *m/s*

$\Rightarrow 435 = n\left[\frac{332+50}{332-50}\right] \Rightarrow n = 321.12\ sec^{-1} \approx 320\ sec^{1}$

56. (c) Since apparent frequency is lesser than the actual frequency, hence the relative separation between source and listener should be increasing.

57. (c)

58. (d) $n' = n\left(\frac{v+v_0}{v-v_s}\right) = n\left(\frac{v+v/2}{v-v/2}\right) = 3n$

59. (c) When engine approaches towards observer $n' = n\left(\frac{v}{v-v_S}\right)$

when engine going away from observer $n'' = \left(\frac{v}{v+v_S}\right)n$

$\therefore \frac{n'}{n''} = \frac{v+v_S}{v-v_S} \Rightarrow \frac{5}{3} = \frac{340+v_S}{340-v_S} \Rightarrow v_S = 85\ m/s$.

60. (a) Frequency heard by the observer

$n' = n\left(\frac{v+v_0}{v}\right) = 240\left(\frac{330+11}{330}\right) = 248 Hz.$

61. (c) According the concept of sound image

$n' = \frac{v+v_{person}}{v-v_{person}}.272 = \frac{345+5}{345-5} \times 272 = 280\ Hz$

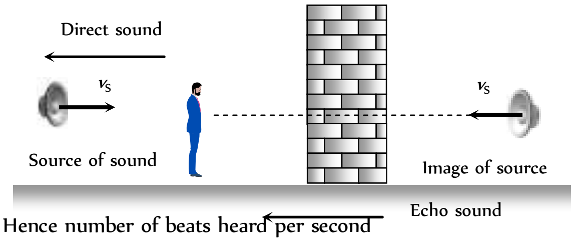
$\Delta n =$ Number of beats =280 – 272 = 8 *Hz*

62. (b) According the concept of sound image

$n' = \frac{v+v_B}{v-v_B} \times n = \frac{355+5}{355-5} \times 165 = 170\ Hz$

Number of beats $= n' - n = 170 - 165 = 5$

63. (a) The observer will hear two sound, one directly from source and other from reflected image of sound



Hence number of beats heard per second

$= \left(\frac{v}{v-v_S}\right)n - \left(\frac{v}{v+v_S}\right)n$

$= \frac{2nvv_S}{v^2 - v_S^2} = \frac{2 \times 256 \times 330 \times 5}{335 \times 325} = 7.8\ Hz$

64. (a) When a listener moves towards a stationary source apparent frequency

$n' = \left(\frac{v+v_O}{v}\right) n = 200$ .....(i)

When listener moves away from the same source

$n'' = \frac{(v-v_O)}{v}n = 160$ .....(ii)

From (i) and (ii)

$\frac{v+v_O}{v-v_O} = \frac{200}{160} \Rightarrow \frac{v+v_O}{v-v_O} = \frac{5}{4} \Rightarrow v = 360 m/\sec$

65. (b) When observer moves towards stationary source then apparent frequency

$n' = \left[\frac{v+v_O}{v}\right]n = \left[\frac{v+v/5}{v}\right]n = \frac{6}{5}n = 1.2n$

Increment in frequency = 0.2 n so percentage change in frequency = $\frac{0.2n}{n} \times 100$ = 20%.

Musical Sound

1. (d)

2. (a) Intensity = $\frac{\text{Power}}{\text{Area}} = \frac{4}{4\pi \times (200)^2} = 7.9 \times 10^{-6}\ W/m^2$

3. (a) Intensity $\propto$ (Amplitude)²

4. (c) $I = 2\pi^2 a^2 n^2\ v\rho \Rightarrow I \propto a^2 n^2 \Rightarrow \frac{I_1}{I_2} = \left(\frac{a_1}{a_2}\right)^2 \times \left(\frac{n_1}{n_2}\right)^2$

$= \left(\frac{1}{2}\right)^2 \times \left(\frac{1}{1/4}\right)^2 \Rightarrow I_2 = \frac{I_1}{4}$

5. (b) $L = 10\log_{10}\left(\frac{I}{I_0}\right) = 30 \Rightarrow \frac{I}{I_0} = 10^3$

6. (c)

7. (a) The quality of sound depends upon the number of harmonics present. Due to different number of harmonics present in two sounds, the shape of the resultant wave is also different.

8. (d) The sounds of different source are said to differ in quality. The number of overtones and their relative intensities determines the quality of any musical sound.

9. (d)

10. (d) $\text{Energy density} \propto (\text{amplitude})^2$

11. (d) Energy $\propto a^2n^2 \Rightarrow \frac{a_B}{a_A} = \frac{n_A}{n_B}$ ($\because$ energy is same)

$\Rightarrow \frac{a_B}{a_A} = \frac{8}{1}$

12. (c) Loudness depends upon intensity while pitch depends upon frequency.

13. (d) Reverberation time $T = \frac{kV}{\alpha S} \Rightarrow T \propto V.$

14. (c) $I \propto \frac{1}{r^2} \Rightarrow \frac{I_2}{I_1} = \frac{r_1^2}{r_2^2} \Rightarrow \frac{I_2}{1\times 10^{-2}} = \frac{2^2}{10^2} = \frac{4}{100}$

$\Rightarrow I_2 = \frac{4\times 10^{-2}}{100} = 4\times 10^{-4}\ \mu W/m^2$

15. (b) After passing the 3 meter intensity is given by

$I_3 = \frac{90}{100}\times\frac{90}{100}\times\frac{90}{100}\times I = 72.9\%\text{ of } I$

So, the intensity is 72.9 decibel.

16. (c)

17. (b)

18. (a) $P \propto I$

$L_1 = 10\log_{10}\left(\frac{I_1}{I_0}\right)$ and $L_2 = 10\log_{10}\left(\frac{I_2}{I_0}\right)$

So $L_2 - L_1 = 10\log_{10}\left(\frac{I_2}{I_1}\right)$

$= 10\log_{10}\left(\frac{P_2}{P_1}\right) = 10\log_{10}\left(\frac{400}{20}\right) = 10\log_{10} 20$

$= 10\log(2\times 10) = 10(0.301 + 1) = 13dB$

19. (d) $I \propto \frac{1}{r^2} \Rightarrow \frac{\Delta I}{I} = -2\frac{\Delta r}{r} = -2\times 2 = -4\%$

Hence intensity is decreased by 4%.

20. (b) Musical interval is the ratio of frequencies $= \frac{320}{240} = \frac{4}{3}$

21. (c)

22. (d) By using $L = \log_{10}\frac{I}{I_0}$

$L_2 - L_1 = \log_{10}\frac{I_2}{I_0} - \log_{10}\frac{I_1}{I_0}$

$5 - 1 = \log_{10}\frac{I_2}{I_1} \Rightarrow 4 = \log_{10}\frac{I_2}{I_1} \Rightarrow \frac{I_2}{I_1} = 10^4$

$\Rightarrow \frac{a_2^2}{a_1^2} = 10^4 \Rightarrow \frac{a_2}{a_1} = \frac{10^2}{1} \Rightarrow \frac{a_1}{a_2} = \frac{1}{10^2}$

23. (b)

24. (a) Pitch of mosquito is higher among all given options.

25. (b) The frequency of note 'Sa' is 256 *Hz* while that of note 'Re' and 'Ga' respectively are 288 *Hz* and 320 *Hz*.

26. (d)

27. (d) Indian classical vocalists don't like harmoniuim because it uses tempered scale.

28. (b)

29. (b) $I \propto \frac{1}{r^2} \Rightarrow \frac{I_2}{I_1} = \frac{r_1^2}{r_2^2} = \frac{2^2}{(40)^2} = \frac{1}{400} \Rightarrow I_1 = 400I_2$

Intensity level at point 1, $L_1 = 10\log_{10}\left(\frac{I_1}{I_0}\right)$

and intensity at point 2, $L_2 = 10\log_{10}\left(\frac{I_2}{I_0}\right)$

$\therefore\ L_1 - L_2 = 10\log\frac{I_1}{I_2} = 10\log_{10}(400)$

$\Rightarrow L_1 - L_2 = 10\times 2.602 = 26$

$L_2 = L_1 - 26 = 80 - 26 = 54\ dB$

30. (a) Intensity $\propto \frac{1}{(\text{Distance})^2} \Rightarrow \frac{I_1}{I_2} = \left(\frac{d_2}{d_1}\right)^2 = \left(\frac{3}{2}\right)^2 = \frac{9}{4}.$

31. (d)

32. (a) The pitch depends upon the frequency of the source. As the two waves have different amplitude therefore they having different intensity. While quality depends on number of harmonics/overtone produced and their relative intensity. Assuming that their frequencies are the same.

Critical Thinking Questions

1. (a,b,c,d) $y = 0.02\cos(10\pi x)\cos\left(50\pi t + \frac{\pi}{2}\right)$

At node, amplitude = 0

$\Rightarrow \cos(10\pi x) = 0 \Rightarrow 10\pi x = \frac{\pi}{2}, \frac{3\pi}{2}$

$\Rightarrow x = \frac{1}{20} = 0.05\ m,\ 0.15m$ .....

At antinode, amplitude is maximum

$\Rightarrow \cos(10\pi x) = \pm 1 \Rightarrow x = 0, \pi, 2\pi...$

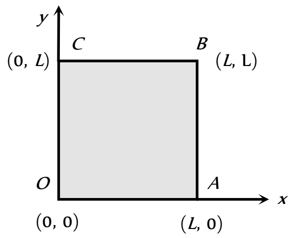
$\Rightarrow x = 0,\ 0.1m,\ 0.2m$ ...

Now $\lambda = 2\times$ Distance between two nodes or antinodes

$= 2\times 0.1 = 0.2\ m$ and $\frac{2\pi vt}{\lambda} = 50\pi t$

$v = 25\lambda = 25\times 0.2 = 5m/\sec$.

2. (b,c) Since the edges are clamped, displacement of the edges $u(x, y) = 0$ for line –



OA i.e. $y = 0,\ 0 \le x \le L$

AB i.e. $x = L,\ 0 \le y \le L$

BC i.e. $y = L,\ 0 \le x \le L$

OC i.e. $x = 0,\ 0 \le y \le L$

The above conditions are satisfied only in alternatives (b) and (c).

Note that $u(x,y)=0$, for all four values e.g. in alternative (d), $u(x,y)=0$ for $y=0, y=L$ but it is not zero for $x=0$ or $x=L$. Similarly in option (a). $u(x,y)=0$ at $x=L, y=L$ but it is not zero for $x=0$ or $y=0$, while in options (b) and (c), $u(x,y)=0$ for $x=0, y=0, x=L$ and $y=L$

3. (c) Energy $(E) \propto$ (Amplitude)^2 (Frequency)^2

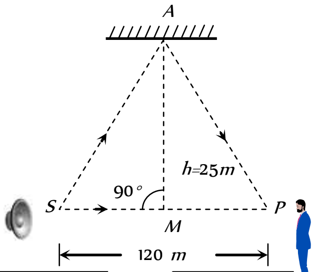
Amplitude is same in both the cases, but frequency 2ω in the second case is two times the frequency (ω) in the first case. Hence $E_2 = 4E_1$.

4. (a) Let S be source of sound and P the person or listner.

The waves from S reach point P directly following the path SMP and being reflected from the ceiling at point A following the path SAP. M is mid-point of SP (*i.e.* $SM = MP$) and $\angle SMA = 90^o$

Path difference between waves $\Delta x = SAP - SMP$

We have $SAP = SA + AP = 2(SA)$



$= 2\sqrt{[(SM)^2 + (MA)^2]} = 2\sqrt{(60^2 + 25^2)} = 130\ m$

$\therefore$ Path difference = SAP – SMP $= 130 - 120 = 10\ m$

Path difference due to reflection from ceiling = $\frac{\lambda}{2}$

$\therefore$ Effective path difference $\Delta x = 10 + \frac{\lambda}{2}$

For constructive interference

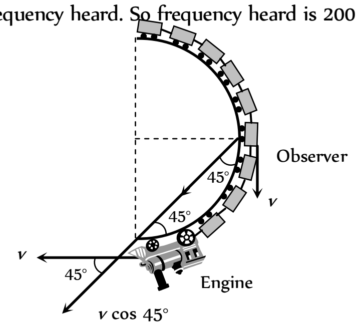
$$\Delta x = 10 + \frac{\lambda}{2} = n\lambda \Rightarrow (2n-1)\frac{\lambda}{2} = 10 (n = 1,\ 2,\ 3....)$$

$\therefore$ Wavelength $\lambda = \frac{2\times 10}{(2n-1)} = \frac{20}{2n-1}$. The possible wavelength are $\lambda =$ 20, $\frac{20}{3}, \frac{20}{5}, \frac{20}{7}, \frac{20}{9}, ...$

$= 20\ m,\ 6.67\ m,\ 4m,\ 2.85\,m,\ 2.22\ m, ...$

5. (c) The situation is shown in the fig.

Both the source (engine) and the observer (Person in the middle of the train) have the same speed, but their direction of motion is right angles to each other. The component of velocity of observer towards source is $v\cos 45°$ and that of source along the time joining the observer and source is also $v\cos 45°$. There is number relative motion between them, so there is no change in frequency heard. So frequency heard is 200 *Hz.*



6. (b) Velocity of sound increases if the temperature increases. So with $v = n\lambda$, if v increases n will increase

at $27^o C, v_1 = n\lambda$, at $31^o C$, $v_2 = (n+x)\lambda$

Now using $v \propto \sqrt{T}$ $\left(\because v = \sqrt{\frac{\gamma RT}{M}}\right)$

$$\frac{v_2}{v_1} = \sqrt{\frac{T_2}{T_1}} = \frac{n+x}{n}$$

$$\Rightarrow \frac{300+x}{300} = \sqrt{\frac{(273+31)}{(273+27)}} = \sqrt{\frac{304}{300}} = \sqrt{\frac{300+4}{300}}$$

$$\Rightarrow 1 + \frac{x}{300} = \left(1 + \frac{4}{300}\right)^{1/2} = \left(1 + \frac{1}{2}\times\frac{4}{300}\right) \Rightarrow x = 2.$$

$[\because (1+x)^n = 1 + nx]$

7. (b) Let *x* be the end correction then according to question.

$$\frac{v}{4(l_1 + x)} = \frac{3v}{4(l_2 + x)} \Rightarrow x = 2.5\ cm = 0.025\ m.$$

8. (c) Frequency of first over tone of closed pipe = Frequency of first over tone of open pipe

$$\Rightarrow \frac{3v}{4L_1} = \frac{v}{L_2} \Rightarrow \frac{3}{4L_1}\sqrt{\frac{\gamma P}{\rho_1}} = \frac{1}{L_2}\sqrt{\frac{\gamma P}{\rho_2}} \quad \left[\because v = \sqrt{\frac{\gamma P}{\rho}}\right]$$

$$\Rightarrow L_2 = \frac{4L_1}{3}\sqrt{\frac{\rho_1}{\rho_2}} = \frac{4L}{3}\sqrt{\frac{\rho_1}{\rho_2}}$$

9. (b) For string, $\frac{\text{Mass}}{\text{Length}} = m = \frac{10^{-2}}{0.4} = 2.5\times 10^{-2} kg/m$

$\therefore$ Velocity $v = \sqrt{\frac{T}{m}} = \sqrt{\frac{16}{2.5\times 10^{-2}}} = 8m/s$

For constructive interference between successive pulses.

$$\Delta t_{\min} = \frac{2l}{v} = \frac{2(0.4)}{8} = 0.1\sec$$

(After two reflections, the wave pulse is in same phase as it was produced since in one reflection it's phase changes by π, and If at this moment next identical pulse is produced, then constructive interference will be obtained.

10. (d) Frequency of vibration in tight string

$$n = \frac{p}{2l}\sqrt{\frac{T}{m}} \Rightarrow n \propto \sqrt{T} \Rightarrow \frac{\Delta n}{n} = \frac{\Delta T}{2T} = \frac{1}{2}\times(4\%) = 2\%$$

$\Rightarrow$ Number of beats = $\Delta n = \frac{2}{100}\times n = \frac{2}{100}\times 100 = 2$

11. (b) When the source approaches the observer

Apparent frequency $n' = \frac{v}{v - v_s}.n = n\left[\frac{1}{1 - \frac{v_s}{v}}\right]$

$= n\left[1 - \frac{v_s}{v}\right]^{-1} = n\left[1 + \frac{v_s}{v}\right]$

(Neglecting higher powers because $v_s << v$)

When the source recedes the observed apparent frequency $n'' = n\left[1 - \frac{v_s}{v}\right]$

Given $n' - n'' = \frac{2}{100}n$, $v = 300\ m/\sec$

$$\therefore \frac{2}{100}n = n\left[1 + \frac{v_s}{v}\right] - n\left[1 - \frac{v_s}{v}\right] = n\left[2\frac{v_s}{v}\right]$$

$$\Rightarrow \frac{2}{100} = 2\frac{v_s}{v} \Rightarrow v_s = \frac{v}{100} = \frac{300}{100} = 3\ m/\sec.$$

12. (a,b,c) Number of waves striking the surface per second (or the frequency of the waves reaching surface of the moving target) $n' = \frac{(c+v)}{\lambda} = \frac{\nu(c+v)}{c}$

Now these waves are reflected by the moving target

(Which now act as a source). Therefore apparent frequency of reflected second $n'' = \left(\frac{c}{c-v}\right)n' = \nu\left(\frac{c+v}{c-v}\right)$

The wavelength of reflected wave $= \frac{c}{n''} = \frac{c(c-v)}{\nu(c+v)}$

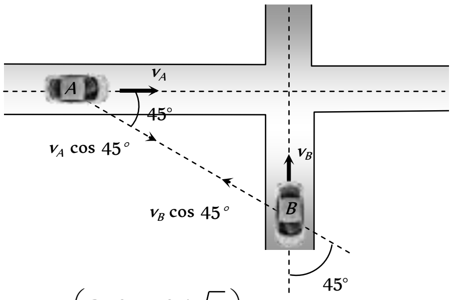
The number of beats heard by stationary listener $= n'' - \nu = \nu\left(\frac{c+v}{c-v}\right) - \nu = \frac{2\nu v}{(c-v)}$

Hence option (a) (b) and (c) are correct.

13. (b) Here $v_A = 72km/hr = 20m/\sec$

$v_B = 36km/hr = 10m/\sec$

$$n' = n\left(\frac{v + v_B \cos 45^o}{v - v_A \cos 45^o}\right)$$



$$\Rightarrow n' = 280\left(\frac{340 + 10/\sqrt{2}}{340 - 20/\sqrt{2}}\right) = 298\ Hz$$

14. (b) For observer note of B will not change due to zero relative motion.

Observed frequency of sound produced by A

$= 660\,\frac{(330-30)}{330} = 600\ Hz$

$\therefore$ No. of beats = 600 – 596 = 4

15. (a) $\lambda = \frac{v}{n} = \frac{340}{170} = 2m,\ n' = \frac{340}{340-17} \times 170 \Rightarrow n' = 178.9 Hz$

Now $\lambda' = \frac{v}{n'} = \frac{340}{178.9} = 1.9$

$\Rightarrow \lambda - \lambda' = 2 - 1.9 = 0.1$

16. (b) n_1 = Frequency of the police car horn observer heard by motorcyclist

n_2 = Frequency of the siren heard by motorcyclist.

v = Speed of motor cyclist

$n_1 = \frac{330 - v}{330 - 22} \times 176\ ;\ n_2 = \frac{330 + v}{330} \times 165$

$\because\ n_1 - n_2 = 0 \Rightarrow v = 22\ m/s$.

17. (a) $n' = \frac{v + v_0}{v}.n = \frac{v + \frac{v}{5}}{v}.f = \frac{6}{5}f = 1.2f$ and since the source is stationary, so wave length remains unchanged for observer.

18. (d) Time of fall = $\sqrt{\frac{2h}{g}} = \sqrt{\frac{2 \times 10}{1000}} = \frac{1}{\sqrt{50}}$

In this time number of oscillations are eight.

So time for 1 oscillation = $\frac{1}{8\sqrt{50}}$

Frequency = $8\sqrt{50}\ Hz$ = 56 Hz

19. (a) Density of mixture $= \rho_{\text{mix}} = \frac{V_{O_2}\rho_{O_2} + V_{H_2}\rho_{H_2}}{V_{O_2} + V_{H_2}}$

$= \frac{V(\rho_{O_2} + \rho_{H_2})}{2V} = \frac{\rho_{O_2} + \rho_{H_2}}{2}$ (since $V_{O_2} = V_{H_2} = V$)

$= \frac{\rho_{H_2} + 16\rho_{H_2}}{2} = 8.5\rho_{H_2} \Rightarrow v \propto \frac{1}{\sqrt{\rho}}$

$\Rightarrow \frac{V_{\text{mix}}}{V_{H_2}} = \sqrt{\frac{\rho_{H_2}}{\rho_{\text{mxn}}}} = \sqrt{\frac{\rho_{H_2}}{8.5\rho_{H_2}}} \approx \sqrt{\frac{1}{8}}$

20. (c) $y_1 = 10\sin\left(3\pi t + \frac{\pi}{3}\right)$ ...(i)

and $y_2 = 5[\sin 3\pi t + \sqrt{3}\cos 3\pi t]$

$= 5 \times 2\left[\frac{1}{2} \times \sin 3\pi t + \frac{\sqrt{3}}{2} \times \cos 3\pi t\right]$

$= 10\left[\cos\frac{\pi}{3}\sin 3\pi t + \sin\frac{\pi}{3}\cos \pi t\right]$

$= 10\left[\sin\left(3\pi t + \frac{\pi}{t}\right)\right]$ ... (ii)

($\because$ $\sin(A + B) = \sin A\cos B + \cos A\sin B$)

Comparing equation (i) and (ii) we get ratio of amplitude 1 : 1.

21. (a) The given equation can be x written as

$y = \frac{A}{2}\cos\left(4\pi nt - \frac{4\pi x}{\lambda}\right) + \frac{A}{2}\quad \left(\because \cos^2\theta = \frac{1 + \cos 2\theta}{2}\right)$

Hence amplitude $= \frac{A}{2}$ and frequency $= \frac{\omega}{2\pi} = \frac{4\pi n}{2\pi} = 2n$

and wave length $= \frac{2\pi}{k} = \frac{2\pi}{4\pi/\lambda} = \frac{\lambda}{2}$.

22. (a,b,c,d) In case of sound wave, y can represent pressure and displacement, while in case of an electromagnetic wave it represents electric and magnetic fields.

(In general y is any general physical quantity which is made to oscillate at one place and these oscillations are propagated to other places also).

23. (b) In case of interference of two waves resultant intensity

$I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$

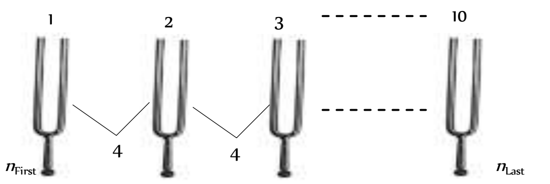
If ϕ varies randomly with time, so $(\cos\phi)_{av} = 0$

$\Rightarrow I = I_1 + I_2$

For n identical waves, $I = I_0 + I_0 + ...\ = nI_0$

here $I = 10I_0$.

24. (d)



Using $n_{Last} = n_{First} + (N-1)x$

where N = Number of tuning fork in series

x = beat frequency between two successive forks

$\Rightarrow 2n = n + (10 - 1) \times 4 \Rightarrow n = 36\ Hz$

$\therefore$ $n_{First} = 36\ Hz$ and $n_{Last} = 2 \times n_{First} = 72\ Hz$

25. (a) Similar to previous question

$n_{Last} = n_{First} + (N-1)x$

$2n = n + (41 - 1) \times 5$

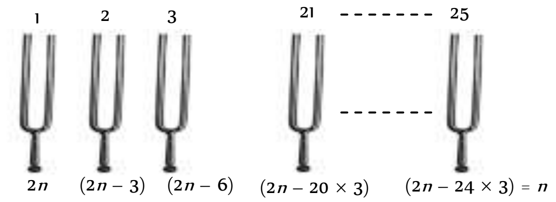
$\Rightarrow n_{first} = 200\ Hz$ and $n_{last} = 400\ Hz$

26. (a) $n \propto \sqrt{T} \Rightarrow \frac{\Delta n}{n} = \frac{1}{2}\frac{\Delta T}{T}$

Beat frequency $= \Delta n = \left(\frac{1}{2}\frac{\Delta T}{T}\right)n = \frac{1}{2}\times\frac{2}{100}\times 400 = 4$

27. (c) According to the question frequencies of first and last tuning forks are $2n$ and n respectively.

Hence frequency in given arrangement are as follows



$\Rightarrow 2n - 24 \times 3 = n \Rightarrow n = 72\ Hz$

So, frequency of 21st tuning fork

$n_{21} = (2\times 72 - 20\times 3) = 84 Hz$

28. (a) Using $n_{last} = n_{first} + (N-1)x$

$\Rightarrow 2n = n + (16-1)\times 8 \Rightarrow n = 120\ Hz$

29. (b) Using $n = \frac{1}{2l}\sqrt{\frac{T}{m}}$;

As $T_1 > T_2 \Rightarrow n_1 > n_2$ giving $n_1 - n_2 = 6$

The beat frequency of 6 will remain fixed when

(i) n_1 remains same but n_2 is increased to a new value $(n_2' - n_2 = 12)$ by increasing tension T_2.

(ii) n_2 remains same but n_1 is decreased to a new value $(n_1 - n_1' = 12)$ by decreasing tension T_1.

30. (a) According to problem

$$\frac{1}{2L}\sqrt{\frac{T}{m}} = \frac{v}{4L} \quad .....(i)$$

and $$\frac{1}{2L}\sqrt{\frac{T+8}{m}} = \frac{3v}{4L} \quad .....(ii)$$

Dividing equation (i) and (ii), $\sqrt{\frac{T}{T+8}} = \frac{1}{3} \Rightarrow T = 1N$

31. (b) In condition of resonance, frequency of a.c. will be equal to natural frequency of wire

$$n = \frac{1}{2l}\sqrt{\frac{T}{m}} = \frac{1}{2\times 1}\sqrt{\frac{10\times 9.8}{9.8\times 10^{-3}}} = \frac{100}{2} = 50\ Hz$$

32. (b) For wire if

M = mass, ρ = density, A = Area of cross section

V = volume, l = length, Δl = change in length

Then mass per unit length $m = \frac{M}{l} = \frac{Al\rho}{l} = A\rho$

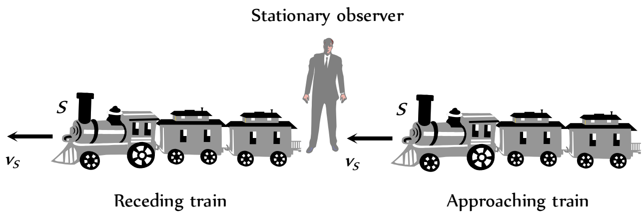
And Young's modules of elasticity $y = \frac{T/A}{\Delta l / l}$

$\Rightarrow T = \frac{Y\Delta l A}{l}$. Hence lowest frequency of vibration

$$n = \frac{1}{2l}\sqrt{\frac{T}{m}} = \frac{1}{2l}\sqrt{\frac{y\left(\frac{\Delta l}{l}\right)A}{A\rho}} = \frac{1}{2l}\sqrt{\frac{y\Delta l}{l\rho}}$$

$$\Rightarrow n = \frac{1}{2\times 1}\sqrt{\frac{9\times 10^{10}\times 4.9\times 10^{-4}}{1\times 9\times 10^{3}}} = 35 Hz$$

33. (a)



Frequency of sound heard by the man from approaching train

$$n_a = n\left(\frac{v}{v - v_s}\right) = 240\left(\frac{320}{320-4}\right) = 243\ Hz$$

Frequency of sound heard by the man from receding train

$$n_r = n\left(\frac{v}{v + v_s}\right) = 240\left(\frac{320}{320+4}\right) = 237 Hz$$

Hence, number of beats heard by man per sec

$= n_a - n_r = 243 - 237 = 6$

Short trick : Number of beats heard per sec

$$= \frac{2nvv_S}{v^2 - v_S^2} = \frac{2nvv_S}{(v - v_S)(v + v_S)} = \frac{2\times 240\times 320\times 4}{(320-4)(320+4)} = 6$$

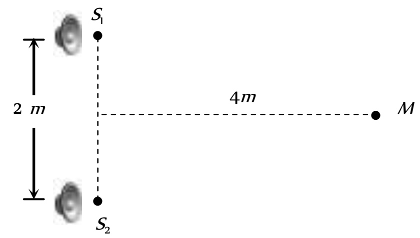
34. (c) Open pipe resonance frequency $f_1 = \frac{2v}{2L}$

Closed pipe resonance frequency $f_2 = \frac{nv}{4L}$

$f_2 = \frac{n}{4}f_1$ (where n is odd and $f_2 > f_1$) $\therefore n = 5$

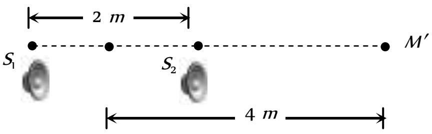
35. (b) Initially $S_1M = S_2M$

$\Rightarrow$ Path Difference (Δx) = $S_1M - S_2M = 0$.



Finally when the box is rotated

Path Difference $= S_1M' - S_2M' \Rightarrow \Delta x = 5 - 3 = 2m$



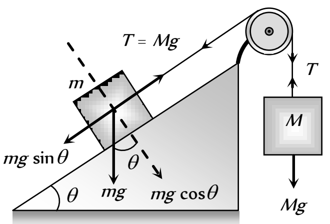
For maxima

Path Difference = (Even multiple) $\frac{\lambda}{2} \Rightarrow \Delta x = (2n)\frac{\lambda}{2}$

For 5 maximum responses

$\Rightarrow 2 = 2(5)\frac{\lambda}{2}$ $\left\{\because \Delta x = (2n)\frac{\lambda}{2}\right\}$ $\Rightarrow \lambda = \frac{2}{5} = 0.4m$.

36. (a) $v = \sqrt{\frac{T}{\mu}}$



For equilibrium $Mg = mg\sin 30 = T$

$\Rightarrow M = \frac{m}{2} \Rightarrow 100 = \sqrt{\frac{Mg}{9.8\times 10^{-3}}} = \sqrt{\frac{M(9.8)}{9.8\times 10^{-3}}}$

$\Rightarrow 100 = \sqrt{M(1000)} \Rightarrow M = 10kg$ and $m = 20kg$

37. (d) For not hearing the echo the time interval between the beats of drum must be equal to time of echo.

$\Rightarrow t_1 = \frac{2d}{v} = \frac{60}{40} = \frac{3}{2}$ ......(i)

and $t_2 = \frac{2(d-90)}{v} = \frac{60}{60} = 1$

$\Rightarrow 2d - 180 = v$ ......(ii)

Form (i), we get $2d = \frac{3}{2}v$. Substituting in (ii), we get

$\Rightarrow \frac{3}{2}v - 180 = v \Rightarrow 180 = \frac{v}{2} \Rightarrow v = 360ms^{-1}$

$\Rightarrow \frac{2(d)}{360} = \frac{3}{2} \Rightarrow d = 270m$.

38. (b) Path difference between the wave reaching at D

$\Delta x = L_2P - L_1P = \sqrt{40^2+9^2} - 40 = 41 - 40 = 1m$

For maximum $\Delta x = (2n)\frac{\lambda}{2}$

For first maximum $(n = 1)$ $\Rightarrow 1 = 2(1)\frac{\lambda}{2} \Rightarrow \lambda = 1m$

$\Rightarrow n = \frac{v}{\lambda} = 330Hz$.

39. (a) In a wave equation, x and t must be related in the form $(x - vt)$.

We rewrite the given equations $y = \frac{1}{1+(x-vt)^2}$

For $t = 0$, this becomes $y = \frac{1}{(1+x^2)}$, as given

For $t = 2$, this becomes $y = \frac{1}{[1+(x-2v)^2]} = \frac{1}{[1+(x-1)^2]}$

$\Rightarrow 2v = 1$ or $v = 0.5m/s$.

40. (c) $dB = 10\log_{10}\left(\frac{I}{I_0}\right)$; where $I_0 = 10^{-12}Wm^{-2}$

Since $40 = 10\log_{10}\left(\frac{I_1}{I_0}\right) \Rightarrow \frac{I_1}{I_0} = 10^4$ ....(i)

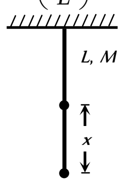
Also $20 = 10\log_{10}\left(\frac{I_2}{I_0}\right) \Rightarrow \frac{I_2}{I_0} = 10^2$ ....(ii)

$\Rightarrow \frac{I_2}{I_1} = 10^{-2} = \frac{r_1^2}{r_2^2} \Rightarrow r_2^2 = 100r_1^2 \Rightarrow r_2 = 10m$

$\{\because r_1 = 1m\}$

41. (b) Velocity $v = \sqrt{\frac{T}{m}}$; where T = weight of part of rope hanging below the point under consideration $= \left(\frac{M}{L}\right)xg$

$\Rightarrow v = \sqrt{\frac{\left(\frac{M}{L}\right)xg}{\left(\frac{M}{L}\right)}} = \sqrt{xg}$.



42. (b) When the piston is moved through a distance of $8.75cm$, the path difference produced is $2\times 8.75\,cm = 17.5\,cm$. This must be equal to $\frac{\lambda}{2}$ for maximum to change to minimum. $\therefore$

$\frac{\lambda}{2} = 17.5\,cm \Rightarrow \lambda = 35cm = 0.35m$

So, $v = n\lambda \Rightarrow n = \frac{v}{\lambda} = \frac{350}{0.35} = 1000Hz$

43. (c) Frequency of vib. is stretched string $n = \frac{1}{2(\text{Length})}\sqrt{\frac{T}{m}}$

When the stone is completely immersed in water, length changes but frequency doesn't ($\because$ unison reestablished)

Hence length $\propto \sqrt{T} \Rightarrow \frac{L}{l} = \sqrt{\frac{T_{air}}{T_{water}}} = \sqrt{\frac{V\rho g}{V(\rho-1)g}}$

(Density of stone = ρ and density of water =1)

$\Rightarrow \frac{L}{l} = \sqrt{\frac{\rho}{\rho-1}} \Rightarrow \rho = \frac{L^2}{L^2-l^2}$

44. (a,c) $y = \cos kx \sin\omega t$ and $y = \cos(kx+\omega t)$ represent wave motion, because they satisfies the wave equation $\frac{\partial^2}{\partial t^2} = v^2\frac{\partial^2 y}{\partial x^2}$.

45. (c) The wave 1 and 3 reach out of phase. Hence resultant phase difference between them is π.

$\therefore$ Resultant amplitude of 1 and 3 = $10 - 7 = 3\ \mu m$

This wave has phase difference of $\frac{\pi}{2}$ with 4 μm

$\therefore$ Resultant amplitude = $\sqrt{3^2+4^2} = 5\ \mu m$

46. (b) Let $n-1$ (= 400), n (= 401) and $n+1$ (= 402) be the frequencies of the three waves. If a be the amplitude of each then

$y = a\sin 2\pi(n-1)t,\quad y = a\sin 2\pi nt$ and

$y_3 = a\sin 2\pi(n+1)t$

Resultant displacement due to all three waves is

$$y = y_1 + y_2 + y_3$$

$$= a\sin 2\pi nt + a[\sin 2\pi(n-1)t + \sin 2\pi(n+1)t]$$

$$= a\sin 2\pi nt + a[2\sin 2\pi nt \cos 2\pi t]$$

$$\left[\text{Using} \sin C + \sin D = 2\sin\frac{C+C}{2}\cos\frac{C-D}{2}\right]$$

$$\Rightarrow y = a(1+\cos 2\pi t)\sin 2\pi nt$$

This is the resultant wave having amplitude $= (1+\cos 2\pi t)$

For maximum amplitude $\cos 2\pi t = 1 \Rightarrow 2\pi t = 2m\pi$ where m = 0, 1, 2, 3, ...

$\Rightarrow t$ = 0, 1, 2, 3 ...

Hence time interval between two successive maximum is 1 *sec*. So beat frequency = 1

Also for minimum amplitude ($2\cos 2\pi t$) = 0

$$\Rightarrow \cos 2\pi t = -\frac{1}{2}$$

$$\Rightarrow 2\pi t = 2m\pi + \frac{2\pi}{3} \Rightarrow t = +\frac{1}{3}$$

$$\Rightarrow t = \frac{1}{3}, \frac{4}{3}, \frac{7}{3}, \frac{10}{3}, \ldots \quad (\text{for } m = 0, 1, 2, ..)$$

Hence time interval between two successive minima is 1 *sec* so, number of beats per second = 1

Note : PET/PMT Aspirants can remember result only.

47. (d) Because the tuning fork is in resonance with air column in the pipe closed at one end, the frequency is $n = \frac{(2N-1)v}{4l}$ where

N = 1, 2, 3 .... corresponds to different mode of vibration

putting n = 340*Hz*, v = 340 *m/s*, the length of air column in the pipe can be

$$l = \frac{(2N-1)340}{4\times 340} = \frac{(2N-1)}{4}m = \frac{(2N-1)\times 100}{4}cm$$

For N = 1, 2, 3, ... we get l = 25 *cm*, 75 *cm*, 125 *cm* ...

As the tube is only 120 *cm* long, length of air column after water is poured in it may be 25 *cm* or 75 *cm* only, 125 *cm* is not possible, the corresponding length of water column in the tube will be (120 – 25) *cm* = 95 *cm* or (120 – 75) *cm* = 45 *cm*.

Thus minimum length of water column is 45 *cm*.

48. (c) Critical hearing frequency for a person is 20,000*Hz*.

If a closed pipe vibration in N^{th} mode then frequency of vibration $n = \frac{(2N-1)v}{4l} = (2N-1)n_1$

(where n_1 = fundamental frequency of vibration)

Hence 20,000 $= (2N-1)\times 1500 \Rightarrow N = 7.1 \approx 7$

Also, in closed pipe

Number of over tones = (No. of mode of vibration) –1

= 7 – 1 = 6.

49. (c) Frequency of vibration of string is given by

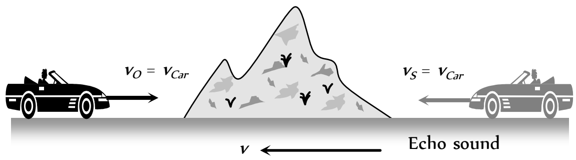
$$n = \frac{p}{2l}\sqrt{\frac{T}{m}} \Rightarrow p\sqrt{T} = \text{constant} \Rightarrow \frac{p_1}{p_2} = \sqrt{\frac{T_2}{T_1}}$$

Hence $\frac{4}{6} = \sqrt{\frac{T_2}{(50+15)gm\text{-}force}} \Rightarrow T_2 = 28.8\ gm\text{-}f$

Hence weight removed from the pan

$= T_1 - T_2 = 65 - 28.8 = 3.62$ *gm-force* = 0.036 *kg-f.*

50. (c) Frequency of reflected sound heard by driver $n' = n\left(\frac{v+v_O}{v-v_S}\right)$



It is given that $n' = 2n$

Hence, $2n = n\left(\frac{v+v_{car}}{v-v_{car}}\right) \Rightarrow v_{car} = v/3.$

51. (c) Suppose d = distance of epicenter of Earth quake from point of observation

v_S = Speed of *S*-wave and v_P = Speed of *P*-wave then $d = v_P t_P = v_S t_S$ or $8\,t_P = 4.5\,t_S$

$$\Rightarrow t_P = \frac{45}{8}t_S, \text{ given that } t_S - t_P = 240$$

$$\Rightarrow t_S - \frac{4.5}{8}t_S = 240 \Rightarrow t_S = \frac{240\times 8}{3.5} = 548.5\ s$$

$$\therefore d = v_S t_S = 4.5\times 548.5 = 2468.6 \approx 2500\ km$$

Graphical Questions

1. (c) Speed = $n\lambda = n(4ab) = 4n \times ab$ $\left(\text{As } ab = \frac{\lambda}{4}\right)$

Path difference between b and e is $\frac{3\lambda}{4}$

So the phase difference = $\frac{2\pi}{\lambda}$. Path difference

$= \frac{2\pi}{\lambda} \cdot \frac{3\lambda}{4} = \frac{3\pi}{2}$

2. (b) After 2 sec the pulses will overlap completely. The string becomes straight and therefore does not have any potential energy and its entire energy must be kinetic.

3. (a) When the train is approaching the stationary observer frequency heard by the observer $n' = \frac{v + v_0}{v} n$

when the train is moving away from the observer then frequency heard by the observer $n'' = \frac{v - v_0}{v} n$

it is clear that n' and n'' are constant and independent of time. Also and $n' > n''$.

4. (b) Equation of *A, B, C* and *D* are

$y_A = A \sin \omega t$, $y_B = A \sin(\omega t + \pi / 2)$

$y_C = A \sin(\omega t - \pi / 2)$, $y_D = A \sin(\omega t - \pi)$

It is clear that wave *C* lags behind by a phase angle of $\pi / 2$ and the wave *B* is ahead by a phase angle at $\pi / 2$.

5. (d) Points *B* and *F* are in same phase ass they are λ distance apart.

6. (c) The particle velocity is maximum at *B* and is given by $\frac{dy}{dt} = (v_p)_{\max} = \omega A$

Also wave velocity is $\frac{dx}{dt} = v = \frac{\omega}{k}$

So slope $\frac{dy}{dx} = \frac{(v_p)_{\max}}{v} = kA$

7. (d) When pulse is reflected from a rigid support, the pulse is inverted both lengthwise and sidewise

8. (d) Given equation $y = y_0 \sin(\omega t - \phi)$

at $t = 0$, $y = -y_0 \sin\phi$

this is the case with curve marked *D*.

9. (c) We know frequency $n = \frac{p}{2l}\sqrt{\frac{T}{\pi r^2 \rho}} \Rightarrow n \propto \frac{1}{\sqrt{\rho}}$

i.e., graph between *n* and $\sqrt{\rho}$ will be hyperbola.

10. (c) Energy density (*E*) $= \frac{I}{v} = 2\pi^2 \rho n^2 A^2$

$v_{\max} = \omega A = 2\pi n A \Rightarrow E \propto (v_{\max})^2$

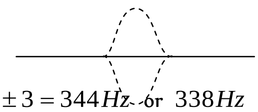
i.e., graph between *E* and $v_{\max}$ will be a parabola symmetrical about *E* axis.

11. (c) Here $A = 0.05m$, $\frac{5\lambda}{2} = 0.025 \Rightarrow \lambda = 0.1m$

Now standard equation of wave

$y = A \sin \frac{2\pi}{\lambda}(vt - x) \Rightarrow y = 0.05 \sin 2\pi(33t - 10x)$

12. (c) After two seconds each wave travel a distance of 2.5 × 2 = 5 *cm i.e.* the two pulses will meet in mutually opposite phase and hence the amplitude of resultant will be zero.



13. (c) $n_Q = 341 \pm 3 = 344 Hz$ or $338 Hz$

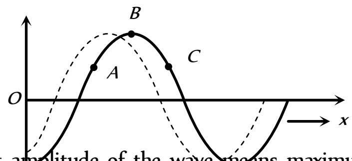
on waxing *Q*, the number of beats decreases hence $n_Q = 344 Hz$

14. (b) For observer approaching a stationary source

$n' = \frac{v + v_0}{v} . n$ and given $v_0 = at \Rightarrow n' = \left(\frac{an}{v}\right) t + n$

this is the equation of straight line with positive intercept *n* and positive slope $\left(\frac{n}{v}\right)$.

15. (b,d) Since *A* is moving upwards, therefore, after an elemental time interval the wave will be as shown dotted in following fig. It means, the wave is travelling leftward. Therefore, (a) is wrong.



Displacement amplitude of the wave means maximum possible displacement of medium particles due to propagation of the wave, which is equal to the displacement at *B* at the instant shown in fig. Hence (b) is correct.

From figure, it is clear that *C* is moving downwards at this instant. Hence (c) is wrong.

The phase difference between two points will be equal to $\frac{\pi}{2}$ if distance between them is equal to $\frac{\lambda}{4}$. Between *A* and *C*, the distance is less than $\frac{\lambda}{2}$. It may be equal to $\frac{\lambda}{4}$. Hence, phase difference between these two points may be equal to $\frac{\pi}{2}$.

16. (d) Intensity $\propto a^2 \omega^2$

here $\frac{a_A}{a_B} = \frac{2}{1}$ and $\frac{\omega_A}{\omega_B} = \frac{1}{2} \Rightarrow \frac{I_A}{I_B} = \left(\frac{2}{1}\right)^2 \times \left(\frac{1}{2}\right)^2 = \frac{1}{1}$

17. (b) At $t = 0$ and $x = \frac{\pi}{2k}$. The displacement

$y = a_0 \sin\left(\omega x_0 - k \times \frac{\pi}{2x}\right) = -a_0 \sin\frac{\pi}{2} = -a_0$

from graph. Point of maximum displacement (*a*) in negative direction is *Q*.

18. (d) Particle velocity $(v_p) = -v \times$ Slope of the graph at that point

At point 1 : Slope of the curve is positive, hence particle velocity is negative or downward (↓)

At point 2 : Slope negative, hence particle velocity is positive or upwards (↑)

At point 3 : Again slope of the curve is positive, hence particle velocity is negative or downward (↓)

Assertion and Reason

1. (a) Sound waves require material medium to travel. As there is no atmosphere (vacuum) on the surface of moon, therefore the sound waves cannot reach from one person to another.

2. (b) Transverse waves travel in the form of crests and troughs involving change in shape of the medium. As liquids and gases do not possess the elasticity of shape, therefore, transverse waves cannot be produced in liquid and gases. Also light wave is one example of transverse wave.

3. (b) Sound waves cannot propagate through vacuum because sound waves are mechanical waves. Light waves can propagate through vacuum because light waves are electromagnetic waves. Since sound waves are longitudinal waves, the particles moves in the direction of propagation, therefore these waves cannot be polarised.

4. (c) Velocity of sound in gas medium is $v = \sqrt{\frac{K}{\rho}} = \sqrt{\frac{\gamma p}{\rho}}$

γ is ratio of its principal heat capacities (C_P / C_v). For moist air ρ is less than that for dry air and γ is slightly greater.

$\therefore$ velocity of sound increases with increase in humidity.

5. (c) Ocean waves are transverse waves travelling in concentric circles of ever increasing radius. When they hit the shore, their radius of curvature is so large that they can be treated as plane waves. Hence they hit the shore nearly normal to the shore.

6. (a) A compression is a region of medium in which particles come closer *i.e.*, distance between the particles becomes less than the normal distance between them. Thus there is a temporary decrease in volume and a consequent increase in density of medium. Similarly in rarefaction, particle get farther apart and a consequent decrease in density.

7. (e) Since transverse wave can propagate through medium which posses elasticity of shape. Air posses only volume elasticity therefore transverse wave cannot propagate through air.

8. (c) The velocity of sound in a gas is directly proportional to the square root of its absolute temperature (as $v = \sqrt{\frac{\gamma RT}{M}}$). Since temperature of a hot day is more than cold winter day, therefore sound would travel faster on a hot summer day than on a cold winter day.

9. (c) According to Laplace, the changes in pressure and volume of a gas, when sound waves propagated through it, are not isothermal, but adiabatic. A gas is a bad conductor of heat. It does not allow the free exchange of heat between compressed layer, rarefied layer and surrounding.

10. (e) The velocity of every oscillating particle of the medium is different of its different positions in one oscillation but the velocity of wave motion is always constant *i.e.*, particle velocity vary with respect to time, while the wave velocity is independent of time.

Also for wave propagation medium must have the properties of elasticity and inertia.

11. (d) A bucket can be treated as a pipe closed at one end. The frequency of the note produced $= \frac{v}{4L}$, here L equal to depth of water level from the open end. As the bucket is filled with water L decreases, hence frequency increases. Therefore, frequency or pitch of sound produced goes on increasing.

Also, the frequency of woman voice is usually higher than that of man.

12. (b) A tuning fork is made of a material for which elasticity does not change. Since the alloy of nickel, steel and chromium (elinvar) has constant elasticity, therefore it is used for the preparation of tuning fork.

13. (e) Speed of sound in cases in independent of pressure because $v = \sqrt{\frac{\gamma P}{\rho}}$. At constant temperature, if P changes then ρ also changes in such a way that the ratio $\frac{P}{\rho}$ remains constant hence there is no effect of the pressure change on the speed of sound.

14. (a) For the propagation of transverse waves, medium must have the property of rigidity. Because gases have no rigidity, (they do not posses shear elasticity), hence transverse waves cannot be produced is gases. On the other hand, the solids possess both volume and shear elasticity and likewise both the longitudinal and transverse waves can be transmitted through them.

15. (c) Velocity of sound in a gas $v = \sqrt{\frac{\gamma P}{\rho}}$. For monoatomic gas $\gamma = 1.67$; for diatomic $\gamma = 1.40$. Therefore v is larger in case of monoatomic gas compared to its values in diatomic gas.

16. (a) The velocity of sound in solid is given by, $v = \sqrt{E / \rho}$.

Though ρ is large for solids, but their coefficient of elasticity E is much larger (compared to that of liquids and gases). That is why v is maximum in case of solid.

17. (d) When moisture is present in air, the density of air decreases. It is because the density of water vapours is less than that of dry air. The velocity of sound is inversely proportional to the square root of density, hence sound travel faster in moist air than in the dry air. Therefore, on a rainy day sound travels faster than on a dry day.

18. (b) According to the property of persistence of hearing, the impression of a sound heard persists on our mind for $\frac{1}{10}$ *sec*.

Therefore, number of beats per *sec* should be less than 10. Hence difference in frequencies of two sources must be less than 10.

19. (b) Sound produced by an open organ pipe is richer because it contains all harmonics and frequency of fundamental note in an open organ pipe is twice the fundamental frequency in a closed organ pipe of same length.

Reason is also correct, but it is not explaining the assertion.

20. (a) Since the initial phase difference between the two waves coming from different violins changes, therefore, the waves produced by two different violins does not interfere because two waves interfere only when the phase difference between them remain constant throughout.

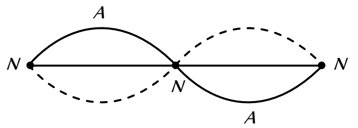
21. (d) As emission of light from atom is a random and rapid phenomenon. The phase at a point due to two independent light source will change rapidly and randomly. Therefore,

instead of beats, we shall get uniform intensity. However if light sources are LASER beams of nearly equal frequencies, it may possible to observe the phenomenon of beats in light.

22. (c) The person will hear the loud sound at nodes than at antinodes. We know that at anti-nodes the displacement is maximum and pressure change is minimum while at nodes the displacement is zero and pressure change is maximum. The sound is heard due to variation of pressure.

Also in stationary waves particles in two different segment vibrates in opposite phase.

23. (a) Stationary wave



A node is a place of zero amplitude and an antinode is a place of maximum amplitude.

24. (c) The principle of superposition does not state that the frequencies of the oscillation should be nearly equal. For beats to be heard the condition is that difference in frequencies of the two oscillations should not be more than 10 times per seconds for a normal human ear to recognise it. Hence we cannot hear beats in the case of two tuning forks vibrating at frequencies 256 *Hz* and 512 *Hz* respectively.

25. (a) The fundamental frequency of an open organ pipe is $n = \frac{v}{2l}$.

As temperature increases, both v and l increase but v increases more rapidly than l. Hence, the fundamental frequency increases as the temperature increases.

26. (b) Since, velocity of sound,

$$v = \sqrt{\frac{E}{\rho}}$$

As, the elasticity of solid is large than that of gases. Hence, it is obvious that velocity of sound is greater in solids than in gases.

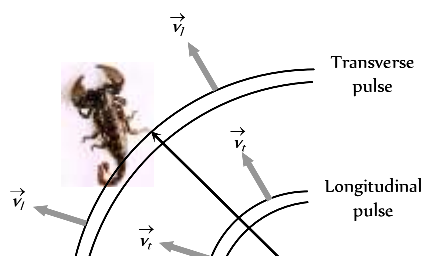
27. (d)

28. (b) Velocity of wave $= \frac{\text{Distance travelled by wave } (\lambda)}{\text{Time period } (T)}$

Wavelength is also defined as the distance between two nearest points in phase.

29. (c) Speed of light is greater than that of sound, hence flash of lightening is seen before the sound of thunder.

30. (a) A beetle motion sends fast longitudinal pulses and slower transverse waves along the sends surface. The sand scorpion first intercept the longitudinal pulses and learns the direction of the beetle; it is in the direction of which ever leg is disturbed earliest by the pulses. The scorpion then senses the time interval (Δt) between that first interception and the interception of slower transverse waves and uses it to determine the distance of the beetle. The distance is given by $\Delta t = \frac{d}{v_t} - \frac{d}{v_l}$



31. (e)

Waves and Sound

SET Self Evaluation Test -17

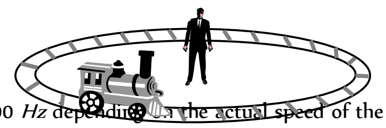
1. An engine is moving on a circular track with a constant speed. It is blowing a whistle of frequency 500 *Hz*. The frequency received by an observer standing stationary at the centre of the track is

(a) 500 *Hz*

(b) More than 500 *Hz*

(c) Less than 500 *Hz*

(d) More or less than 500 *Hz* depending on the actual speed of the engine



2. In a resonance tube, the first resonance is obtained when the level of water in the tube is at 16*cm* from the open end. Neglecting end correction, the next resonance will be obtained when the level of water from the open end is

(a) 24*cm* (b) 32*cm*

(c) 48*cm* (d) 64*cm*

3. To raise the pitch of a stringed musical instrument the player can

(a) Loosen the string (b) Tighten the string

(c) Shorten the string (d) Both (b) and (c)

4. A wave travelling along positive *x*-axis is given by $y = A\sin(\omega t - kx)$. If it is reflected from rigid boundary such that 80% amplitude is reflected, then equation of reflected wave is

(a) $y = A\sin(\omega t + kx)$ (b) $y = -0.8A\sin(\omega t + kx)$

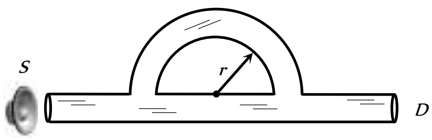
(c) $y = 0.8A\sin(\omega t + kx)$ (d) $y = A\sin(\omega t + 0.8\,kx)$

5. The frequency of the first harmonic of a string stretched between two points is 100 *Hz*. The frequency of the third overtone is

(a) 200 *Hz* (b) 300 *Hz*

(c) 400 *Hz* (d) 600 *Hz*

6. A sound wave of wavelength 32 *cm* enters the tube at *S* as shown in the figure. Then the smallest radius *r* so that a minimum of sound is heard at detector *D* is



(a) 7*cm* :m

(c) 21*cm* (d) 28 *cm*

7. A stretched wire of length 110 *cm* is divided into three segments whose frequencies are in ratio 1 : 2 : 3. Their lengths must be

(a) 20 *cm* ; 30 *cm* ; 60 *cm*

(b) 60 *cm* ; 30 *cm* ; 20 *cm*

(c) 60 *cm* ; 20 *cm* ; 30 *cm*

(d) 30 *cm* ; 60 *cm* ; 20 *cm*

8. Unlike a laboratory sonometer, a stringed instrument is seldom plucked in the middle. Supposing a sitar string is plucked at about $\frac{1}{4}$ *th* of its length from the end. The most prominent harmonic would be

(a) Eighth (b) Fourth

(c) Third (d) Second

9. If n_1, n_2, n_3......... are the frequencies of segments of a stretched string, the frequency *n* of the string is given by

(a) $n = n_1 + n_2 + n_3 + ...$ (b) $n = \sqrt{n_1 \times n_2 \times n_3 \times ....}$

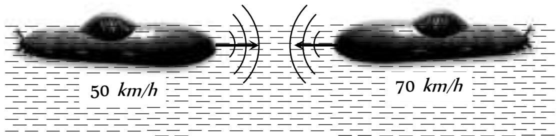
(c) $\frac{1}{n} = \frac{1}{n_1} + \frac{1}{n_2} + \frac{1}{n_3} + ...$ (d) None of these

10. The equation of stationary wave along a stretched string is given by $y = 5\sin\frac{\pi x}{3}\cos 40\pi t$ where *x* and *y* are in centimetre and *t* in second. The separation between two adjacent nodes is :

(a) 6 *cm* (b) 4 *cm*

(c) 3 *cm* (d) 1.5 *cm*

11. An Indian submarine and an enemy submarine move towards each other during maneuvers in motionless water in the Indian ocean. The Indian submarine moves at 50 *km/h*, and the enemy submarine at 70 *km/h*. The Indian sub sends out a sonar signal (sound wave in water) at 1000 *Hz*. Sonar waves travel at 5500 *km/h*. What is the frequency detected by the Indian submarine



(a) 1.02 *kHz* (b) 2 *kHz*

(c) 2.5 *kHz* (d) 4.7 *kHz*

12. Two trains, one coming towards and another going away from an observer both at 4 *m/s* produce whistle simultaneously of frequency 300 *Hz*. Find the number of beats produced

(a) 5 (b) 6

(c) 7 (d) 12

13. A source of sound emits $200\pi W$ power which is uniformly distributed over a sphere of 10 *m* radius. What is the loudness of sound on the surface of a sphere

(a) 200 *dB* (b) 200 π *dB*

(c) 120 *dB* (d) 120 π *dB*

14. When a wave travels in a medium, the particle displacement is given by $y(x, t) = 0.03\sin\pi(2t - 0.01x)$ where *y* and *x* are meters and *t* in seconds. The phase difference, at a given instant of time between two particle 25 *m*. apart in the medium, is

(a) $\frac{\pi}{8}$ (b) $\frac{\pi}{4}$

(c) $\frac{\pi}{2}$ (d) π

15. A sine wave has an amplitude A and wavelength λ. Let V be the wave velocity and v be the maximum velocity of a particle in the medium. Then [KCET 2001]

(a) $V = v \text{ if } \lambda = \frac{3A}{2\pi}$ (b) $V = v \text{ if } A = 2\pi\lambda$

(c) $V = v \text{ if } A = \frac{\lambda}{2\pi}$ (d) V can not be equal to v

16. A pipe open at both ends produces a note of frequency f_1. When the pipe is kept with $\frac{3}{4}$ *th* of its length it water, it produced a note of frequency f_2. The ratio $\frac{f_1}{f_2}$ is

[KCET 1998]

(a) $\frac{3}{4}$ (b) $\frac{4}{3}$

(c) $\frac{1}{2}$ (d) 2

17. A man fires a bullet standing between two cliffs. First echo is heard after 3 seconds and second echo is heard after 5 seconds. If the velocity of sound is 330 *m/s*, then the distance between the cliffs is

(a) 1650 *m* (b) 1320 *m*

(c) 990 *m* (d) 660 *m*

18. The equation for spherical progressive wave is (where r is the distance from the source) [CPMT 2002]

(a) $y = a\sin(\omega t - kx)$ (b) $y = \frac{a}{\sqrt{r}}\sin(\omega t - kx)$

(c) $y = \frac{a}{2}\sin(\omega t - kx)$ (d) $y = \frac{a}{r}\sin(\omega t - kx)$

19. A tuning fork A produces 4 *beats/sec* with another tuning fork B of frequency 320 *Hz*. On filing the fork A, 4 *beats/sec* are again heard. The frequency of fork A, after filing is

[KCET (Engg./Med.) 1999]

(a) 324 *Hz* (b) 320 *Hz*

(c) 316 *Hz* (d) 314 *Hz*

20. The number of beats produced per second by two vibrations: $x_1 = x_0 \sin 646\pi t$ and $x_2 = x_0 \sin 652\,\pi t$ is

[UPSEAT 2005]

(a) 2 (b) 3

(c) 4 (d) 6

21. 50 tuning forks are arranged in increasing order of their frequencies such that each gives 4 beats/sec with its previous tuning fork. If the frequency of the last fork is octave of the first, then the frequency of the first tuning fork is [DPMT 2005]

(a) 200 *Hz* (b) 204 *Hz*

(c) 196 *Hz* (d) None of these

22. The fundamental frequency of a closed pipe is 220 *Hz*. If $\frac{1}{4}$ of the pipe is filled with water, the frequency of the first overtone of the pipe now is

[EAMCET (Med.) 2000]

(a) 220 *Hz* (b) 440 *Hz*

(c) 880 *Hz* (d) 1760 *Hz*

23. A glass tube 1.5 *m* long and open at both ends, is immersed vertically in a water tank completely. A tuning fork of 660 *Hz* is vibrated and kept at the upper end of the tube and the tube is gradually raised out of water. The total number of resonances heard before the tube comes out of water, taking velocity of sound air 330 *m/sec* is

[EAMCET (Engg.) 1999]

(a) 12 [AFMC 2000] (b) 6

(c) 8 (d) 4

24. In the 5^{th} overtone of an open organ pipe, these are (N-stands for nodes and A-for antinodes)

(a) 2N, 3A (b) 3N, 4A

(c) 4N, 5A (d) 5N, 4A

25. An engine approaches a hill with a constant speed. When it is at a distance of 0.9 *km* it blows a whistle, whose echo is heard by the driver after 5 *sec*. If speed of sound in air is 330 *m/s*, the speed of engine is

(a) 10 *m/s* (b) 20 *m/s*

(c) 30 *m/s* (d) 40 *m/s*

Answers and Solutions

(SET -17)

1. (a) Since there is no relative motion between the source and listener, So apparent frequency equals original frequency.

2. (c) Next resonance length after the fundamental is $3l_1 = 3 \times 16 = 48cm$.

3. (d) Higher pitch means higher frequency

Frequency of a stringed system is given by

$$n = \frac{p}{2l}\sqrt{\frac{T}{m}} \Rightarrow n \propto \frac{\sqrt{T}}{l}$$

Hence, to get higher frequency (higher pitch) tension should be increase and length should be shorten.

4. (b) On getting reflected from a rigid boundary the wave suffers

Hence if $y_{incident} = A\sin(\omega t - kx)$

then $y_{reflected} = (0.8A)\ \sin\{\omega t - k(-x) + \pi\}$

$= -0.8A\sin(\omega t + kx)$ an additional phase change of π .

5. (c) Third overtone is the fourth harmonic i.e., $n_4 = 4n_1 = 4 \times 100 = 400$ Hz

6. (b) Path difference $(\pi r - 2r) = \frac{\lambda}{2} = \frac{32}{2} = 16$,

$$r = \frac{16}{\pi - 2} = 14cm .$$

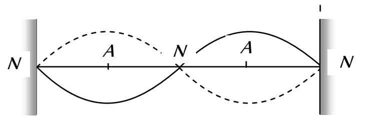
7. (b) $l_1 + l_2 + l_3 = 110\ cm$ and $n_1 l_1 = n_2 l_2 = n_3 l_3$

$n_1 : n_2 : n_3 :: 1 : 2 : 3$

$\because \frac{n_1}{n_2} = \frac{1}{2} = \frac{l_2}{l_1} \Rightarrow l_2 = \frac{l_1}{2}$ and $\frac{n_1}{n_3} = \frac{1}{3} = \frac{l_3}{l_1} \Rightarrow l_3 = \frac{l_1}{3}$

$\therefore l_1 + \frac{l_1}{2} + \frac{l_1}{3} = 110$ so $l_1 = 60cm, l_2 = 30cm, l_3 = 20cm$.

8. (d) When plucked at one fourth it gives two loops, and hence 2nd harmonic is produced.



9. (c) For a vibrating string

$n_1 l_1 = n_2 l_2 = n_3 l_3 ..... =$ constant = k (say) = nl

Also $l_1 + l_2 + l_3 + l_4 + ... = 1$

$$\frac{k}{n_1} + \frac{k}{n_2} + \frac{k}{n_3} + \frac{k}{n_4} + ... = \frac{k}{n} \Rightarrow \frac{1}{n} = \frac{1}{n_1} + \frac{1}{n_2} + \frac{1}{n_3} + ...$$

10. (c) Given $y = 5\sin\frac{\pi x}{3}\cos 40\pi t$

Comparing with $y = 2a\cos\frac{2\pi vt}{\lambda}\sin\frac{2\pi x}{\lambda} \Rightarrow \lambda = 6\ cm.$

$\therefore$ The separation between adjacent nodes $= \frac{\lambda}{2} = 3\ cm.$

11. (a) Frequency detected by Indian submarine

$$n' = n\left[\frac{v + v_{sub}}{v - v_{sub}}\right] = 1000\left[\frac{5500 + 50}{5500 - 50}\right] \approx 1.02 kHz.$$

12. (c) $\Delta n = \left[\frac{v}{v - u} - \frac{v}{v + u}\right] n = \frac{2uv}{v^2 - u^2} n$

$$= \frac{2 \times 4 \times 332}{(332)^2 - (4)^2} \times 300 \approx 7$$

13. (c) Intensity = $\frac{\text{power}}{\text{area}} = \frac{200\pi}{2\pi \times 10^{-2}}$ = 1 *Watt/m*

Now $L = 10\log_{10}\frac{I}{I_0}$ = $10\log_{10}\left(\frac{1}{10^{-12}}\right)$

$= 10\log_{10}10^{12} = 120\ dB$

14. (b) $y(x, t) = 0.03\sin\pi(2t - 0.01x) = 0.03\sin(2\pi t - 0.01\pi x)$

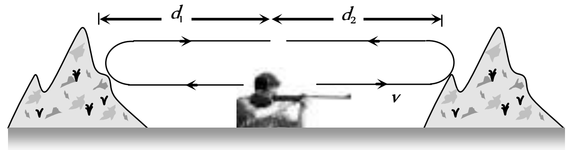
$$k = 0.01\pi = \frac{2\pi}{\lambda} \Rightarrow \Delta\phi = \frac{2\pi}{\lambda}\Delta x = 0.01\pi \times 25 = \frac{\pi}{4}$$

15. (c)Let wave velocity (V) = maximum particle velocity $\Rightarrow$ $n\lambda = \omega A = 2\pi\, nA \Rightarrow A = \frac{\lambda}{2\pi}$

16. c) For open pipe $f_1 = \frac{v}{2l}$ and for closed pipe

$$f_2 = \frac{v}{4 \times \left(\frac{l}{4}\right)} = \frac{v}{l} = 2f_1 \Rightarrow \frac{f_1}{f_2} = \frac{1}{2}$$

17. (b)



$$2(d_1 + d_2) = v(t_1 + t_2) \Rightarrow d_1 + d_2 = \frac{330 \times (3 + 5)}{2} = 1320\ m$$

18. (d) For spherical wave intensity $(I) \propto \frac{1}{(\text{Distance } r)^2}$

also $I \propto a^2 \Rightarrow a \propto \frac{1}{r}$. Hence equation of a cylindrical wave is $y = \frac{1}{r}\sin(\omega t - kx)$

19. (a) n_A = ?, n_B = Known frequency = 320 *Hz*

x = 4 *bps*, which remains same after filing.

Unknown fork *A* is filed so $n_A\uparrow$

Hence $n_A\uparrow - n_B = x$ ⟶ Wrong

$n_B - n_A\uparrow = x$ ⟶ Correct

$\Rightarrow$ $n_A = n_B - x = 320 - 4 = 316$ *Hz.*

This is the frequency before filing.

But in question frequency after filing is asked which must be greater than 316 *Hz*, such that it produces 4 *beats per sec.* Hence it is 324 *Hz.*

20. (b) From the given equation $\omega_1 = 2\pi n_1 = 646\pi \Rightarrow n_1 = 323$

and $\omega_2 = 2\pi n_2 = 652\pi \Rightarrow n_2 = 326$

Hence, beat frequency $= 326 - 323 = 3$

21. (c) Frequencies of tuning forks is given by

$$n_{\text{last}} = n_{\text{first}} + (N - 1)x$$

$$2n = n + (50 - 1) \times 4 \Rightarrow n = 196Hz.$$

***

22. (c) Fundamental frequency of closed pipe

$$n = \frac{v}{4l} = 220\ Hz \Rightarrow v = 220 \times 4l$$

If $\frac{1}{4}$ of the pipe is filled with water then remaining length of air column is $\frac{3l}{4}$

Now fundamental frequency = $\frac{v}{4\left(\frac{3l}{4}\right)} = \frac{v}{3l}$ and

First overtone = $3\times$ fundamental frequency

$$= \frac{3v}{3l} = \frac{v}{l} = \frac{220 \times 4l}{l} = 880\ Hz.$$

23. (b) Suppose *N* resonance occurred before tube coming out.

Hence by using $l = \frac{(2N-1)v}{4n}$

$$\Rightarrow 1.5 = \frac{(2N-1)\times 330}{4 \times 660} \Rightarrow N \approx 6.$$

24. (c) In open organ pipe 5^{th} overtone corresponds to 4^{th} harmonic mode.

Also in open pipe, Number of nodes = Order of mode of vibration and number of antinodes = (Number of nodes + 1). Here number of nodes = 4, Number of antinodes = 4 + 1 =5.

25. (c) If the speed of engine is *v*, the distance traveled by engine in 5 *sec* will be $5v$, and hence the distance traveled by sound in reaching the hill and coming back to the moving driver = 900 + (900 − 5*v*) = 1800 − 5*v*

So the time interval between original sound and it's echo $t = \frac{(1800-5v)}{330} = 5 \Rightarrow v = 30\ m/s.$