WAVES

Que.1. The equation for a wave is given below. **[Marks :(5)]**

y=A sin (kx+ωt)

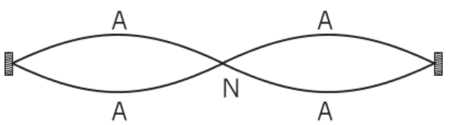
a) Is it a travelling or stationary wave?

b) Draw the stationary waves in a stretched string in the second harmonic

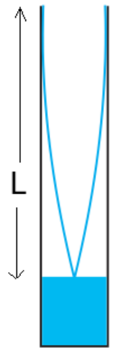
c) Show that the fundamental frequency of an open pipe is twice the fundamental frequency of a closed pipe of the same length.

Ans. a)Travelling wave

b)



c)Fundamental mode of vibration in a closed pipe is shown below:

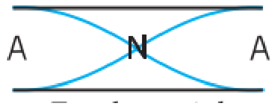


$L=\lambda/4$

Therefore, $\lambda=4L$

Fundamental frequency $\nu_{closed}=V/\lambda=V/4L$

Fundamental mode of vibration in an open pipe of the same length L is shown below:



$L=\lambda/2$

$\lambda=2L$

Fundamental frequency $\nu_{open}=V/\lambda=V/2L$

$\nu_{open}=2x\ (V/4L)$

= **2x v_{closed}**

Que.2. While conducting a Resonance Column experiment in the laboratory, you can hear the maximum sound at a certain height. [Marks :(6)]

a. Explain the phenomenon of sound.

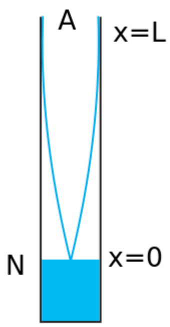
b. Show that in a closed pipe at one end, the frequencies of the first two harmonics are in the ratio v1 :v2:v3 = 1:3:5

c. Open pipes are preferred to closed ones in musical instruments. Why?

Ans. a)If a wave is produced at the open end of the tube, it travels through the gas column and gets reflected at the closed end. At a certain height of tube, the incident wave and the reflected wave superimpose each other and produce stationary wave and a sound is heard. This is called Resonance. The open end always represent an anti-node.

b)

First normal mode of vibration:



Let l_1 be the length of the standing wave set up in the pipe corresponding to n=1

$L=\lambda_1/4$

Therefore, $\lambda_1=4L$

Fundamental frequency $v_1=V/\ \lambda_1=V/4L$-----------------(1)

Second normal mode of vibration, (1^{st} overtone and 3^{rd} harmonic)

Let λ_2 be the wavelength of the standing wave set up in the pipe corresponding to n=2

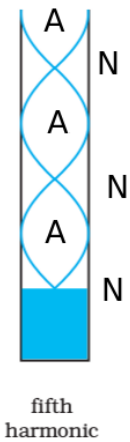
$L=3\lambda_2/4$

$\lambda_2=4L/3$

Frequency of second mode= $v_2=V/\lambda_2=3V/4L$

But, $V/4L= v_1$

Therefore, $v_2=3 v_1$



Third normal mode of vibration (Fifth harmonic and second overtone)

Let λ_3 be the length of the standing wave set up in the pipe corresponding to n=3

$L=5\lambda_3/4$

$\lambda_3=4L/5$

Frequency $v_3=V/\lambda_3=5V/4L$

Since, $V/4L= v_1$

$\lambda_3=5v_1$

The ratio of the first, second and third mode.

$v_1 : v_2 : v_3 = 1:3:5$

c) In open pipe, all harmonics are present. In closed pipe only odd harmonics are present. So open pipe is preferred musical instruments

Que.3. Nobody can imagine a world without sound. Sound is a part of our life- Musics, ripples , echoes, etc.have a lot of applications. [Marks :(6)]

a)Can you say how a bat can ascertain directions and distances without any eyes?

b) Doctors use an ultrasonic scanner to diagnose scanner to diagnose tumour tissues. If the frequency of the scannner is 4.2 MHz and the speed of sound wave in the tissue is1.7 kms-1, find the wavelength of the sound wave.

c) Obtain the equation of a standing wave. Then plot it to locate the nodal and anti-nodal points.

Ans. a) Bats produce ultrasonic waves which reflect from the obstacle and is properly sensed.

b) v=vλ=velocity of sound

1.7x103=4.2x106x λ

Therefore, λ=1.7x103 / 4.2x106

= 4x10-4m

c) A standing wave or stationary wave is the superposition of a forward progressive wave and its reflected wave.

Equation of forward wave in the positive x direction,

$$y_1 = a\sin(\omega t - \frac{2\pi}{\lambda}x)$$

equation of reflected wave,

$y_2 = -a\sin(\omega t - \frac{2\pi}{\lambda}x)$ (-ve sign for phase change of π)

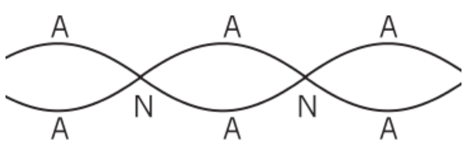
By the principle of Superposition, y=y1+y2

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

= $-2a\cos\omega t \sin\frac{2\pi}{\lambda}x$

Here, $2a\sin\frac{2\pi}{\lambda}x$ is the amplitude of the standing wave

Plot of standing wave



Que.4. In laboratory Raju uses a turning fork in resonance column experiment.

a) What type of wave is produced by the turning fork in this case ? [Marks :(3)]

b) Mention four characteristics of these wave.

Ans. a) Longitudinal wavelength

b) i) medium is necessary for the propagation of wave.

ii) wave propagates in the form of compressions and rarefactions.

Iii) vibration of the particle in the medium are parallel to the direction of propagation of the wave.

iv) Distance between two consecutive compression or rarefaction is equal to wavelength.

Que.5. A sonometer wire of lenght 30 cm vibrates in the second overtone. [Marks :(4)]

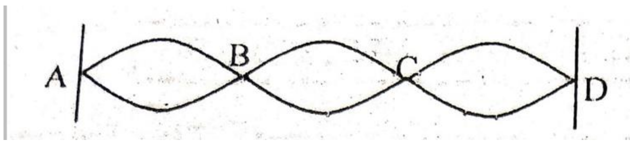
(i). Represent it pictorially

(ii). What is the wavelength.?

(iii). How many nodes are there ?

(iv). What is the phase difference between two points 20 cm apart.

Ans.

i) 

ii) Each loop is of the wavelength λ/2.

Therefore total length = 3 x. λ/2. = 30

or λ/2.= 10

or λ = 0.2 m.

iii) four nodes .

iv) As the wavelength is 0.2 m , there is no phase difference between two points 0.2 m apart,. i.e., the two points are in the same phase.

Que.6. A boy plucks at the centre of a stretched string of length 1m and observes a wave pattern. [Marks :(3)]

a. Which type of wave is produced on the string? (1)

b. What are nodes and antinodes? (1)

c. The distance between consecutive nodes is ________ (1)

(i) λ (ii) λ/2 (iii) 2λ (iv) λ/4d.

Ans. a) Standing wave or stationary wave.

b) The point of the string having zero displacement are called nodes (N) and having maximum displacement are called antinodes (A).

c) Distance between two successive nodes or antinodes is equal to half the wavelength. (λ/2)

Que.7. The air column inside the pipe can vibrate in different modes. Schematically represent the first three modes of vibration of air column in a pipe closed at one end and Show that the frequencies of the first 3 harmonics are in the ratio [Marks :(4)]

1 : 3 : 5 : ......

Ans. The air column inside the pipe can vibrate in different modes. Always a node is formed at the closed end and an antinode at the open end.

Fundamental mode or first harmonics :

Here, there is one node at the closed end and an antinode at the open end.

$L = \lambda_1 /4$ or $\lambda_1 = 4L$

$v_1 = V/\lambda_1 = V/4L$

$v_1 = V/4L$

Second mode or second harmonics or first overtones:

Here, there is one node an antinode in between the open end and the closed end.

$L = 3\lambda_2 / 4$ or $\lambda_2 = 4L/3$

$v_2 = V/\lambda_2 = 3 \{V/4L\}$

$v_2 = 3 v_1$

Third mode or second overtone :

Here , there are two node and two antinode in between the open end and the closed end.

$L = 5\lambda_3 / 4$ or $\lambda_3 = 4L/5$

$v_3 = V/\lambda_3 = 5 \{V/4L\}$

$v_3 = 5 v_1$

Frequency of all modes are odd multiple of fundamental frequency.

$v_1 : v_2 : v_3 : ...... = 1 : 3 : 5 : ....$

Que.8. The air column inside the pipe can vibrate in different modes. Schematically

represent the first three modes of vibration of air column in a pipe closed at

one end and Show that the frequencies of the first 3 harmonics are in the ratio 1 : 3 : 5 : ...... [Marks :(4)]

Ans. The air column inside the pipe can vibrate in different modes.Always a node is firmed at the closed end and an antinode at the open end.

Fundamental mode or first harmonics :

Here, there is one node at the closed end and an antinode at the open end.

$L = \lambda_1 /4$ or $\lambda_1 = 4L$

$v_1 = V/\lambda_1 = V/4L$

$v_1 = V/4L$

Second mode or second harmonics or first overtones:

Here, there is one node an antinode in between the open end and the closed end.

$L = 3\lambda_2 / 4$ or $\lambda_2 = 4L/3$

$v_2 = V/ \lambda_2 = 3 \{V/4L\}$

$v_2 = 3\, v_1$

Third mode or second overtone :

Here , there are two node and two antinode in between the open end and the closed end.

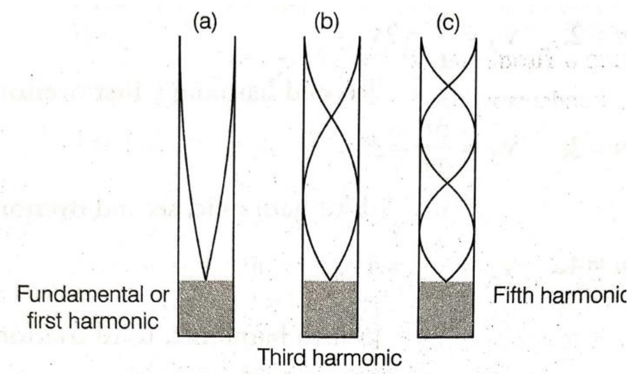
$L = 5\lambda_3 / 4$ or $\lambda_3 = 4L/5$

$v_3 = V/ \lambda_3 = 5 \{V/4L\}$

$v_3 = 5\, v_1$

Frequency of all modes are odd multiple of fundamental frequency.

$v_1 : v_2 : v_3 : .... = 1 : 3 : 5 : ....$



Que.9. Which of the following is not a wave characteristic: [Marks :(1)]

Reflection, refraction , diffraction , polarisation , interference, rectilinear propagation

Ans. rectilinear propagation.

Que.10. Write two examples for transverse wave and longitudinal wave ? [Marks :(2)]

Ans. Transverse waves : 1. waves in a stretched string.

2. waves on the surface of a liquid.

Longitudinal waves : 1. wave along a spring.

2. sound wave.

Que.11. A wave motion is a propagation of energy through a material medium due to repeated periodic motions. [Marks :(4)]

i) Distinguish between longitudinal wave and transverse wave.

ii) Mention the type of wave produced in the following cases.

a) waves on the surface of water

b) waves inside the water.

c) waves through solids.

d) waves on the surface of a solid.

e) waves through gases.

Ans. (i)

Sl.No	Transverse waves	Longitudinal waves
1.	Particles of the medium vibrate in a direction perpendicular to the direction of propagation of wave.	Particles of the medium vibrate parallel to the direction of propagation of wave.
2	The medium gets divided into crests and troughs when the wave is propagated through it.	The medium gets divided into compressions and rarefactions when the wave is propagated through it.
3.	It can be polarised	It cannot be polarised
4.	It can propagate only in solids and on the surface of the liquid	It can propagate in all types of media.

ii) a) transverse wave b) longitudinal waves c) longitudinal waves

d) transverse wave e) longitudinal waves

Que.12. a) Explain Doppler effect in sound. Write two application of it? [Marks :(4)]

b) What happens to the apparent frequency of sound produced by the whistle of

a train in the following cases ?

i) when the train approaches the stationary listener.

ii) When the train moves away from stationary listener.

Ans. a) Apparent change in the freequency of sound due to the relative motion between the source of sound and the listner is called Doppler effect .

Applications

i) It is used at airport to guide aircraft and in military to detect enemy aircraft.

ii) Doctors are using it to study heart beats and blood flow (sonograpohy)

b) i) increases ii) de creases.

Que.13. a) What do you mean by reverberation ? What is reverberation time ? [Marks :(4)]

b) Thick and long curtains are preferred in a big hall. Why ?

Ans. a) The phenomenon of persistence or prolongation of sound after the source has stopped emitting sound is called reverberation.

The time for which the sound persists until it becomes inaudible is called the reverberation time.

b) A big hall has large reverberation time due to which different syllables are not heard distinctly. By using thick and long curtains which has large absorption coefficient, reverberation time can be suitably decreased.

Que.14. Two tuning forks of frequencies 256 Hz and 258 Hz are sounded together

a) Explain the phenomenon experienced ? (1) **[Marks :(3)]**

b) What is the time interval between two consecutive minimum intensity of the sound ? (1)

c) Can you observe the phenomenon if the two tuning forks have the same frequency? (1)

Ans. a) Beats. The periodic variations in the intensity of sound caused by the superposition of two sound waves of slightly different frequencies are called beats .

b) The beat frequency will be 258 - 256 = 2. One maximum and one minimum together constitute one beat. As there are two beats in one second. The time interval between two minima will be 0.5 second.

Similarly the time interval between two consecutive maximum is 0.5 second

(c) No , beats produced only forks having slight different freequencies.

Que.15. Explain Why **[Marks :(3)]**

a) Open pipes are preferred for musical instruments than closed

pipes.

b) A turning dork is in resonance with a closed pipe. But the

same turning fork cannot be in resonance with an open pipe of same

length.

Ans. a) The node produced by open pipe consists of both odd and even harmonics but the node produced by closed pipe consists of only the odd harmonics.

b) For closed pipe ,

frequency $v = V/4L$

For open pipe,

frequency, $v_c = V/2L$, Hence it cannot be in resonance with the tuning fork of frequency $v = V/4L$

Que.16. Show that the fundamental frequency of an open pipe is twice that of a closed pipe of the same length. **[Marks :(2)]**

Ans. Fundamental frequency of an open pipe is

$v_o = V/2L$

Fundamental frequency of a closed pipe is

$v_c = V/4L$

$v_o / v_c = 2$

$v_o = 2\ v_c$

Que.17. If a wave propagates through a medium **[Marks :(1)]**

a) particles of the medium move to different places

b) particles of the medium are at rest.

c) particles of the medium vibrate about their mean position .

d) all the above are true.

Ans. c) particles of the medium vibrate about their mean position

Que.18. What is a non-dispersive medium? Give an example. **[Marks :(2)]**

Ans. A medium in which speed of Wave is independent of its frequency is called a non-dispersive medium.

Example: air is a non-dispersive medium for sound wave.

Que.19. Can mechanical wave propagate through vacuum ? **[Marks :(1)]**

Ans. No. For propagation of mechanical wave an elastic continuous medium is required.

Que.20. a) The nodes produced by an open organ pipe is sweeter than that produced by the closed organ pipe. Why? **[Marks :(4)]**

b) In which cases, the fundamental frequency is higher

i) a pipe opened at both ends and

ii) a pipe closed at one end.

Ans. a) The node produced by open organ pipe consists of both odd and even harmonics but the note produced by closed organ pipe consists of only the odd harmonics. Due to the presence of higher number of overtones or harmonics , the node produced by the open organ pipe is sweeter.

b) For first case $v_1 = V/2L$

For second case $v_2 = V/4L = (1/2)\ V/2L = v_1/2$

The fundamental frequency is higher in a pipe opened at both ends.

Que.21. a) Sound produced by an open pipe contains **[Marks :(3)]**

(i) Fundamental component only **(ii) Odd harmonics only**

(iii) All the harmonics **(iv) Even harmonics only**

b) A flute consists of several holes. Why?

Ans. a) iii) all harmonics

b) The flute is basically an open organ pipe. The length of the air column inside it can be changed by keeping the one hole open and closing other holes. Thus frequency of the note produced by the flute can be changed.

Que.22. A flute is an example of an open pipe, in which standing wave pattern can be produced. [Marks :(4)]

a) How standing waves are produced?

b) Show that an open pipe the frequencies of the first 3 harmonics are in the ratio 1 : 2 : 3.

Ans. a) Air in pipe at its open end is made to vibrate longitudinal wave is produced. The longitudinal wave travel through the air column and reflected from the other end. Due to superposition of incident and reflected waves , stationary waves are formed in pipe.

b) The air column inside the pipe can vibrate in different modes

Fundamental mode or first harmonics(v_1):

Here, there is one node in between the ends of the tube and anti nodes are always formed at the open ends.

L - Length of the tube.   V - Speedof sound in air.

$L = \lambda_1 /2$ or $\lambda_1 = 2 L$

$v_1 = V/ \lambda_1 = V/2L$

$v_1 = V/2L$

Second mode or second harmonics or first overtones(v_2): Here, there are two nodes and one antinode in between the ends.

$L = 2\lambda_2 / 2$ or $\lambda_2 = L$

$v_2 = V/ \lambda_2 = 2 \{V/2L\}$

$v_2 = 2 v_1$

Third mode or second overtone(v_3) :

Here , there three nodes and two antinodes in between the free ends.

$L = 3\lambda_3 / 2$ or $\lambda_3 = 2L/3$

$v_3 = V/ \lambda_3 = 3 \{V/2L\}$

$v_3 = 3 v_1$

Frequency of all modes are integral multiple of fundamental frequency.

$v_1 : v_2 : v_3 = 1 : 2 : 3$

Que.23. Two resonance tube with air columns 100cm and 101 cm long gives 17 beats in 20 seconds, when each is sounding its fundamental mode. Calculate the velocity of sound. [Marks :(2)]

Ans. Here, Li =100cm = 1m and L2 = 1.01 m

Beat frequency = $v_1 - v_2$

$17/20 = [V/4L_1] - [V/4L_2]$

$= V/4 [1/1.00 – 1/1.01]$

solving , V = 343.4 m/s.

Que.24. a) What are overtones ? [Marks :(3)]

b) Two identical wires of length L and 2L vibrate with fundamental frequencies 100 Hz and 150 Hz, respectively. What is the ratio of their tensions?

Ans. a) The frequency other than fundamental frequency produced by a vibrating body are called overtones.

b) Here $m_1 = m_2 = m$

$v_1 = 100 = (1/2L)\sqrt{(T_1/m)}$

$v_2 = 150 = (1/4L)\sqrt{(T_2/m)}$

$v_1 / v_2 = 100/150 = 2\sqrt{(T_1/T_2)}$

$T_1/T_2 = (1/3)^2 = 1/9$

$T_2 = 9 T_1$

Que.25. a) Strings of different thickness and materials are used in sitar or a violin. Why? [Marks :(4)]

b) A guitar string is 1 m long and has a fundamental frequency of 125 Hz. Where should it be pressed to produce a fundamental frequency of 200 Hz?

Ans. a) The fundamental frequency of a stretched string is given by

$v = (1/2L)\sqrt{(T/m)}$

When we use strings of different thickness and material they have different values of mass per unit length (m) . So the string will produce notes of different frequencies.

b) fundamental frequency, $v = V/2L = (1/2L)\sqrt{(T/m)}$

As T and m are fixed, $v_1 / v_2 = L_2/L_1$

$L_2 = (125/200)$ Two x 100

= 0.625 m.

Que.26. A string is attached between two points, is plucked at one end and released. The wave will travel from one end to another and will reflect back. [Marks :(3)]

a) what will be the name of resulting wave?

b) What are its characteristics ?

Ans. a) standing wave.

b) i) Amplitude of vibration of particle is maximum at anti node and

minimum at nodes

ii) Energy is not transferred from particle to particle

iii) pressure variation is minimum at antinodes and maximum at nodes.

iv) wavelength of standing wave is same as that of the component wave.

Que.27. What are the two essential properties of a medium to propagate mechanical waves? [Marks :(1)]

Ans. Inertia and elasticity.

Que.28. Can we hear sound on moon. Give reason. [Marks :(1)]

Ans. No .Sound wave (mechanical wave) require a medium to propagate. Since moon has no atmosphere, propagation of sound is not possible in moon.

Que.29. Explain why [Marks :(2)]

i) sound travels faster in solids than in gases ?

ii) sound travels faster in warm water than in cold water ?

Ans. i) the speed of sound through any medium of bulk modulus B and

density ρ is given by

$v = \sqrt{(B/\rho)}$

The ratio of (B/ρ) is much higher for solids than that for gases.

ii) speed of sound is directly proportional to the square root of the

temperature of air, i.e., $v = \sqrt{T}$

As temperature of the warm air is more than that of the cool air, so

sound travels faster in warm water.

Que.30. A wave is disturbance which propagates through a medium in which energy

is transferred with out actual motion of matter. [Marks :(5)]

a. How is a stationary or standing wave formed? (1)

b. Schematically represent the first three modes of vibration of a stretched

string and deduce the expression for n th harmonics. (4)

Ans. a) When two identical waves of same amplitude and frequency travelling in opposite directions with same speed along same path superpose each other , the resultant wave is called stationary or standing wave.

b) Consider a string of length L stretched under tension T. Let m be the mass per unit length of the string, the speed of transverse wave on the string will be

$V = \sqrt{(T/m)}$

First mode of vibration : If the string is plucked in the middle and released , it vibrate in one segment with nodes at its ends and an antinode in the middle.

Here length of the string, $L = n\lambda/2$, for first harmonics , $n = 1$

$L = \lambda_1 / 2$ or $\lambda_1 = 2L$

Therefore frequency of vibration, $v_1 = V/\lambda_1 = (1/2L)\sqrt{(T/m)}$, is called fundamental note or first harmonic.

Second mode of vibration : Here $L = n\lambda/2$, for second harmonics , $n = 2$

$L = 2\lambda_2 / 2$ or $\lambda_2 = L$

Therefore frequency of vibration, $v_2 = V/\lambda_2 = (1/L)\sqrt{(T/m)}$, is called first overtone or second harmonic.

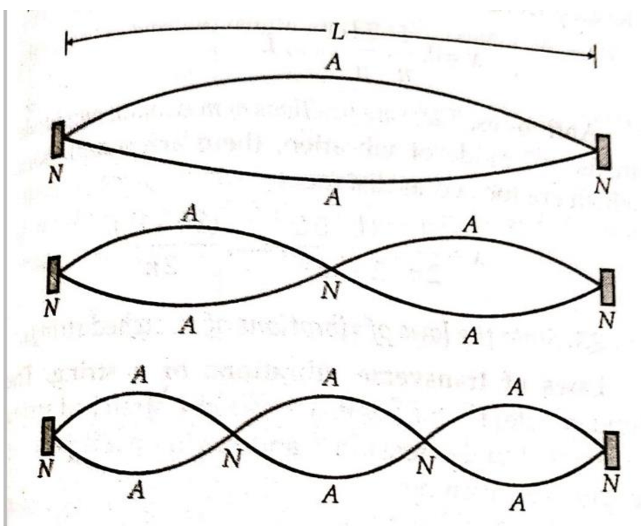
$v_2 = 2\,v_1$

*Third mode of vibration :*Here $L = 3\lambda_3 / 2$ or $\lambda_3 = (2L/3)$

Therefore frequency of vibration, $v_3 = V/\lambda_3 = (3/2L)\sqrt{(T/m)}$, is called second overtone third harmonic.

$v_3 = 3\,v_1$.

Figure below shows the first three harmonics of a stretched string fixed at both ends.



Que.31. An incident wave is represented by y(x,t) = 30 sin(4x – 8t). Write the

expression for reflected wave : **[Marks :(2)]**

i) from a rigid boundary.

ii) from an open boundary.

Ans. i) the wave reflected from a rigid boundary is

$y(x,t) = - 30 \sin(4x + 8t)$.

ii) The wave reflected from an open boundary is

$y(x,t) = 30 \sin(4x + 8t)$.

Que.32. If a progressive wave travelling in +ve X direction having the amplitude of 0.06 m, frequency 200 Hz and velocity is 400m/s then write the equation of that progressive wave. [Marks :(2)]

Ans. A= 0.06 m , v = 200Hz

$k= 2\pi / \lambda = 2\pi V/v = 2\pi [200/400] = \pi\ m^{-1}$

$\omega = 2\pi v = 400\pi$ rad/s

The standard equation of progressive wave is

$y(x,t) = a \sin (kx – \omega t)$

put the values we get, $y(x,t) = 0.06 \sin (\pi x – 400\pi\, t)$ m.

Que.33. Stationary waves are set up by the superposition of two waves given by y1 = 0.05 sin(5πt – x) and y2 = 0.05 sin (5πt + x) [Marks :(2)]

where x and y are in meters and t in seconds. Find the displacement of a particle situated at a distance x = 1m.

Ans. according to principle of superposition , the resultant displacement is

given by

$y = y1 + y2 = 0.05 \sin(5\pi t – x) + 0.05 \sin (5\pi t + x)$

$= 0.05 \times 2\sin \{ 5\pi t – x+ 5\pi t + x \}\cos \{ 5\pi t + x - 5\pi t + x \}$

$= 0.1 \cos x \sin 5\pi t$

therefore , Amplitude , a = 0.1 cos x.

At x = 1m, $a = 0.1 \cos 1 = 0.1 \cos 180^o/\pi = 0.1 \cos 57.3^o$

= 0.1 x 0.54 = 0.054 m.

Que.34. A wave travelling along a string is described by y(x,t) = 0.005 sin (80.0x – 3.0t) in which the numerical constants are in S.I. units (0.005 m , 80.0 rad m-1 and 3.0 rad s-1). Calculate [Marks :(4)]

i) the amplitude of the 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.

Ans. Given, y(x,t) = 0.005 sin (80.0x – 3.0t)

Then, y(x,t) = a sin (kx – ωt)

Comparing the given equation with standard equation,

a = 0.005 m, k = 80.0 rad/m ,ω = 3.0 rad/s

i) amplitude , a = 0.005 m = 5 mm

ii) wavelength, λ = 2π / k = 2π / 80 = 7.85 cm.

iii) Time period, T = 2π / ω = 2π / 3 = 2.09 s.

Frequency, v = 1/T = 1/2.09 = 0.48 Hz.

Now displacement y of the particle at a distance.

X = 0.3 m and time t = 20s.

Y(0.3,20) = 0.005 sin (80x 0.3 – 3.0x20)

= 0.005 sin (24 – 60) = 5 mm.

Que.35. A metallic wire of length of 100 m and a mass of 10 kg. How much tension in the wire is required so that the speed of transverse wave in wire is equal to speed of sound in air ? Given, speed of sound in air = 340 m/s. **[Marks :(2)]**

Ans. given , m = 10 kg and L = 100m.

Mass per unit length μ = m/L = 10/100 = 1/10 kg/m.

Speed , v = √ (T/μ)

or T = v2 μ = (340)2 x 0.1 = 11560 N.

Que.36. Find the ratio of velocity of sound in hydrogen gas (γ = 1.4) to that of helium gas (γ = 1.67) at the same temperature. Given that molecular weight of hydrogen and helium are 2 and 4 respectively. **[Marks :(2)]**

Ans. velocity of sound, v = √ (γ RT/M)

here at constant temperature, $V_H = \sqrt{(\gamma_H / M_H)}$

$V_{He} = \sqrt{(\gamma_{He} / M_{He})}$

$V_H / V_{he} = \sqrt{(\gamma_H / M_H)} / \sqrt{(\gamma_{He} / M_{He})}$

$= \sqrt{(1.4 / 1 \ / \ 1.67 / 2)}$

$V_H / V_{he} = 1.68.$

Que.37. In which medium , do the sound wave travel faster , solids, liquids or gases ? Give reason. **[Marks :(2)]**

Ans. Solids

Sound waves travel in solids with highest speed. This is because the coefficient of elasticity of solids is much greater than coefficient of elasticity of liquids and gases.

Que.38. Explain why **[Marks :(2)]**

i) sound can be heard over a long distance on a rainy day ?

ii) In which gas, hydrogen or oxygen , will sound have greater velocity ?

Ans. since , $v \propto 1/(\sqrt{\rho})$

i) In rainy day humidity of air increases. This lowers the density of air, hence there is an increase of velocity of sound.

ii) Density of hydrogen gas is lower than that of oxygen. So velocity of sound will have greater for hydrogen gas.

Que.39. "Sound produced by a cracker travel faster than the sound produced by a humming bee". Comment on the statement . **[Marks :(2)]**

Ans. The velocity of sound in a medium does not depends upon its loudness , pitch or quality. Thus the sound of cracker and of a humming bee travel with same speed.

Que.40. When sound wave travels from air to water , which of the following remains constant. **[Marks :(1)]**

i) wavelength ii) velocity iii) frequency iv) all of the above.

Ans. iii) frequency.

Que.41. a) Give Newton-Laplace formula for finding velocity of sound ? **[Marks :(2)]**

b) How does the velocity of sound vary with pressure when the temperature is kept constant ?

Ans. a. Newton-Laplace formula , $v = \sqrt{\gamma (P/\rho)}$

Ans: b. At constant temperature, PV = a constants

or P/ρ = a constant. (since $V \propto 1/\rho$)

or $\gamma (P/\rho)$ = a constant. Therefore velocity of sound does not vary with pressure at constant temperature.

Que.42. Calculate the speed of sound wave in water if at an extra pressure of 10^5 nm^{-2} the volume strain is observed to be 5x 10^{-5}. Density of water is 1000 kgm^{-3}. [Marks :(2)]

Ans. Bulk modulus , k = P / {ΔV/V}

= 10^5 / { 5x 10^{-5} } = 2 x 10^9 Nm^{-2}

Speed of sound in water v = √(k/ ρ) = √(2 x 10^9/ 1000) = 1.414 x 10^3 m/s.

Que.43. A stone is dropped from the top of a tower 300m high splashes into water of pond near the base of the tower . When is the splash heard at the top ? [Marks :(2)] Speed of sound in air is 340 m/s. And g = 9.8m/s^2.

Ans. s = 300m , u = 0 ,g = 9.8m/s2 ,

s = ut + (1/2) gt2.

300 = 4.9t2

t = 7.82 s.

Time taken by the splash to reach from water surface nto the top is t' , then

t' = 300/340 = 0.88 s.

Therefore total time taken = t + t' = 7.82 + 0.88 = 8.7 s.

Que.44. Sound wave of wavelength 'λ' travelling in a medium with a speed of v m/s enters into another medium where , its speed is 2v m/s. Find the wavelength of sound wave in the second medium? [Marks :(2)]

Ans. frequency in the first medium , v = v/λ

Frequency will remain same in the second medium, as the source.

v' = v we get, 2v/λ' = v/λ

or λ' = 2 λ.

Que.45. Use the formula v = √ (γP/ρ) to explain why the speed of sound in air

i) is independent on pressure. [Marks :(5)]

ii) increases with temperature.

Iii) increases with humidity.

Ans. i) speed of sound in gas , v = √ (γP/ρ)

Dendity , ρ = M/V

v = √ (γPV/ M)

When T is constant. PV = a constant, v = constant. Hence velocity of sound is independent of the change in pressure of the gas provided temperature remains constant.

ii) According to standard gas equation

$PV = RT$ or $P = RT/V$

$v = \sqrt{(\gamma RT/ \rho V)} = \sqrt{(\gamma RT/ M)}$

where ρV = molecular weight of the gas.

Or $v \propto \sqrt{T}$, hence v increases with temperature.

iii) Due to the presence of water vapours in air density changes. Hence velocity of sound changes with humidity.

Vm – velocity of sound in moist air

Vd - velocity of sound in dry air

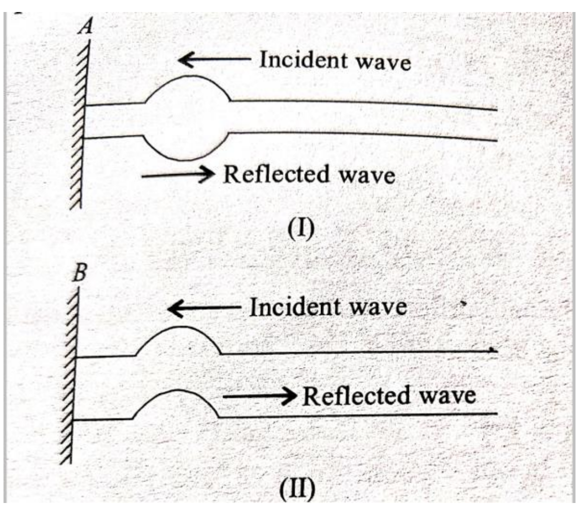
Then $V_m/ V_d = \sqrt{(\rho_d/ \rho_m)}$

as $\rho_d > \rho_m$, $V_m > V_d$

Que.46. a).Explain the principle of superposition of waves. [Marks :(2)]

Ans. a) The principle of superposition of waves states that when a number of waves travel through a medium simultaneously the resultant displacement of any particle of the medium at any given time is equal to the vector sum of the displacement due to the individual waves.

Que.47. Figure (I and II) below shows two boundaries A and B with incident and reflected waves. Which one of the two is a rigid boundary ? Explain [Marks :(2)]



Ans. In figure I

The phase difference between incident and reflected wave is π radian.

In figure II

The phase difference between incident and reflected wave is zero.

A phase reversal (π radian) takes place only at rigid boundary. So boundary A is rigid one.

Que.48. when a stone is dropped in the surface of water, transverse wave is produced, given by y = 4 sin (0.01x – 2 t) where y and x are in cm and t in seconds. [Marks :(4)]

Find i) amplitude

ii) wavelength

iii) initial phase

iv) speed and

v) frequency of wave.

Ans. The general expression for transverse wave is given by

$y = A \sin (2\pi/\lambda) [(x – vt) + \varnothing]$

Comparing we get,

i) amplitude A = 0.04 m.

ii) $2\pi/\lambda = 0.01$

$\lambda = 2\pi/ 0.01 = 200 \pi$ m.

Iii) initial phase $\varnothing = 0$

iv) speed v = 2/0.01 = 2 m/s

v) frequency , $\nu = v/\lambda = 2/2 = 1\ s^{-1}$