CBSE Test Paper 05

Chapter 15 Waves

1. The speed of sound in air is 333 m/s. The fundamental frequency of the open pipe is 333 Hz. The second overtone of the open organ pipe can be produced with a pipe of length **1**
   a. 1.0 m
   b. 2.0 m
   c. 0.5 m
   d. 1.5 m
2. There are three sources of sound of equal intensities with frequencies 400, 401 and 402 Hz. The number of beats per seconds is **1**
   a. 2
   b. 0
   c. 1
   d. 3
3. Two waves represented by Y_1 = a_1 sin wt and Y_2 = a_2 cos wt are superimposed at a point at a particular instant. The amplitude of resultant wave is **1**
   a. $a_1 + a_2$
   b. $\sqrt{a_1^2 - a_2^2}$
   c. $\sqrt{a_1^2 + a_2^2}$
   d. $a_1 - a_2$
4. A string when stretched with a weight of 9 kg. weight produces a note of frequency 256 Hz. The weight required to produce an octave of the note is **1**
   a. 4 kg wt.
   b. 36 kg wt.
   c. 18 kg wt.
   d. 9/4 kg wt.
5. If y(x, t) = a sin (kx + ωt + φ) represents a wave function then ‘a’ is **1**
   a. the period
   b. the frequency
   c. the amplitude

d. the phase

6. Why do the stages of large auditoriums give curved backs? **1**

7. At what temperature will the speed of sound be double its value at 273’ K? **1**

8. What is the nature of water waves produced by a motorboat sailing in water? **1**

9. An aluminium rod of length 90 cm and of mass 'm' is clamped at its mid-point and is set into longitudinal vibrations by stroking it with resined cloth. Assume that the rod vibrates in its fundamental mode of vibration. The density of aluminium is 2.6 g/cm^3 and its Young's modulus is 7.80×10^{10} N/m^2. Find the speed of the sound in aluminium. If the wavelength is 180 m then, find frequency of vibration. **2**

10. Equation of a plane progressive wave is given by y =0.6sin$2\pi\left(t-\frac{x}{2}\right)$. On reflection from a denser medium, its amplitude becomes 2/3 of the amplitude of incident wave. What will be the equation of reflected wave? **2**

11. What do you mean by node and antinodes in stationary waves? What is the separation between them in terms of wavelength? **2**

12. What do you mean by wave motion? Discuss its four important characteristics. **3**

13. Two similar sonometer wires of the same material produce 2 beats per second. The length of one is 50cm and that of the other is 50.1cm. Calculate the frequencies of two wires? **3**

14. A wave travelling along a string is described by y(x,t) = 0.005sin(80.0x -3.0t) in which the numerical constants are in SI units (0.005 m, 80.0 rad m^{-1} and 3.0 rad s^{-1}). Calculate **3**

    i. the amplitude of particle,
    ii. the wavelength and
    iii. the period and frequency of the wave. Also, calculate displacement y of the particle at a distance x = 30.0 cm and time t = 20s?

15. Explain why (or how): **5**

a. In a sound wave, a displacement node is a pressure antinode and vice versa,
b. Bats can ascertain distances, directions, nature, and sizes of the obstacles without any "eyes",
c. A violin note and sitar note may have the same frequency, yet we can distinguish between the two notes,
d. Solids can support both longitudinal and transverse waves, but only longitudinal waves can propagate in gases,
e. The shape of a pulse gets distorted during propagation in a dispersive medium.

Answer

1. d. 1.5 m
   Explanation: using $f_n = \frac{nv}{2L}$
   $L = \frac{3\times333}{2\times333}$
   L = 1.5 m for 2nd overtone n=3

2. c. 1
   Explanation: Beat frequency formula for calculating the beat between two overlapping sound waves is f_b = f_1-f_2 (f_1& f_2 are two incident sound waves).

   $f1$= 402 - 401 = 1 Hz

   $f2$ = 402 - 400 = 2 Hz

   F_b = 2 - 1 = 1 Hz

3. c. $\sqrt{a_1^2 + a_2^2}$
   Explanation: Resultant amplitude is given by
   $A^2 = a^2{}_1 + a^2{}_2 + 2a_1a_2\cos\triangle$
   where $\triangle$ is phase difference between two waves.
   $here\ \triangle = \frac{\pi}{2}$
   thus $A^2 = a^2{}_1 + a^2{}_2$

4. b. 36 kg wt.
   Explanation: Here octave means double of frequency thus According to the law of tension
   $f\alpha\sqrt{T}$
   $\frac{f_1}{f_2} = \frac{\sqrt{T_1}}{\sqrt{T_2}}$
   $\frac{256}{2\times256} = \frac{\sqrt{9\times9.8}}{\sqrt{m_2\times9.8}}$
   m_2 = 36 kg

   Or the tension will be T = 36 kg wt

5. c. the amplitude

Explanation: In the equation

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

the term before trignometric function is called amplitude

Hence a (term before trignometric function) is the amplitude.

6. The stages of large auditorium have curved backs because when speaker stands at or near the focus of curved surface his voice is rendered parallel after reflection from the concave or parabolic seer face. Hence the voice can be heard at larger distances.

7. Say v_1 is the velocity of sound at $T_1 = 273^0$k and $v_2 = 2v_1$ at temperature T_2

Now $\frac{v_2}{v_1} = \sqrt{\frac{T_2}{T_1}}$

$\therefore \frac{2v_1}{v_1} = \sqrt{\frac{T_2}{273}}$

Or $T_2 = 4 \times 273 = 1092°K$

8. Water waves produced by a motorboat sailing in water are both longitudinal and transverse.

9. Given, Young's modulus of aluminium, $Y = 7.80 \times 10^{10}$ N/m^2

Given, density of aluminium, $\rho = 2.6$ g/cm$^3 = \frac{26\times(100)^3}{1000}\mathrm{kg/m^3}$

$\Rightarrow \rho = 2600$ kg/m^3

Wavelength, $\lambda = 180$ m

Speed of the sound in aluminium, v = $\sqrt{\frac{Y}{\rho}}$

$= \sqrt{\frac{7.80\times10^{10}\mathrm{N/m^2}}{2600\mathrm{kg/m^3}}}$

$\Rightarrow$ v = 5477 m/s

As, $\lambda = \frac{\nu}{v} \Rightarrow \nu = \frac{v}{\lambda} = \frac{5477\mathrm{m/s}}{180\mathrm{m}}$ = 30.42 Hz, ν being frequency.

Hence frequency of vibration is 30.42 Hz.

Sound has generally higher speeds in solids and liquids than in gases.

10. On reflection from the denser medium, there will be a phase change of 180° i.e. of π.

Net amplitude $= \frac{2}{3} \times 0.6$ = 0.4 unit

Hence, equation of reflected wave will be y = 0.4 sin $2\pi\left[t+\frac{x}{2}+\pi\right]$ [changing upon the direction of the movement of the wave, 'x/2' also becomes opposite in nature]

= - 0.4 sin 2π(t + $\frac{x}{2}$) [since sin(π+θ) = - sin θ]

11. In a stationary wave at 'node' points, the displacement is permanently zero. However, at 'antinode' points displacement amplitude is maximum. In a stationary wave, nodes and antinodes are alternate and are equally spaced. Distance between two consecutive nodes and between two consecutive antinodes is $\frac{\lambda}{2}$. Consequently, the distance between a node and neighbouring antinode is $\frac{\lambda}{4}$.

12. Wave motion is a form of disturbance which travels through a medium due to repeated periodic motion of the particles of the medium about their mean positions.. Four important characteristics of wave motion are:

    i. Wave motion is a form of disturbance which travels through a medium due to the vibrations of the particles of the medium.
    ii. It is the disturbance which travels in the forward direction and not the particles. The particles simply vibrate about their mean position.
    iii. The energy of a particle is wholly kinetic at the mean position and wholly potential at the extreme position.
    iv. The motion of each particle begins a little later than that of its predecessor. In other words, there is always a constant phase difference between any two neighbouring particles. The wave always advances in that direction in which it meets particles with decreasing phase.

13. The frequency (f) of a sonometer wire of length = l, mass = m and Tension = T is given by

$\Rightarrow f=\frac{1}{2l}\sqrt{\frac{T}{m}}$

Let $k=\frac{1}{2}\sqrt{\frac{T}{m}}$

So, $f=\frac{k}{l}$

In first case;

$\Rightarrow f_1=\frac{k}{l_1}\rightarrow(1)$

In second case;

$\Rightarrow f_2=\frac{k}{l_2}\rightarrow(2)$

Subtract equation (1) & (2)

$\Rightarrow \mathrm{f}_1 - \mathrm{f}_2 = \frac{k}{l_1} - \frac{k}{l_2} = k\left(\frac{1}{l_1} - \frac{1}{l_2}\right)$

Now, given l_1 = 50cm; l_2 = 50.1 cm

$\Rightarrow f_1 - f_2 = 2$

So, $2 = k\left[\frac{1}{50} - \frac{1}{50.1}\right]$

$\Rightarrow 2 = k\left[\frac{50.1-50}{50\times50.1}\right]$

$2 = K\left[\frac{0.1}{2505.0}\right]$

$\Rightarrow \frac{2\times2505}{0.1} = k$

$\Rightarrow \frac{5010\times10}{01.1} = k$

$\Rightarrow$ 50100 = k

So, $f_1 = \frac{k}{l_1} = \frac{50100}{50} = 1002\ Hz$

$\Rightarrow f_2 = \frac{k}{l_2} = \frac{50100\ \times\ 10}{50} = 10020\ Hz$

14. Given, y(x,t) =0.005 sin(80.0x-3.0t) m .....(i)

We know the general form of the equation of an SHM as, y(x,t) = asin(kx - ωt) .....(ii)

Now, comparing the given equation (i) with the general equation (ii) we get,

a = 0.005 m (amplitude)

k = 80.0 rad/m (awave number)

ω = 3.0 rad/s (angular frequency)

The physical quantities by using the given fundamental physical quantities.

i. Amplitude, a = 0.005 m = 5 mm
ii. Wavelength, $\lambda = \frac{2\pi}{k} = \frac{2\pi}{80}$ = 7.85 cm
iii. Time period, T = $2\pi/\omega = \frac{2\pi}{3}$ =2.09 s

and frequency , v $= \frac{1}{T} = \frac{1}{2.09}$

= 0.478 $\simeq$ 0.48Hz

Now, the displacement y of the particle at a distance.

x = 30.0 cm = 0.3 m and time t = 20 s

y(0.3, 20) = 0.005 sin (80 $\times$ 0.3 - 3.0 $\times$ 20)

y (0.3, 20) = 0.005 sin (24 - 60)

= 0.00495 m $\simeq$ 5 mm

15. a. A node is a point where the amplitude of vibration is minimum and pressure is

maximum. On the other hand, an antinode is a point where the amplitude of vibration is maximum and pressure is minimum. Therefore, a displacement node is simply a pressure antinode and vice versa.

b. Bats emit very high-frequency ultrasonic sound waves. These waves get reflected back towards them by obstacles. As a result, a bat receives a reflected wave (frequency) and estimates the distance, direction, nature, and size of the obstacle with the help of its brain senses.

c. The strengths of overtones produced by a sitar and a guitar are different. Hence, one can distinguish between the notes produced by a sitar and a violin even if they have the same frequency of vibration.

d. Solids have shear modulus. They can sustain shearing stress but not the fluids. The propagation of a transverse wave is such that it produces shearing stress in a medium. The propagation of such a wave is possible only in solids, and not in gases.

   Both solids and fluids have their respective bulk moduli. They can sustain compressive stress. Hence, longitudinal waves can propagate through solids and fluids.

e. A sound pulse is a combination of waves of different wavelengths. As waves of different wavelengths travel in a dispersive medium with different velocities, therefore, the shape of the pulse gets distorted.