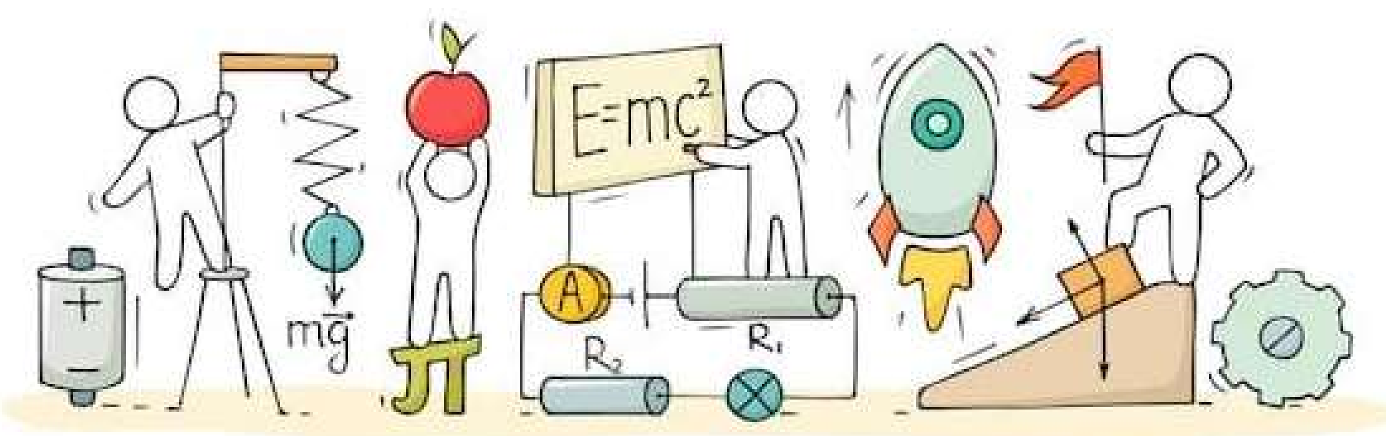
PHYSICS

Chapter 15: Waves



Waves

Top Formulae

Velocity of wave motion	$v = \upsilon\lambda = \lambda/T$, where λ is wavelength, T is period and υ is frequency.
Angular wave number	$k = \frac{2\pi}{\lambda}$
Angular frequency	$\omega = \frac{2\pi}{T}$
Newton's formula (corrected) for velocity of sound in air	$\upsilon = \sqrt{\frac{B_a}{\rho}} = \sqrt{\frac{\gamma P}{\rho}}$, where B_a is coefficient of volume elasticity of air under adiabatic conditions, P is pressure and ρ is density of air.
Velocity of transverse waves in stretched string	$\upsilon \quad \sqrt{T/m}$, where T is tension in the string and m is mass/length of the string.
Equation of a plane progressive harmonic wave travelling along the positive direction of the x-axis	$y = r\sin\frac{2\pi}{\lambda}(vt - x)$, where y = displacement of particle at time t, r = amplitude of vibration of particle, v = velocity of wave, λ = wavelength of wave, x = distance of the starting point (or wave) from the origin.
Velocity of a particle at time t	= dy/dt
Acceleration of a particle at time t	$= \frac{d^2y}{dt^2}$
Equation of a stationary wave	$y = 2r\sin\frac{2\pi}{\lambda}x\cos\frac{2\pi}{}\upsilon t$
Fundamental frequency	$\nu_1 = \frac{\upsilon}{2L} = \frac{1}{2L}\sqrt{\frac{T}{m}} = \frac{1}{\ell D}\sqrt{\frac{T}{\pi\rho}}$
Second harmonic or 1st overtone	$\nu_2 = 2\nu_1$
Third harmonic or 2nd overtone	$\nu_3 = 3\nu_1$

Top Concepts

- Waves carry energy from one place to another.
- The amplitude is the magnitude of the maximum displacement of the elements from their equilibrium positions as the wave passes through them.
- The wavelength λ of a wave is the distance between repetitions of the shape of the wave. In a stationary wave, it is twice the distance between two consecutive nodes or antinodes.
- The period T of oscillation of a wave is the time any string element takes to move through one full oscillation.
- A mechanical wave travels in some material called the medium. Mechanical waves are governed by Newton's laws.
- The speed of the wave depends on the type of wave and the properties of the medium.
- The product of wavelength and frequency equals the wave speed.
- $y = A\sin(kx - \omega t)$ is an equation which describes a travelling wave.
- In transverse waves, the particles of the medium oscillate perpendicular to the direction of wave propagation.
- In longitudinal waves, the particles of the medium oscillate along the direction of wave propagation.
- A progressive wave is a wave which moves from one point of the medium to another.
- The speed of a transverse wave on a stretched string is set by the properties of the string. The speed on a string with tension T and linear mass density μ is $v = \sqrt{\frac{T}{\mu}}$
- Sound waves are longitudinal mechanical waves which can travel through solids, liquids or gases. The speed v of a sound wave in a fluid with bulk modulus B and density ρ is

$$v = \sqrt{\frac{B}{\rho}}$$

- The speed of longitudinal waves in a metallic bar of Young's modulus Y and density ρ is

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

- For gases, because $B = \gamma P$, the speed of sound is

$$v = \sqrt{\frac{\gamma P}{\rho}}$$

- When two or more waves traverse the same medium, the displacement of any element of the medium is the algebraic sum of the displacements due to each wave. This is known as the principle of superposition of waves.

- Two sinusoidal waves on the same string exhibit interference, adding or cancelling according to the principle of superposition.

- A travelling wave, at a rigid boundary or a closed end, is reflected with a phase reversal, but the reflection at an open boundary occurs without any phase change.

  For an incident wave,

  $y_i (x, t) = a \sin (kx - \omega t)$

  The reflected wave at a rigid boundary is

  $y_r (x, t) = -a \sin (kx + \omega t)$

  For reflection at an open boundary,

  $y_r (x,t) = a \sin (kx + \omega t)$

- The interference of two identical waves moving in opposite directions produces standing waves. For a string with fixed ends, the standing wave is given by

  $y (x, t) = [2a \sin kx] \cos \omega t$

- Standing waves are characterized by fixed locations of zero displacement called nodes and fixed locations of maximum displacement called antinodes. The separation between two consecutive nodes or antinodes is λ/2.

- A stretched string of length L fixed at both the ends vibrates with frequencies given by

$$\upsilon = \frac{1}{2}\frac{v}{2L}, \quad n = 1,2,3.....$$

- The set of frequencies given by the above relation are called the normal modes of oscillation of the system. The oscillation mode with lowest frequency is called the fundamental mode or the first harmonic. The second harmonic is the oscillation mode with n = 2 and so on.

- A string of length L fixed at both ends or an air column closed at one end and open at the other end vibrates with frequencies called its normal modes. Each of these frequencies is a resonant frequency of the system.

- Beats arise when two waves with slightly different frequencies, ν_1 and ν_2 and comparable amplitudes, are superposed.

  The beat frequency, $V_{\text{beat}} = V_1 \sim V_2$

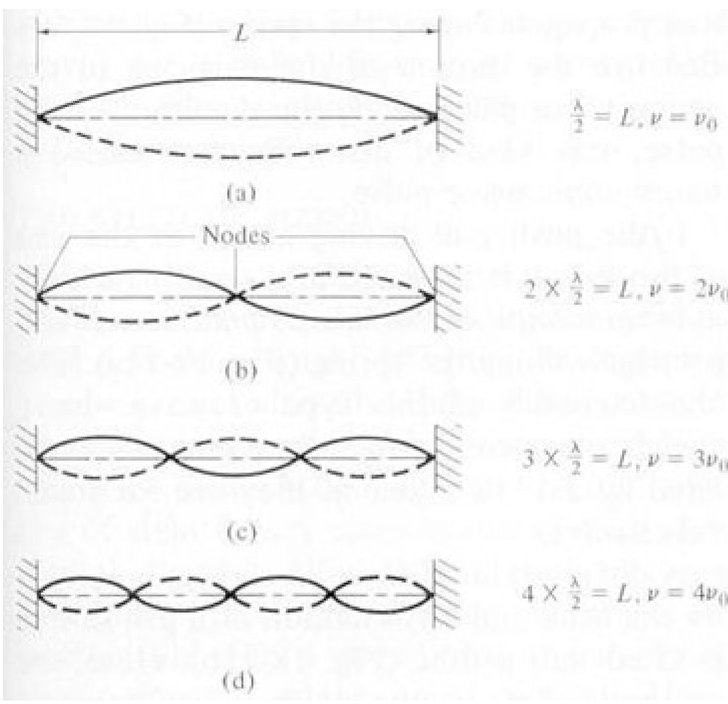
- The Doppler effect is a change in the observed frequency of a wave when the source and the observer move relative to the medium.

- The velocity of sound changes with change in pressure, provided the temperature remains constant.

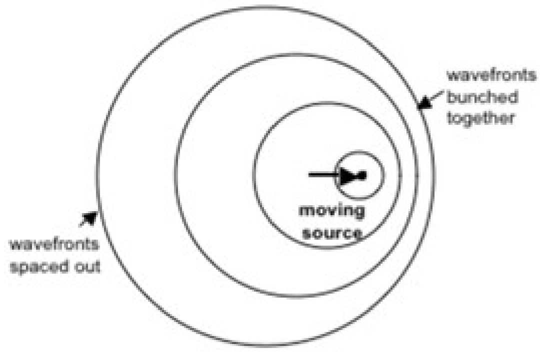
- The plus/minus sign is decided by loading/filling any of the prongs of either tuning fork. On loading a fork, its frequency decreases. On filling a fork, its frequency increases.

Diagrams

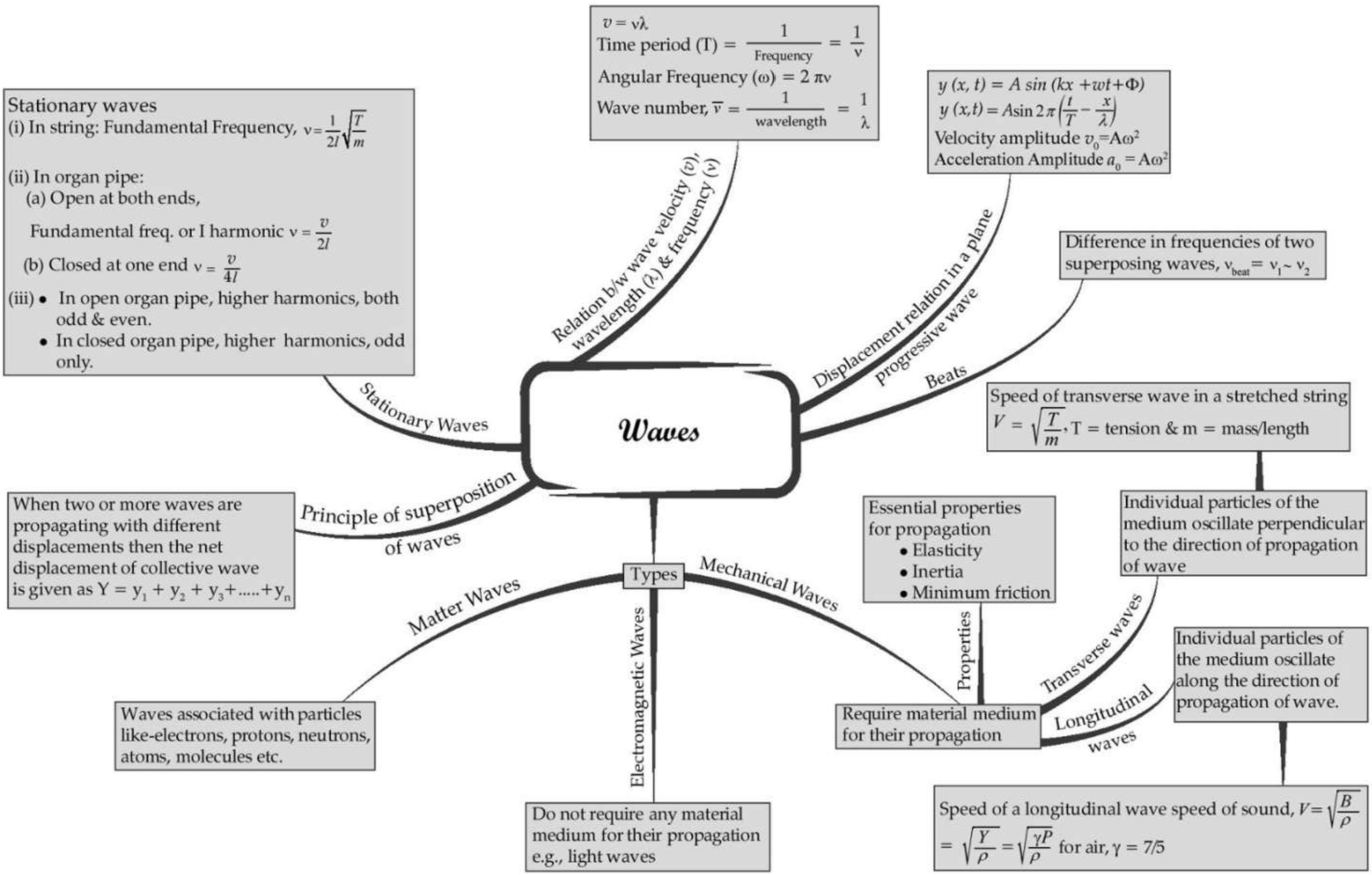
Harmonics in a string fixed at both ends



Doppler effect



CHAPTER - 15 : WAVES



Important Questions

Multiple Choice questions-

Question 1. Which of the following expressions is that of a simple harmonic progressive wave

(a) a sin wt

(b) a sin (wt) cos (kx)

(c) a sin (wt – kx)

(d) a cos kx

Question 2. Energy is not carried by

(a) Longitudinal progressive waves

(b) Electromagnetic waves

(c) Transverse progressive waves

(d) Stationary wave

Question 3. In stationary waves

(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) None of these

Question 4. Two tuning forks of frequencies 256 and 258 vibrations/second are sounded together. Then the time interval between two consecutive maxima heard by an observer is

(a) 2 sec

(b) 0.5 sec

(c) 250 sec

(d) 252 sec

Question 5. Which one of the following cannot represent a traveling wave

(a) y = f (x – nt)

(b) y = ym sin k (x + nt)

(c) y = ym log (x – nt)

(d) y = f (x^2 – nt^2)

Question 6. The wavelength of sound in air is 10 cm. its frequency is, (Given velocity of sound = 330 m/s)

(a) 330 cycles per second

(b) 3.3 kilo cycles per second

(c) 30 mega-cycles per second

(d) 305 cycles per second

Question 7. 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 freq ency?

(a) 0.50%

(b) zero

(c) 20%

(d) 5%

Question 8. In the longitudinal waves the direction of vibration in medium of particle is

(a) Perpendicular to propagation of wave

(b) Parallel to propagation

(c) Different from each other

(d) Variable for time to time

Question 9. Two identical straight wires are stretched so as to produce 6 beats per second when tension slightly in one of them, the beat frequency remains unchanged. Denoting by T1 and T2 the higher and lower initial tension in the strings, then it could be said that while making the above changes in tension

(a) T2 was decreased

(b) T2 was increased

(c) T1 was decreased

(d) Both (b) and (c)

Question 10. Two closed pipe produces 10 beats per second when emitting their fundamental nodes. If their lengths are in the ratio of 25 : 26 their fundamental frequency in Hz are

(a) 270, 280

(b) 260, 270

(c) 260, 250

(d) 240, 250

MCQ Answers-

1. Answer: (c) a sin (wt – kx)
2. Answer: (d) Stationary wave

3. Answer: (b) Energy is minimum at nodes and maximum at antinodes
4. Answer: (b) 0.5 sec
5. Answer: (c) y = ym log (x – nt)
6. Answer: (b) 3.3 kilo cycles per second
7. Answer: (c) 20%
8. Answer: (b) Parallel to propagation
9. Answer: (d) Both (b) and (c)
10. Answer: (c) 260, 250

Very Short Questions-

1. Explosions on other planets are not heard on earth. Why?
2. Why longitudinal waves are called pressure waves?
3. Why do tuning forks have two prongs?
4. Velocity of sound increases on a cloudy day. Why?
5. Sound of maximum intensity is heard successively at an interval of 0.2 second on sounding two tuning fork to gather. What is the difference of frequencies of two tuning forks?
6. If two sound waves have a phase difference of 600600, then find out the path difference between the two waves?
7. A hospital uses an ultrasonic scanner to locate tumors in a tissue. What is the wavelength of sound in the tissue in which the speed of sound is 1.7km−151.7km5−1 ? The operating frequency of the scanner is 4.2MHz4.2MHz.
8. Given below are some functions of xx and tt to represent the displacement (transverse or longitudinal) of an elastic wave. State which of these represent (i) a traveling wave, (ii) a stationary wave or (iii) none at all:

   (a) $y = 2\cos(3x)\sin(10t)$

   (b) $y = 2\sqrt{x - 13}$

   (c) $y = 3\sin(5x - 0.5n) + 4\cos(5x - 0.5t)$

   (d) $y = \cos x \sin t + \cos 2x \sin 2t$

9. A narrow sound pulse (for example, a short pap by a whistle) is sent across a medium. (a) Does the pulse have a definite (i) frequency, (ii) wavelength, (iii) speed of propagation? (b) if the pulse rate is 1 after every 20s, (that is the whistle is blown for a split of second after

every 20s), is the frequency of the note produced by the whistle equal to $\frac{1}{20}$ or 0.05Hx0.05Hx ?

10. What causes the rolling sound of thunder?

Very Short Answers-

1. Explosions on other planets are not heard on earth because there is no material medium between the earth and the planets over a long distance, and without a material medium for propagation, sound waves cannot travel.
2. Longitudinal waves are called pressure waves because the propagation of longitudinal waves through a medium consists of the variations in the volume and the pressure of the air, these variations in volume and air pressure result in the formation of compressions and rarefactions.
3. The tuning fork has two prongs because the two prongs of a tuning fork produce resonant vibrations that help to keep the vibrations going for longer.
4. Velocity of sound increases on a cloudy day, because the air is wet on a cloudy day, it contains a lot of moisture, the density of air is lower, and because velocity is inversely proportional to density, velocity increases.
5. The beat period is 0.2 second so that the beat frequency is $\mathrm{fb} = \frac{1}{0.2} = 5\mathrm{Hz}$ Therefore, the difference of frequencies of the two tuning forks is 5HZ.
6.

Phase difference, $\phi = 60^0 = \frac{\pi}{3}\text{rad}$

Now, in general for any phase difference, (Φ), the path difference (x)

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

Given $\phi = \frac{\pi}{3}, x = ?$

$$\frac{\pi}{3} = \frac{2\pi}{\pi} \times x$$

$$x = \frac{\pi}{3} + \frac{2\pi}{\pi}$$

$$x = \frac{\pi}{3} \times \frac{\pi}{2\pi}$$

$$x = \frac{\pi m}{6}$$

7.

Given data :

Speed of sound in the tissue, $v = 1.7 \text{ km/s} = 1.7 \times 10^3 \text{ m/s}$

Operating frequency of the scanner, $\text{v} = 4.2\text{MHz} = 4.2 \times 10^5 \text{ Hz}$

Now,
The wavelength of sound in the tissue is given as:

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

$$= \frac{1.7 \times 10^2}{4.2 \times 10^8} = 4.1 \times 10^{-4} \text{ m}$$

8.

(a) It is a stationary wave because the harmonic terms are present individually in the equation, the preceding equation indicates a stationary wave kxkx and ωtωt appear separately in the equation.

(b) There is no harmonic term in the provided equation. As a result, it doesn't represent either a moving or stationary wave.

(c) The harmonic terms in the preceding equation describe a moving wave and are in the combination of kx and ωt are in the combination of kx−ωt.

(d) The given equation represents a stationary wave because the harmonic terms kx and ωt appear separately in the equation. This equation actually represents the superposition of two stationary waves.

9. (a) No, the pulse doesn't have a definite .

   (ii) No, It doesn't have frequency.

   (iii) Yes, It have a wavelength.

(b) No, the frequency of the note produced by the whistle is not equal .

Explanation:

(a) There is no defined wavelength or frequency for the narrow sound pulse. However, the sound pulse's speed remains constant, i.e., it is equal to the speed of sound in that medium.

(b) The short pip produced after every 20 s does not mean that the frequency of the whistle is 120120 or 0.05H0.05H. It means that 0.06H0.06H s is the frequency of the repetition of the pip of the whistle.

10.The multiple reflections of the sound of lighting results in the rolling ' sound of thunder.

Short Questions-

1. Here are the equations of three waves:

   (a) y (x, t) = 2 sin (4x – 2t)

   (b) y (x, t) = sin (3x – 4t)

   (c) y (x, t) = 2 sin (3x – 3t).

   Rank the waves according to their (A) wave speed and (B) maximum transverse speed, greatest first.

2. Which physical quantity is represented by the ratio of the intensity of wave and energy density? Why?
3. When are the tones called harmonics?
4. What will be the effect on the frequency of the sonometer wire if the load stretching the sonometer wire is immersed in water?
5. An organ pipe is in resonance with a tuning fork. If the pressure of air in the pipe is increased by a factor of 139, then how should the length be changed for resonance?
6. Sound waves travel through longer distances during the night than during the day. Why?
7. Water is being continuously poured into a vessel. Can you estimate the height of the water level reached in the vessel simply by listening to the sound produced?
8. A sonometer wire resonates with a tuning fork. If the length of the wire between the bridges

is made twice even then it can resonate with the same fork. Why?

Short Answers-

1.

(A) b, c, a.

Standard wave equation is y (x, t) = A sin (ωt − kx)

∴ (a) $v_a = \frac{\omega}{k} = \frac{2}{4} = \frac{1}{2}$ unit = 0.5 unit.

(b) $v_b = \frac{\omega}{k} = \frac{4}{3}$unit = 1.33 unit.

(C) $V_c = \frac{\omega}{k} = \frac{3}{3}$ = 1 unit.

clearly $v_b > v_c > v_a$, so order is b, c, a.

(b) Transverse speed (vt) = $\frac{dy}{dt}$

∴ $|(v_t)_a| = 2 \times 2 = 4$

$|(v_t)_b| = 4$

$|(v_t)_c| = 2 \times 3 = 6$

∴ clearly (c), (a) and (b) tie.

2.

Velocity.

$$\text{We know that intensity} = \frac{\text{energy}}{\text{area} \times \text{time}}$$

and $$\text{energy density} = \frac{\text{energy}}{\text{volume}}$$

$$\therefore \quad \frac{\text{intensity}}{\text{energy density}} = \frac{\text{energy}}{\text{area} \times \text{time}} \div \frac{\text{energy}}{\text{volume}}$$

$$= \frac{\text{energy} \times \text{volume}}{\text{area} \times \text{time} \times \text{energy}}$$

$$= \frac{\text{area} \times \text{length}}{\text{area} \times \text{time}} = \frac{\text{length}}{\text{time}}$$

$$= \frac{\text{distance}}{\text{time}} = \text{velocity.}$$

3. The tones are called harmonics if the frequencies of the fundamental tone and other overtones produced by a source of sound are in the harmonic series.
4. Due to the upthrust due to buoyancy experienced by the load, the effective weight will decrease, so tension and hence frequency will decrease as $v \propto \sqrt{T}$
5. We know that the velocity of sound is independent of pressure, so there is no change in frequency and hence there is no need to change the length of the pipe.
6. Earth's atmosphere is warmer as compared to the surface of the earth at night. The temperature increases with altitude and thus the velocity of sound increases. It is a case of reflection from denser to rarer medium.
7. Yes, the frequency of the sound produced by an air column is inversely proportional to the length of the air column. As the level of water in the vessel rises, the length of the air column in the vessel decreases, so the frequency of sound increases, and hence shrillness of sound increases.
8. When the length of the wire is doubled, the fundamental frequency is halved and the wire vibrates in two segments so the sonometer wire will still resonate with the given tuning fork.
9. Sound waves require a material medium for their propagation.

   The apparent frequency is different whether the source moves towards the stationary observer or an observer moves towards the stationary source. Thus the Doppler's effect is said to be asymmetric. No such asymmetry occurs in light because apparent frequency remains the same in either the case whether the source or the listener moves.

Hence Doppler's effect is said to be symmetric in light.

10. It is due to Doppler's effect in the case of light waves. It is known that all stars are moving away from each other. So apparent frequency of light from a star as received by an observer on earth is less than the actual frequency. Since wavelength is inversely proportional to the frequency, the apparent wavelength of light from stars is more than the actual wavelength.

    In other words, due to the Doppler effect, the wavelength of light shifts towards a longer end i.e. towards red color and so it is called redshift.

Long Questions-

1. Derive expressions for apparent frequency when

(i) source is moving towards an observer at rest.

(ii) the observer is moving towards the source at rest.

(iii) both source and observer are in motion.

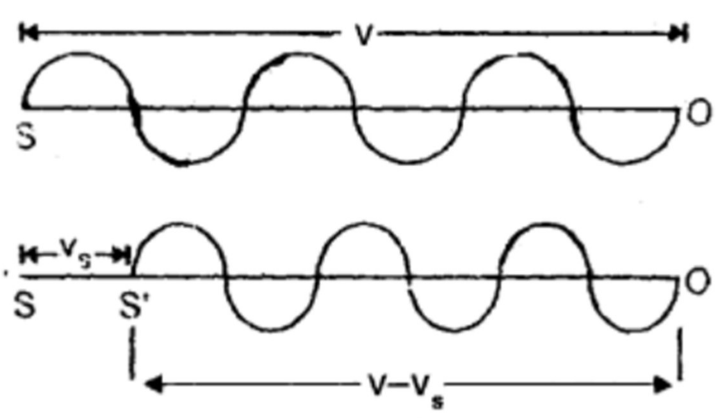
2. Give the analytical treatment of beats.
3. What conditions are necessary for the good acoustical properties of the building? How are they met?
4. The speed of sound in hydrogen is 1270 ms-1. What will be the speed in a mixture of oxygen and hydrogen mixed in a volume ratio of 1:4?
5.

Long Answers-

1. Let S and O be the positions of. source and observer respectively.

υ = frequency of sound waves emitted by the source.

v = velocity of sound waves.



Case (i) Source (S) in motion and observer at rest: When S is at rest, it will emit waves in one second and these will occupy a space of length v in one second.

If λ = wavelength of these waves, then

$$\lambda = \frac{v}{\upsilon} \ldots(i)$$

Let vs = velocity of a source moving towards O at rest and let S reaches to S' in one second. Thus the sound waves will be crowded in length ($v - v_s$). So if λ' be the new wavelength,

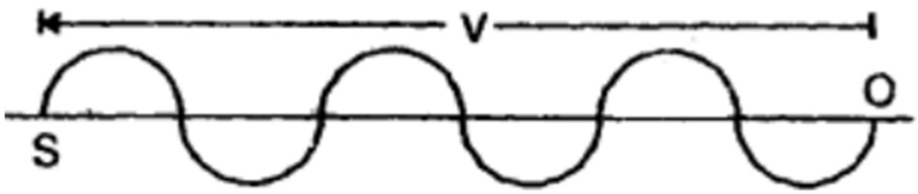
$$\text{Then } \lambda' = \frac{v - v_s}{\upsilon}$$

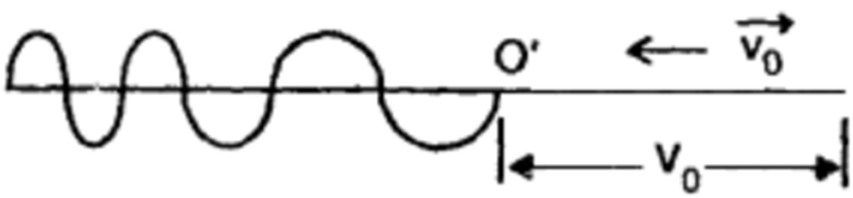
if υ' be the apparent frequency, then

$$\upsilon' = \frac{v}{\lambda'} = \frac{v}{v - v_s}\upsilon$$

∴ υ' > v i.e. when S moves towards O, the apparent frequency of sound waves is greater than the actual frequency.

(ii) If the observer moves towards the source at rest:





Let v_o = velocity of an observer moving towards S at rest.

As the observer moves towards S at rest, so the velocity of sound waves w.r.t. the observer is $v + v_o$.

If υ' = apparent frequency, then

$$\upsilon' = \frac{\mathbf{v} + \mathbf{v_0}}{\lambda} = \frac{\mathbf{v} + \mathbf{v_0}}{\mathbf{v}}\upsilon$$

clearly v' > υ.

(iii) If both S and O are moving

1. towards each other: We know that when S moves towards stationary observer,

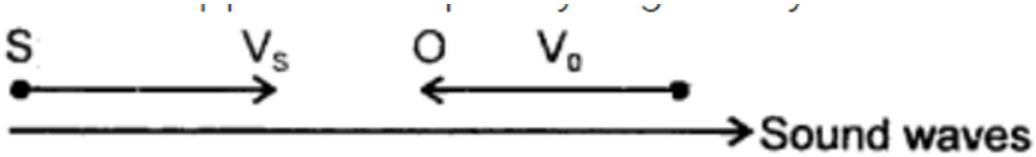
then $\upsilon' = \frac{v}{v - v_s}$

When O moves towards S, then

$$\upsilon'' = \left(\frac{v+v_0}{v}\right) \upsilon' = \left(\frac{v+v_0}{v-v_s}\right) \upsilon$$

(b) If both S and O move in the direction of sound waves:

Then the apparent frequency is given by



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

(c) When both S and O are moving away from each other:

When source moves away from O at rest, then apparent frequency is given by

$$\nu'' = \left(\frac{v-v_0}{v}\right) \nu'$$

$$= \frac{v-v_0}{v} \times \frac{v}{v+v_s} \nu$$

$$\nu'' = \left(\frac{v-v_0}{v+v_s}\right) \nu.$$

2.

Consider two simple harmonic progressive waves traveling simultaneously in the same direction and in the same medium. Let

A be the amplitude of each wave.

There is no initial phase difference between them.

Let v_1 and v_2 be their frequencies.

If y_1 and y_2 be displacements of the two waves, then

$y_1 = A \sin 2\pi v_1 t$ and

$y_2 = A \sin 2\pi v_2 t$

If y be the result and displacement at any instant, then

$y = y_1 + y_2$

$= A (\sin 2\pi v_1 t) + \sin (2\pi v_2 t)$

$$= A\left[2\sin\left(\frac{2\pi(v_1+v_2)t}{2}\right)\cos\left(\frac{2\pi(v_1-v_2)t}{2}\right)\right]$$

$$= 2A\cos\pi(v_1 - v_2)t \sin\pi(v_1 + v_2)t$$

$$= R \sin \pi (v_1 + v_2) t \quad .... (1)$$

where $R = 2A\cos \pi (v_1 - v_2) t \quad .... (2)$

is the amplitude of the resultant displacement and depends upon t. The following cases arise.

(a) If R is maximum, then

$\cos \pi (v1 - v2) t = \text{max.} = \pm 1 = \cos n\pi$

$\therefore \pi (v1 - v2) t = n\pi$

$$t = \frac{n}{v_1 - v_2} \quad ...(3)$$

where n = 0, 1, 2, ...

∴ Amplitude becomes maximum at times given by

$t = 0, \frac{1}{v_1-v_2}, \frac{2}{v_1-v_2}, \frac{3}{v_1-v_2} .....$

∴ Time interval between two consecutive maxima is

$$= \frac{1}{v_1 - v_2}$$

∴ Time interval between two consecutive maxima is

$$= \frac{1}{v_1 - v_2}$$

$\therefore$ Beat period = $\frac{1}{v_1 - v_2}$

$\therefore$ Beat frequency = $v_1 - v_2$

$\therefore$ no. of beasts formed per sec. = $v_1 - v_2$.

(b) If R is minimum, then

$$\cos \pi (v_1 - v_2) t = \text{min.} = 0 = \cos (2n + 1) \frac{\pi}{2}$$

$$\therefore \quad \pi (v_1 - v_2) t = (2n + 1) \frac{\pi}{2}$$

$$\text{or} \quad t = \frac{(2n+1)}{2(v_1 - v_2)}$$

$$\text{where} \quad n = 0, 1, 2, \ldots\ldots$$

$\therefore$ Amplitude becomes minimum at times given by

$$t = \frac{1}{2(v_1 - v_2)}, \frac{3}{2(v_1 - v_2)}, \frac{5}{2(v_1 - v_2)}, \ldots\ldots$$

$\therefore$ Time interval between two consecutive minima is $= \frac{1}{V_1 - V_2}$

$\therefore$ Beat period $= \frac{1}{V_1 - V_2}$

$\therefore$ Beat frequency = $v_1 - v_2$

$\therefore$ no. of beasts formed per sec. = $v_1 - v_2$.

Hence the number of beats formed per second is equal to the difference between the frequencies of two component waves.

3. An acoustically good building is one in which the sound is heard clearly in every nook and corner, some conditions must be fulfilled.

   These are:

   (a) the building should have proper reverberation time, the reverberation time is given by Sabine's formula which for a hall is

$$T = \frac{0.166\ V}{\sum \alpha A}$$

The reverberation time is adjusted by:

changing the volume (V): This can be changed little due to the size of the hall already fixed.

changing effective absorbing area: This can be done artificially by putting heavy curtains, paintings, providing open windows, wall coverings, etc.

providing sufficiently energetic sound: The sound should be sufficiently loud and intelligible at every point.

eliminating echo: Except for the desired one, echoes must be eliminated.

properly focussing the sound: The sound has to be properly focussed to avoid the source of silence and also unreliable focussing.

avoiding unique reinforcement: No single overtone should uniquely be reinforced then the total quality of the note will be affected.

avoiding extra noise: Extra noises including resonance within the building has to be avoided.

eliminating smooth curved surfaces: Smooth surfaces reflect sound sharply which may cause several problems.

To achieve these goals following steps need to be taken:

(a) Properly design the building to optimize its acoustic condition.

(b) Decorate selectively the building with paintings, floral designs, perforations.

(c) Use false perforated or cardboard ceilings, and perforated structures at the curved walls.

(d) Use carpets, upholster seats with holes in the bottom.

(e) Use carpets or mats etc. on floors.

(f) Heavy curtains, wall hangings, etc. should be used.

(g) Properly place the mike and loud-speakers in the hall.

(h) Avoid sharp corners in the hall and make the stage back parabolic with mike at its focus.

Assertion Reason Questions:

1. **Directions:**

    (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.

Assertion: Two persons on the surface of moon cannot talk to each other.
Reason: There is no atmosphere on moon.

2. **Directions:**

(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.

Assertion: Ocean waves hitting a beach are always found to be nearly normal to the shore.
Reason: Ocean waves are longitudinal waves.

Assertion Reason Answer:

1. (a) If both assertion and reason are true and the reason is the correct explanation of the assertion.

Explanation:

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. (c) If assertion is true but reason is false.

Explanation:

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.

Case Study Questions-

1. When we speak, the sound moves outward from us, without any flow of air from one part of the medium to another. The disturbances produced in air are much less obvious and only our ears or a microphone can detect them. These patterns, which move without the actual physical transfer or flow of matter as a whole, are called waves. The most familiar type of waves such as waves on a string, water waves, sound waves, seismic waves, etc. is the so-called mechanical waves. These waves require a medium for propagation, they cannot propagate through vacuum. They involve oscillations of constituent particles and depend on the elastic properties of the medium. The electromagnetic waves that you will learn in Class XII are a different type of wave. Electromagnetic waves do not necessarily require a medium – they can travel through vacuum. Light, radio waves, X-rays, are all electromagnetic waves. We have seen that motion of mechanical waves involves oscillations of constituents of the medium. If the constituents of the medium oscillate perpendicular to the direction of wave propagation, we call the wave a transverse wave. If they oscillate along the direction of wave propagation, we call the wave a longitudinal wave. In transverse waves, the particle motion is normal to the direction of propagation of the wave. Therefore, as the wave propagates, each element of the medium undergoes a shearing strain. Transverse waves can, therefore, be propagated only in those media, which can sustain shearing stress, such as solids and not in fluids. Fluids, as well as,

solids can sustain compressive strain; therefore, longitudinal waves can be propagated in all elastic media.

For example, in medium like steel, both transverse and longitudinal waves can propagate, while air can sustain only longitudinal waves. Answer the following.

i. Air can sustain
   a. Transverse waves
   b. longitudinal waves
   c. both a and b
   d. none of these
ii. The electromagnetic waves can pass through
   a. Solids only
   b. Fluids only
   c. Any medium even through vacuum
   d. None of these
iii. Define Transverse waves
iv. Define longitudinal waves
iv. Differentiate between Transverse waves and longitudinal waves

2. What happens if a pulse or a wave meets a boundary? If the boundary is rigid, pulse travelling along a stretched string and being reflected by the boundary. Assuming there is no absorption of energy by the boundary, the reflected wave has the same shape as the incident pulse i.e. crest is reflected as crest and trough as trough but it suffers a phase change of π or 180^0 on reflection. This is because the boundary is rigid and the disturbance must have zero displacement at all times at the boundary. By the principle of superposition, this is possible only if the reflected and incident waves differ by a phase of π, so that the resultant displacement is zero. This reasoning is based on boundary condition on a rigid wall. If on the other hand, the boundary point is not rigid but completely free to move (such as in the case of a string tied to a freely moving ring on a rod), the reflected pulse has the same phase and amplitude (assuming no energy dissipation) as the incident pulse. The net maximum displacement at the boundary is then twice the amplitude of each pulse. An example of non- rigid boundary is the open end of an organ pipe. To summaries, a travelling wave or pulse suffers a phase change of π on reflection at a rigid boundary and no phase change on reflection at an open boundary. We considered above reflection at one boundary. But there are familiar situations (a string fixed at either end or an air column in a pipe with either end closed) in which reflection takes place at two or more boundaries. In a string, for example, a wave travelling in one direction will get reflected at one end, which in turn will travel and get reflected from the other end. This will go

on until there is a steady wave pattern set up on the string. Such wave patterns are called standing waves or stationary waves.

i. A travelling wave or pulse suffers a phase change of π on reflection at
   a. a rigid boundary
   b. open boundary
ii. The electromagnetic waves can pass through
   a. a rigid boundary
   b. open boundary
iii. What are stationary waves?
iv. Write a note on reflection of travelling wave from rigid boundary.
v. Write a note on reflection of travelling wave from open boundary.

Case Study Answer-

1. Answer
   i. (b) longitudinal waves
   ii. (c) Any medium even through vacuum
   iii. If the constituents of the medium oscillate perpendicular to the direction of wave propagation, wave is called as transverse wave.
   iv. If oscillations of constituents of the medium are along the direction of wave propagation that is parallel to direction of propagation we call the wave a longitudinal wave.
   v. Following are differentiation points

Sr No.	Transverse waves	longitudinal waves
1	If the constituents of the medium oscillate perpendicular to the direction of wave propagation, wave is called as transverse wave	If oscillations of constituents of the medium are along the direction of wave propagation that is parallel to direction of propagation we call the wave a longitudinal wave.
2	Can passs trough solids only	Can pass through both solids and fluids

3	Example electromagnetic waves	Example sound wave

2. Answer
    i. (a) a rigid boundary
    ii. (b) open boundary
    iii. A wave travelling in one direction will get reflected at one end, which in turn will travel and get reflected from the other end. This will go on until there is a steady wave pattern set up on the string. This wave remains steady in medium and does not travel further such wave patterns are called standing waves or stationary waves.
    iv. If the boundary is rigid, a pulse travelling along a stretched string and being reflected by the boundary. The reflected wave has the same shape as the incident pulse i.e. crest is reflected as crest and trough as trough but it suffers a phase change of π or 180^0 on reflection. This is because the boundary is rigid and the disturbance must have zero displacement at all times at the boundary. By the principle of superposition, this is possible only if the reflected and incident waves differ by a phase of π, so that the resultant displacement is zero. This reasoning is based on boundary condition on a rigid wall.
    v. If the boundary point is not rigid but completely free to move the reflected pulse has the same phase and amplitude (assuming no energy dissipation) as the incident pulse. The net maximum displacement at the boundary is then twice the amplitude of each pulse. An example of non- rigid boundary is the open end of an organ pipe