WAVES

GUPTA CLASSES

For any help contact:
9953168795, 9268789880

Nishant Gupta, D-122, Vihar, Rohini, Delhi-85
Contact: 9953168795, 9268789880

Waves

Wave motion

A wave motion is a kind of disturbance which is transferred from one part of the medium to the next due to the repeated periodic motion of medium particles about their mean position. The disturbance travels through the medium with a certain definite velocity without any change in its form.

Longitudinal waves: A longitudinal wave is a wave in which the particles of the medium oscillate in simple harmonic fashion along the direction of propagation of the wave. Sound waves in gases and liquids are longitudinal waves. Longitudinal waves propagate in the form of compression and rarefaction.

Transverse waves: A transverse wave is a wave in which the particles of medium execute simple harmonic motion in a direction perpendicular to its direction of propagation. Waves in strings and electromagnetic waves are the examples of transverse waves. In solids, sound waves can be transverse or longitudinal. Transverse waves in a medium essentially require shear modulus. Transverse wave propagate in form of crest and troughs.

1. There are also some such waves in nature which are neither transverse nor longitudinal but a combination of both. Such waves are known as ripples, for example, waves on the surface of a liquid.
2. Only a transverse wave can be polarised but not a longitudinal one. Hence, transverse or longitudinal nature of a wave can be decided on the basis of polarisation.

Mechanical waves

These waves require a material medium for their propagation. These waves transfer energy and momentum through the limited motion of the particles with the medium remaining at its own place. For the propagation of mechanical waves it is essential that the medium must possess elasticity, inertia and low resistance for motion. Mechanical waves can be either longitudinal or transverse.

Mechanical waves can be transmitted in all the three states of matter, namely solids, liquids and gases. In liquids and gases, these waves are always longitudinal waves. In solids, these waves can be either transverse or longitudinal. In string these waves are always transverse.

Non-mechanical waves

These waves do not require any medium for their propagation. All electromagnetic waves are non-mechanical. All non-mechanical waves are transverse in nature.

Mechanical waves in different media

S.No.	Type of media	Type of mechanical wave
1.	Strings	Mechanical waves are always transverse when the string is under a tension.
2.	Gases and liquids	Mechanical waves are always longitudinal as liquids and gases cannot sustain shear
3.	Solids	Mechanical waves can be either transverse or longitudinal depending on the mode of excitation.
4.	Vibrating tuning fork	Waves in the prongs are transverse while in the stem are longitudinal.
5.	Rocks during earthquakes	S (shear) and P (pressure) waves are produced simultaneously which travel through the rock in the crust with different speeds. S-

Nishant Gupta, D-122, Prashant vihar, Rohini, Delhi-85
Contact: 9953168795, 9268789880

		waves are transverse while P-waves are longitudinal.

Wave characteristics

1. The instantaneous displacement of any particle of the medium, in which the wave is propagating, is the displacement of that particle from its equilibrium position.
2. The amplitude of the wave is the maximum value of the displacement. Amplitude is a vector quantity.
3. When two waves of different amplitudes A_1 and A_2 superimpose each other with a phase difference of ϕ, then the resultant amplitude $A = \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos\phi}$
4. The maximum amplitude is $A_1 + A_2$, when $\phi = 0$ and minimum amplitude is $A_1 - A_2$, when $\phi = 180°$.
5. Frequency of wave depends upon the source but not on the medium. Frequency does not change when a wave travels from one medium to other.
6. Wavelength depends upon the nature of medium
7. **Wave velocity :** is the distance travelled by the wave per second and it is given by $v = f\lambda = \lambda/T$.
8. If we consider two points at positions x_1 and x_2 on a wave at a given instant, then the phase difference between the two points is given by $\Delta\phi = \frac{2\pi}{\lambda}(x_1 - x_2)$
9. If two sources emit waves of frequencies f_1 and f_2 simultaneously, then the phase difference between these two waves after a time Δt is given by: $\Delta\phi = (\omega_2 - \omega_1)\,\Delta t = 2\pi(f_2 - f_1)\,\Delta t$

Equation of plane progressive wave

A progressive wave is due to continuous periodic vibration of all the particles of the medium. A progressive wave transfers energy from one part of space to the other. In a progressive wave all the particles vibrate with the same amplitude and with same time period.

One dimensional progressive wave in its most general form is given by: **$y = A\sin(\omega t \pm kx + \phi)$,** where A is amplitude, ω is angular frequency, k is propagation constant and ϕ is initial phase. Here **$k = 2\pi/\lambda$**

1. If the sign between t and x terms is negative the wave is propagating along positive x-axis and vice-versa.
2. The argument **$(\omega t \pm kx + \phi)$** denotes phase of wave at time t..
3. The ratio of coefficient of t to that of x gives wave or phase velocity, i.e., $v = \omega/k$ and is constant for a given medium.
4. During propagation of wave the medium particle velocity is given by $v_p = \omega\sqrt{A^2 - y^2}$, which is similar to velocity of object in SHM.
5. Relation between particle velocity and wave velocity $\frac{dy}{dt} = -\frac{\omega}{k} \times \frac{dy}{dx} = -v\left(\frac{dy}{dx}\right)$

   velocity of particle v = – wave velocity x slope of the wave.

Velocity of mechanical waves in different medium

Transverse wave in stretched string $v = \sqrt{T/m}$,

where T is tension of string and m is mass of string per unit length.

Transverse wave In a solid $v = \sqrt{\eta/\rho}$,

where η is modules of rigidity and ρ is density of material of solid.

Nishant Gupta, D-122, Prashant vihar, Rohini, Delhi-85
Contact: 9953168795, 9268789880

Longitudinal wave in a long bar $v = \sqrt{Y/\rho}$,where Y is Young's modules

Longitudinal wave in Liquid and gases $v = \sqrt{K/\rho}$ where K is bulk modules

Audible or sound waves

Their frequencies lie between 20 Hz and 20,000 Hz. These are generated by vibrating bodies such as vocal cords, stretched strings or membranes. In air at NTP the velocity of sound wave (v = 330 m/sec) and their wavelength range is 16.5 m to 1.65 cm.

Infrasonic waves

These are mechanical waves of frequencies below 20 Hz. These waves are created by earthquakes (P-waves), volcanic eruption, ocean waves.

Ultrasonic waves

These are mechanical waves having frequency more than 20 kHz. Mosquitoes, fish, dogs and bats can detect these waves. Bats not only detect but also produce ultrasonic waves. These waves can be produced by the high frequency vibrations of a quartz crystal under an alternating electric field (Piezoelectric effect). These waves can also be produced by the vibrations of a ferromagnetic rod under an alternating magnetic field (Magnetostriction effect).

Newton's formula for sound speed

Newton assumed that sound propagates through air is isothermal process. Since isothermal bulk modulus = Pressure. So $v = \sqrt{\frac{P}{\rho}}$. When calculated by this, speed at NTP = 279 m/s, which is much lesser than experimental value (= 332 m/s)

Laplace correction to Newton Formula

Laplace modified Newton's formula assuming that propagation of sound in air is an adiabatic process. Since adiabatic bulk modulus = γ x Pressure. So $v = \sqrt{\frac{\gamma P}{\rho}}$. When calculated by this, speed at NTP = 331.3 m/s, which is very much near to experimental value (= 332 m/s).

Effect of various factors on the velocity of sound

Effect of Density of medium : $v = \sqrt{\frac{\gamma P}{\rho}}$ i.e. *Velocity of sound in gaseous medium decreases with increase in density*.

Effect of temperature: Since PV = nRT, so for one mole of gas $v = \sqrt{\frac{\gamma RT}{\rho V}} = \sqrt{\frac{\gamma RT}{M}}$, where M is molar mass of gas. That is why for a given gas $v \propto \sqrt{T}$ i.e., with rise in temperature velocity of sound in a gas increases. When change in temperature is small, the velocity of sound changes by 0.61 m/s when temperature changes by 1°C.

Effect of Pressure : $v = \sqrt{\frac{\gamma P}{\rho}} = \sqrt{\frac{\gamma RT}{M}}$ i.e. *Velocity of sound is independent of pressure it temp is constant*.

Effect of Humidity : The presence of water vapour in air reduces the density. Hence the *velocity of sound will increase with increase of humidity.*

Nishant Gupta, D-122, Prashant vihar, Rohini, Delhi-85
Contact: 9953168795, 9268789880

Effect of Wind Velocity : Because wind drift the air along its directions of motion so the velocity of sound will be affected by wind. If the velocity of wind is 'w' and the angle between direction of wind and sound is θ then effective velocity of sound v' will be $v' = v + w\cos\theta$. Where v is actual velocity of sound

Energy, power and intensity of sound wave

(a) Energy density $u = \frac{1}{2}\rho\omega^2 A^2$

(b) $\text{Intensity}(I) = \frac{1}{2}\rho v\omega^2 A^2$ i.e for a given source and medium, $I \propto A^2$

(c) Human ear responds to sound intensities over a range 10^{-12} W/m² to 1 W/m², so instead of specifying intensity of sound in W/m², we use a logarithmic scale of intensity called sound level defined as

$SL = 10\log\frac{I}{I_o}$ where I_o is the threshold of human ear, i.e., 10^{-12} W/m². The sound level defined in this way is expressed in decibel (dB).

A sound of intensity I_o an SL = 0 dB while sound at the upper range of human hearing called threshold of pain has an intensity of 1 W/m² or a SL = 120 dB.

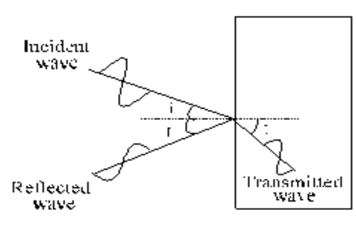
(d) With increase in distance from the source, the total energy or power transmitted remains the same but intensity decreases. For an isotropic point source of power P, intensity I at a distance r from it will be $I = \frac{P}{S} = \frac{P}{4\pi r^2}$

As for a given medium and source, $I \propto A^2$ also $I \propto 1/r^2$ so $A \propto 1/r$

SUPERPOSITION OF WAVES

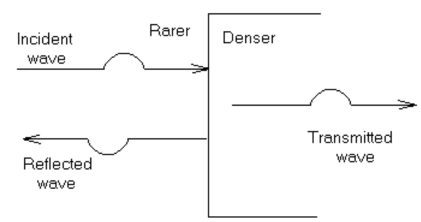
Reflection & Refraction of Waves

When sound waves are incident on a boundary between two media, a part of incident waves reflected while the remaining is partly absorbed and partly transmitted into the second medium. In case of reflection and refraction (transmission of wave) of sound :



1. *The frequency of wave remain unchanged* i.e., $f_i = f_r = f_t = f$ (subscript i, r and t are for incident wave, reflecting wave and transmitting wave)
2. In case of reflection, *angle of incidence (i) = angle of reflection (r)*
3. In case of refraction $\sin i / \sin t = v_i / v_t$
4. In case of reflection from a denser medium or right support or fixed end *there is inversion of reflected wave* i.e.,

   If incident wave is given by $y = A_i \sin(\omega t - kx)$ the The reflected wave will be $y = -A_r \sin(\omega t + kx) = A_r \sin(\omega t + kx + \pi)$



5. In case of reflection from rarer medium or free end *there is no inversion of wave* i.e., if incident wave is given by $y = A_i \sin(\omega t - kx)$ then reflected wave is $y = A_r \sin(\omega t + kx)$

Principle of superposition

If two or more waves arrive simultaneously in a medium, the particles of the medium are subjected to two or more simultaneous displacements and a new wave is produced. This phenomenon of intermixing of two or more waves to produce a new wave is called superposition of waves.

In case of superposition of waves, the resultant wave function at any point is the algebraic sum of the wave-functions of individual waves, i.e., $y = y_1 + y_2 + y_3 + ...$ This principle is called principle of superposition.

Nishant Gupta, D-122, Prashant vihar, Rohini, Delhi-85
Contact: 9953168795, 9268789880

Beats

When two sound waves of nearly equal frequency travelling in same direction superpose each other at a given point, then the intensity of the resulting sound rises and falls periodically. This periodic rise and fall in the intensity of sound at a given point is called as beats.

The time interval between two successive beats (i.e., two successive maxima of sound) is called beat period and is given by $T_B = 1/(f_1 - f_2)$ where f_1 and f_2 are the frequency of two superposing waves.

The no. of beats produced per second is called beat frequency and is given by $f_B = (f_1 - f_2)$.

Stationary or standing waves

When two waves of same frequency and amplitude travel in opposite direction with same speed, their superposition gives rise to a new type of wave called stationary wave.

In standing wave the amplitude of particles at different position is different. *The points at which amplitude is minimum are called nodes.* The points at which amplitude is maximum are called antinodes

1. The distance between two adjacent nodes is $\lambda/2$. The nodes and antinodes are formed alternately and the distance between them is equal to $\lambda/4$.
2. The region between two consecutive nodes appears as loop and called segment. All the particles of a segment vibrate in same phase. But the particles in adjacent segment differ in phase by π.
3. Stationary waves may be transverse or longitudinal. In strings (under tension) the waves are transverse-stationary. In organ pipes the waves are longitudinal-stationary.
4. As in stationary waves nodes are permanently at rest, so energy cannot be transmitted across them, i.e energy of one region (segment) is confined in that region. However, this energy oscillates between elastic potential energy and kinetic energy of the particles of the medium.

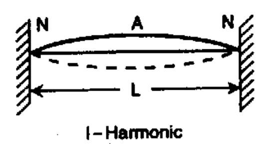
Standing Waves in String

If L is the length of string then $L = n\lambda/2$ (where n = 1, 2, 3, 4 -----) where λ is wavelength of string and n is mode of vibration

Mode of Vibration of String : From above length of string $L = n\lambda/2$ In this value of n represent the normal mode of vibration i.e., when n is one the vibration is said the first normal mode of vibration and when n is two it is called second mode of vibration and so on

The sound produced by first normal mode of vibration is called fundamental note and the frequency of vibration is called fundamental frequency

The sound produced by second mode of vibration is called first overtone.

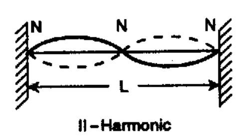


First normal mode of vibration (fundamental note) : from $L = n\lambda/2$ and $\lambda = 2L/n$

Here $n = 1$ i.e., $\lambda_1 = 2L$

As $f_1 = v/2L$ (because $v = f\lambda$)

The frequency generated by this mode is also known as first harmonic frequency



Second normal mode of vibration : Here $n = 2$ i.e., $\lambda_2 = L$

As $f_2 = v/L = 2f_1$

The frequency generated by this mode is also known as second harmonic frequency because $f_2 = 2f_1$

n_{th} normal mode of vibration :Here $n = n$ i.e., $\lambda_n = 2L/n$

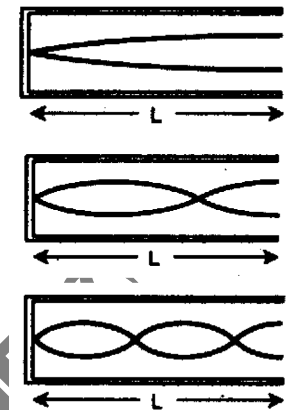
As $f_n = nv/2L = nf_1$

The frequency generated by this mode is also known as n_{th} harmonic frequency because $f_n = nf_1$

Standing Wave is closed Organ Pipe : If length of pipe is L then $L = (2n - 1)\lambda/4$ (where n = 1, 2, 3, 4 ……)

Nishant Gupta, D-122, Prashant vihar, Rohini, Delhi-85
Contact: 9953168795, 9268789880

or $\lambda = 4L/(2n - 1)$



First normal mode of vibration or fundamental note : Here n = 1, $\lambda_1 = 4L$

As $f = \upsilon/\lambda$ $\quad f_1 = v/\lambda_1 = v/4L$

The frequency generated by this mode is also known as first harmonic frequency

Second normal mode of vibration or First Overtone : Here n = 3 i.e. $\lambda_2 = 4L/3$

$$f_2 = v/\lambda_2 = 3v/4L = 3f_1$$

The frequency generated by this mode is third harmonic frequency because $f_2 = 3f_1$

Third normal mode of vibration or second Overtone : Here n = 3 i.e. $\lambda_3 = 4L/5$

$$f_3 = v/\lambda_3 = 5v/4L = 5f_1$$

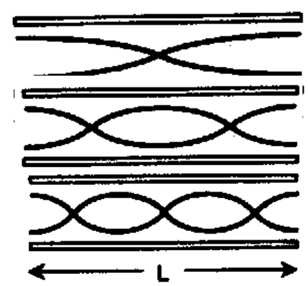
The frequency generated by this mode is fifth harmonic frequency because $f_3 = 5f_1$

n_{th} normal mode of vibration or (n-1)th overtone : Here n = n i.e. $\lambda_n = 4L/(2n-1)$

$$f_n = v(2n-1)/4L = (2n-1)f_1 \text{ . i.e., } (2n-1)_{th} \text{ harmonic}$$

Standing Wave in Open Organ Pipe

If length of open pipe is L then $L = n\lambda/2$ or $\lambda = 2L/n$



First mode of Vibration (Fundamental note or first harmonic) : n = 1 $\lambda_1 = 2L$

$$f_1 = v/\lambda_1 = v/2L$$

Second node of Vibration (Second Overtone) : n = 2 $\lambda_2 = L$

$$f_2 = v/\lambda_2 = v/L = 2f_l \text{ i.e., second harmonic}$$

Third mode of vibration (Second Overtone) : n = 3 $\lambda_3 = 2L/3$

$$f_3 = v/\lambda_3 = 3v/2L = 3f_1 \text{ i.e.., third harmonic}$$

n_{th} mode of vibration (n - 1)$_{th}$ Over tone) : n = n $\lambda_n = 2L/n$

$$f_n = v/\lambda_n = nv/2L = nf_1 \text{ i.e.., } n_{th} \text{ harmonic}$$

Doppler Effect

According to this whenever there is a relative motion between a source of sound and listener, the apparent frequency of sound heard by listener is different from the actual frequency emitted by source. The apparent frequency heard by listener is given by

$$f' = \frac{v - v_L}{v - v_s} f$$

where v = speed of sound, v_s = velocity of source, v_L = velocity of listener and f = actual frequency

When using this general formula, proper sign convention should be consider. i.e., all velocities in direction of sound shall be taken as positive and opposite to sound shall be taken as negative

Doppler Effect in Light and Other Electromagnetic Wave

If relative velocity of observer and source generating electromagnetic wave is 'v' then apparent change in frequency (Δf) and wavelength ($\Delta\lambda$) is given by

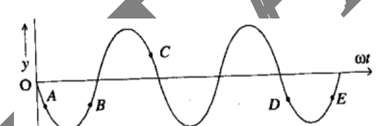
$$\Delta f = \frac{v}{c} f \text{ and } \Delta\lambda = \frac{v}{c}\lambda \text{ (c is speed of light)}$$

If the change is observed after reflection from somewhere then $\Delta f = \frac{2v}{c} f$ and $\Delta\lambda = \frac{2v}{c}\lambda$

Nishant Gupta, D-122, Prashant vihar, Rohini, Delhi-85
Contact: 9953168795, 9268789880

Waves Assignment

1. A progressive wave of frequency 500 Hz is travelling with a speed of 350 m/s. A compressional maximum appears at a place at a given instant. The minimum time interval after which a rarefaction maximum occurs at the same point is
(a) 1/250 s (b) 1/500 s (c) 1/1000 s (d) 1/350 s
2. A progressive wave is represented by the equation y = 0.5 sin (314t -12.56 x) when y and x are in metres and t in seconds. Its wavelength is
(a) 0.5m (b) 1.0m (c) 1.5m (d) 2.0m.
3. The speed of the wave represented by y = A sin (ωt - kx) is
(a) k/ω (b) ω/k (c) ωk (d) 1/ωk
4. The equation of a wave travelling on a string is $y = 4\sin\left[\frac{\pi}{2}\left\{8t - \frac{x}{8}\right\}\right]$ where x, y are in cm and t in seconds. The velocity of the wave is
(a) 64 cm/s in - x direction
(b) 32 cm/s in - x direction
(c) 32 cm/s in + x direction
(d) 64 cm/s in + x direction
5. The diagram shows the profile of a wave. Which of the following pairs of points are in phase?



(a) A, B (b) B, C
(c) B, D (d) B, E
6. Laplace's correction in the formula for the speed of sound given by Newton was needed because sound waves
(a) are longitudinal
(b) propagate isothermally
(c) propagate adiabatically
(d) have long wavelengths.
7. Two strings A and B, made of the same material, have same thickness. The length of A is half that of B while the tension on A is twice that on B. The ratio of the velocities of transverse waves in A and B is
(a) √2: 1 (b) 2 : 1 (c) 1 : √2 (d) 1 : 2
8. 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
(a) 60π cm/s (b) 30π cm/s
(c) 30 cm/s (d) 60 cm/s
9. The velocities of sound in an ideal gas at temperature T_1 and T_2 K are found to be V_1 and V_2, respectively. If the r.m.s, velocities of the molecules of the same gas at the same temperatures T_1 and T_2 are v_1 and v_2, respectively, then
(a) $v_2 = v_1\frac{V_1}{V_2}$ (b) $v_2 = v_1\frac{V_2}{V_1}$
(c) $v_2 = v_1\sqrt{\frac{V_2}{V_1}}$ (d) $v_2 = v_1\sqrt{\frac{V_1}{V_2}}$
10. With the propagation of a longitudinal wave through a material medium, the quantities transferred in the direction of propagation are
(a) energy, momentum and mass
(b) energy and momentum
(c) energy and mass
(d) energy.

11. A tuning fork of frequency 90 Hz is sounded and moved towards an observer with a speed equal to one-tenth the speed of sound. The note heard by the observer will have a frequency
(a) 100 (b) 110 (c) 80 (d) 70

12. A source and a 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
(a) 1.11f (b) 1.22f (c) 1.27f (d)f

13. A car, sounding a horn of frequency 1000 Hz, is moving directly towards a huge wall at a speed of 15 m/s. If speed of sound is 340 m/s, then the frequency of the echo heard by the driver is
(a) 1046 Hz (b) 954 Hz (c) 1092 Hz (d) 908 Hz

14. The apparent wavelength of the light from a star, moving away from the earth s 0.01% more than its real wavelength. The speed of the star with respect to the earth is
(a) 10 km/s (b) 15 km/s (c) 30 km/s (d) 60 km/s

15. The frequency of a radar is 780 MHz. When it is reflected from an approaching aeroplane, the apparent frequency is more than the actual frequency by 2.6 kHz. The speed of the aeroplane is
    (a) 0.25 km/s (b) 0.5 km/s (c) 1.0 km/s (d) 2.0 km/s

16. 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) 4m (b) 5 m (c) 10 m (d) 20 m
17. How many times more intense is a 90 dB sound than a 40 dB sound ?
    (a) 2.5 (b) 5 (c) 50 (d) 10^5
18. The quality of sound produced by an instrument depends on the
    (a) frequency (b) intensity
    (c) number of overtones (d) none of these.

19. The same notes being played on sitar and veena differ in
    (a) quality
    (b) pitch
    (c) both quality and pitch
    (d) neither quality nor pitch,
20. A wave is reflected from a rigid support, The change of phase on reflection will be
    (a) 0 (b) $\pi/4$ (c) $\pi/2$ (d) π
21. When beats are produced by two waves, viz., $y_1 = A \sin 1000 \pi t$ and $y_2 = A \sin 1008 \pi t$, the beat frequency will be
    (a) 4 Hz (b) 8 Hz (c) 4πHz (d) 8πHz
22. When beats are produced by two waves of nearly the same frequency,
    (a) the beat frequency depends on the position where the beats are heard.
    (b) the beat frequency decreases as time passes,
    (c) the particles vibrate simple harmonically with a frequency equal to the difference of the two frequencies.
    (d) the amplitude of vibration at any point changes simple harmonically with a frequency equal to the difference of the two frequencies.
23. The speed of sound in a gas in which two waves of wavelengths 50 cm and 50.4 cm produce 6 beats per second is
    (a) 338 m/s (b) 350 m/s (c) 378 m/s (d) 400 m/s
24. Beats are produced by two waves of the same intensity. The intensity at waxing is x times the intensity of each wave. The value of x is
    (a) $\sqrt{2}$ (b) 2 (c) $2\sqrt{2}$ (d) 4
25. ,65 tuning forks are arranged in order of increasing frequency. Any two successive forks produce 4 beats/s when sounded together. If the last fork gives an octave of the first, the frequency of the first fork is
    (a) 252Hz (b) 256Hz (c) 260Hz (d) 264Hz
26. When a tuning fork A of frequency 100 Hz is sounded with a tunning fork B, the number of beats per second is 2. On putting some wax on the prongs of B, the number of beats per second becomes 1. The frequency of the fork B is
    (a) 98 Hz (b) 99 Hz (c) 101 Hz (d) 102 Hz
27. If the tension in a string stretched between two fixed points is made four times, the frequency of the second harmonic will become
    (a) two times (b) three times
    (c) four times (d) six times
28. The types of waves produced in a sonometer wire are
    (a) transverse progressive
    (b) transverse stationary
    (c) longitudinal progressive
    (d) longitudinal stationary
29. A stretched string of length 1 m has mass per unit length 0.5 g. The tension in the string is 20 N. If it is plucked at a distance of 25 cm from one end, the frequency of vibration will be
    (a) 100 Hz (b)200Hz (c) 300 Hz (d) 400 Hz
30. A stretched string of length 2 m vibrates in 4 segments. The distance between consecutive nodes is
    (a) 0.5 m (b) 0.25 m (c) 1.0 m (d) 0.75 m
31. A string stretched by a weight of 4 kg is vibrating in its fundamental mode. The additional weight required to produce an octave of the first is
    (a) 4 kg (b) 8kg (c) 12 kg (d) 16 kg
32. A cylindrical tube, open at both ends, has a fundamental frequency f in air. The tube is dipped vertically in water so that half of it is in water. The fundamental frequency of the air column is now
    (a) $f/2$ (b) f (c) $3f/4$ (d) $2f$
33. With the increase in temperature, the frequency of the sound from an organ pipe
    (a) decreases (b) increases
    (c) remains unchanged (d) changes erratically
34. For the stationary wave $y = 4 \sin (\pi x/15) \cos (96\pi t)$, the distance between a node and the next anti-node is
    (a) 7.5 units (b) 15 units (c) 22.5 units (d) 30 units
35. Two sound waves, each of amplitude A and frequency ω, superpose at a point with a phase difference of $\pi/2$. The amplitude and frequency of the resultant wave are, respectively,
    (a) $A/\sqrt{2}$, $\omega/2$ (b) $A/\sqrt{2}$, ω
    (c) $A\sqrt{2}$, $\omega/2$ (d) $A\sqrt{2}$, ω
36. A wave represented by the equation $y = A \cos (kx - \omega t)$ is superposed with another wave to form a

Nishant Gupta, D-122, Prashant vihar, Rohini, Delhi-85
Contact: 9953168795, 9268789880

stationary wave such that the point x = 0 is a node. The equation for the other wave is

(a) $y = a \sin(kx + \omega t)$
(b) $y = - a \cos(kx + \omega t)$
(c) $y = - a \cos(kx - \omega t)$
(d) $y = - a \sin(kx - \omega t)$

37. A tuning fork of frequency 340 Hz is vibrated just above a cylindrical tube of length 120 cm. Water is slowly poured in the tube. If the speed of sound in air is 340 m/s, then the minimum height of water required for resonance is

(a) 25 cm (b) 45 cm (c) 75 cm (d) 95 cm

38. For a certain organ pipe, three successive resonance frequencies are observed at 425, 595 and 765Hz. The speed of sound in air is 340 m/s. The pipe is a

(a) closed pipe of length 1 m
(b) closed pipe of length 2 m
(c) open pipe of length 1 m
(d) open pipe of length 2 m

39. A glass tube of 1.0 m length is filled with water. The water can be drained out slowly at the bottom of the tube. If a vibrating tuning fork of frequency 500 c/s is brought at the upper end of the tube and the velocity of sound is 300 m/s, then the total number of resonances obtained will be

(a) 4 (b) 3 (c) 2 (d) 1

40. In stationary longitudinal wave, nodes are points of

(a) maximum pressure
(b) minimum pressure
(c) minimum pressure variation
(d) maximum pressure variation

ANSWERS

1c ,2a ,3b ,4d ,5d ,6c ,7a ,8a ,9b ,10b ,11a ,12b ,13c ,14c ,15b ,16c ,17d ,18c ,19a ,20d ,21a ,22d ,23c ,24d ,25b ,26d ,27a ,28b ,29b ,30a ,31c ,32b ,33b ,34a ,35d ,36b ,37b ,38a ,39b ,40d

Nishant Gupta, D-122, Prashant vihar, Rohini, Delhi-85
Contact: 9953168795, 9268789880