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Class: XI
Subject: Physics
Topic: Waves
No. of Questions: 27

Q1. What is the change in intensity level when the intensity of sound increases by a factor of 105?

a. 50 dB

b. 60 dB

c. 70 dB

d. 80 dB

Sol. a

$I/I_o = 105$
The increase in intensity level is given by
:L = 10 log10($I/I_o$) = 10 log10(105)
=10*5 = 50 dB

Q2. What is the phase difference between two successive crests in a wave?

a. π

b. π/2

c. 2π

d. 4π

Sol. C
Phase difference between any two particles in a wave determines lack of harmony in the vibrating state of two particles, ie, how far one particle leads the other or lags behind the other
Relation of path difference and phase difference is given by

$$\Delta \emptyset = \frac{2\pi}{\lambda} \times \Delta x$$

Where $\Delta x$ is path difference. But path difference between two crests

$$\Delta x = \lambda$$

Hence, $\Delta\phi = \frac{2\pi}{\lambda} \times \lambda = 2\pi$

Q3. A simple harmonic wave is represented by $y = 10\sin\left(\frac{2\pi t}{T} + \alpha\right)$ , the time period is 30 s. At t = 0, the displacement is 5 cm. What is the phase angle at t = 7.5 s?

a. $120^o$

b. $100^o$

c. $80^o$

d. $60^o$

Sol. a

At t = 0, y = 5 cm

5 = 10 sin(0+$\alpha$) =

$$sin\alpha = \frac{5}{10} = \frac{1}{2}$$

$$\alpha = 30^o$$

At t = 7.5 sec, the phase angle is given by

$$\phi = \frac{2\pi t}{T} + \frac{\pi}{6} = \frac{2\pi}{3} = 120^o$$



Q4. The equation of a wave is x = 5sin$\left(\frac{t}{0.04} - \frac{x}{4}\right)$ cm. Find the maximum velocity of the particles of the medium.

a. 1 m/s

b. 1.5 m/s

c. 1.25 m/s

d. 2 m/s

Sol. c

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Comparing it with the standard equation $y = Asin2\pi(\frac{t}{T} - \frac{x}{\lambda})$

$$\frac{2\pi}{T} = \frac{1}{0.04}$$

$$T = 0.08\pi$$

$$\omega = \frac{2\pi}{T} = \frac{2\pi}{2\pi} * 25$$

=25 m/s$^2$

$$v_0 = \omega A = 25 * 5 * 10^{-2} = 1.25\frac{m}{s}$$

Q5. The law applicable for determining the apparent change in frequency when a source and an observer are in motion is __________

a. Doppler's law

b. Huygens's law

c. Newton's law

d. Galileo's law

Sol. a

The law applicable for determining the apparent change in frequency when a source and an observer are in motion is Doppler's law

Q6. What fraction of the total energy is kinetic when the displacement is one half of amplitude?

a. $\frac{1}{4}$

b. $\frac{3}{4}$

c. $\frac{4}{3}$

d. $\frac{2}{3}$

Sol. b

At x = A/2PE / Total energy = (A/2) ^ 2 / A^2 = 1/4
KE / Total energy = (Total energy - PE)/Total energy = 1 - PE/Total energy = 3/4

Q7. A source and observer are approaching each other with 50 ms-1 velocity. What will be its original frequency if the observer receives 400 cycle/s?

a. $f_o \simeq 300$ cycle/s

b. $f_o \simeq 320$ cycle/s

c. $f_o \simeq 340$ cycle/s

d. $f_o \simeq 330$ cycle/s

Sol. a

*Source and observer are approaching each other, hence perceived frequency increases.*

From Doppler's effect in sound, we have

$$f' = f_o\left(\frac{v + v_o}{v - v_s}\right)$$

where $v$ is velocity of sound, $v_o$ of observer and $v_s$ of source.

Given, $f' = 400$ cycle/s, $v = 340$ m/s, $v_o = v_s = 50\ ms^{-1}$.

$$\therefore \quad 400 = f_o\left(\frac{340 + 50}{340 - 50}\right)$$

$$\Rightarrow \quad f_o = \frac{400 \times 290}{390}$$

$$f_o \simeq 300 \text{ cycles/s}$$

Change in frequency depends on the fact that whether the source is moved towards the observer or the observer is moved towards the source. But when the speed of source and observer are much lesser than that of sound, the change in frequency becomes independent of the fact whether the source is moving or the observer.

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Q8. The equation of a simple harmonic wave is given by y = 5 sin π/2 (100t - x), where x and y are in metre and time is in seconds. The period of the wave in seconds will be

a. 0.04

b. 0.01

c. 1

d. 5

Sol. a

The given equation is y = 5 sin $\frac{\pi}{2}\,(100t - x)$

Comparing Eq. (i) with standard wave equation given by

Y =A sin $(\omega t - kx)$

We have

$$\omega = \frac{100\,\pi}{2} = 50\,\pi$$

$\Rightarrow \quad \frac{2\,\pi}{T} = 50\,\pi$

$\Rightarrow \quad T = \frac{2\,\pi}{50\,\pi} = 0.04$ s

Q9. The frequency of a tuning fork is 256 Hz. The velocity of sound in air is 344 ms-1. The distance travelled (in metres) by the sound during the time in which the tuning fork completes 32 vibrations is

a. 21

b. 43

c. 86

d. 129

Sol. b

Wavelength of sound,

$$\lambda = \frac{v}{n} = \frac{344}{256}\ \text{m}$$

So, distance travelled by the sound in 32 vibrations is

$$S = 32\,\lambda$$

$$= 32 \times \frac{344}{256} = 43\ \text{m}$$

Q10. What is the beat frequency produced when the following two waves are sounded together?
$x_1 = 10 \sin (404\pi t - 5\pi x)$, $x_2 = 10 \sin (400\pi t - 5\pi x)$

a. 4 Hz

b. 1 Hz

c. 3 Hz

d. 2 Hz

Sol. d

$$x_1 = 10 \sin (404\pi t - 5\pi x)$$

$$= 10 \sin 2\pi\left(202t - \frac{5x}{2}\right)$$

$\therefore\ n_1 = 202$ Hz

Similarly, $x_2 = 10 \sin (400\pi t - 5\pi x)$

$$= 10 \sin 2\pi\left(200t - \frac{5x}{2}\right)$$

$\therefore\ n_2 = 200$ Hz

$\therefore$ The beat frequency is $n_1 - n_2 = 2$ Hz.

Q11. The factor which determines the pitch of a tuning fork is

a. physical condition

b. frequency

c. wavelength

d. none of these

Sol. b

Pitch is the characteristic of musical sound and depends upon its frequency. The tones of higher frequency are interpreted as shrill and that of low frequency are interpreted as grave.

Q12. When both the listener and source are moving towards each other, then which of the following is true regarding frequency and wavelength of wave observed by the observer?

a. More frequency, less wavelength

b. More frequency, more wavelength

c. Less frequency, less wavelength

d. More frequency, constant wavelength

Sol. a

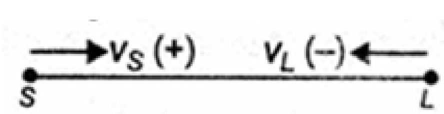
When the distance between the source and listener is decreasing, the apparent frequency increases. According to Doppler's effect, whenever there is a relation motion between a source of sound and listener, the apparent frequency of sound heard by the listener is different from the actual frequency of sound emitted by the source. Let S be source of sound and L the listener of sound. Let v be the actual frequency of sound emitted by the source and $\lambda$ be the actual wavelength of the sound emitted.

It $\nu$ is velocity of sound in still air, then

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

If velocity of listener is $v_L$ and velocity of source is $v_{s'}$ then apparent frequency of sound waves heard by the listener is

$$V' = \frac{\nu - \nu_L}{\nu - \nu_S} \times v$$

Here, 

both source and listener are approaching each other.

Then $\nu_s$ is positive and $V_L$ is negative.

∴ $$V' = \frac{\nu - (-\nu_L)}{\nu - \nu_s}\, \nu$$

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$$= \left(\frac{v+v_L}{v-v_S}\right) v$$

i.e., $v' > v$

Also, $\lambda' < \lambda$

So, listener listens more frequency and observes less wavelengths.

Q13. The first overtone of a stretched wire of given length is 320 Hz. The first harmonic is

a. 320 Hz

b. 160 Hz

c. 480 Hz

d. 640 Hz

Sol. b

If a wire, vibrates in $p$ segments, then its frequency is given by

$$n = \frac{p}{2l}\sqrt{\frac{T}{m}}$$

where $l$ is length of wire, $T$ is tension and $m$ is mass per unit length.

The frequency of first harmonic is

$$n = \frac{1}{2l}\sqrt{\frac{T}{m}} \quad \text{...(i)}$$

The frequency of second harmonic or first overtone is

$$n' = \frac{2}{2l}\sqrt{\frac{T}{m}} \quad \text{...(ii)}$$

$\Rightarrow \quad n' = 2n$

$\Rightarrow \quad n = \frac{n'}{2} = \frac{320}{2} = 160 \text{ Hz}$

Q14. When a wave travels in a medium, the particle displacements are given by y (x, t) = 0.03 sin $^{\pi}$ (2t – 0.01 x) Where y and x are in meters and t is in seconds. The wavelength of the wave is

a. 10 m

b. 20 m

c. 100 m

d. 200 m

Sol. d

The particle displacements are given by

$$y(x, t) = A \sin \left\{\frac{2\pi}{\lambda}(vt - x)\right\}$$

Comparing this with the given equation we have $\frac{2\pi}{\lambda} = 0.01\ \pi$ or $\lambda = 200$ m. Hence the correct choice is (4).



Q15. A source of sound vibrates according to the equation y = 0.05 cos π t. It sends out waves of velocity 1.5 ms–1. The wavelength of the waves is

a. 1.5 m

b. 3.0 m

c. 4.5 m

d. 6.0 m

Sol. b

Angular frequency $\omega = \pi$ or $2\pi$f = $\pi$ or f = 0.5 Hz. Now v = 15 ms$^{-1}$. Therefore $\lambda$ = v/f = 1.5/0.5 = 3 m. Hence the correct choice is (2).

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Q16. Particle displacements (in cm) in a standing wave are given by y (x, t) = 2 sin (0.1 π x) cos (100 π t)
The distance between a node and the next antinode is

a. 2.5 cm

b. 5.0 cm

c. 7.5 cm

d. 10.0 cm

Sol. b

$\frac{2\pi x}{\lambda} = 0.1\,\pi x$ which gives $\lambda = 20$ cm. The distance between a node and the next antinode $= \frac{\lambda}{4} = \frac{20}{4} =$ 5 cm. Hence the correct choice is (2).

Q17. A pipe closed at one end and open at the other will give

a. all the harmonics

b. all even harmonics

c. all odd harmonics

d. none of the harmonics

Sol. c

Q18. A tuning fork of frequency 340 Hz is sounded above a cylindrical tube 1 m high. Water is slowly poured into the tube. If the speed of sound is 340 $ms^{-1}$, at what levels of water in the tube will the sound of the fork be appreciably intensified?

a. 25 cm, 75 cm

b. 20 cm, 80 cm

c. 15 cm, 85 cm

d. 17 cm, 83 cm

Sol. a

Frequency of sound emitted by a closed pipe of length $L$ in the fundamental mode is $\nu = \frac{v}{4L}$. For resonance $\nu = \nu'$ where $\nu'$ is the frequency of the tuning fork. Thus $340 = \frac{340}{4L}$ or $4L = 1$ m or $L = 25$ cm. The next resonance occurs at $\frac{4}{3}L = 1$ m or $L = 75$ cm.

Hence the correct choice is (1).



Q19. Two sources A and B are sounding notes of frequency 680 Hz. A listener moves from A to B with a constant velocity u. If the speed of sound is 340 ms–1, what must be the value of 'u' so that he hears 10 beats per second?

a. 2.0 $ms^{-1}$

b. 2.5 $ms^{-1}$

c. 3.0 $ms^{-1}$

d. 3.5 $ms^{-1}$

Sol. b

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The listener moves away from $A$ and approaches $B$.
Hence the apparent frequencies are

$$\nu_1 = \nu\left(1-\frac{u}{v}\right) \text{ and } \nu_2 = \nu\left(1+\frac{u}{v}\right)$$

$\therefore$ $\nu_2 - \nu_1 = 2\,\nu u/v$. It is given that $\nu_2 - \nu_1 = 10$.
$v = 340 \text{ ms}^{-1}$ and $\nu = 680$ Hz.

Substituting these values we get

$$10 = \frac{2\times 680\times u}{340}$$

or $u = 2.5 \text{ ms}^{-1}$.

Hence the correct choice is (2).

Q20. A bat flying above a lake emits ultrasonic sound of 100 kHz. When this wave falls on the water surface, it is partly reflected and partly transmitted. What are the wavelengths of the reflected and transmitted waves? (The speed of sound in air is 340 m s–1 and in water is 1450 m s-1).

a. 6.8 mm and 2.9 cm

b. 3.4 mm and 1.45 cm

c. 3.4 mm and 7.8 mm

d. 6.8 mm and 1.45 cm

Sol. b

Frequency of sound ($\nu$) = 100 kHz = $10^5$ Hz
Speed of sound in air ($v_a$) = 340 m $s^{-1}$
Speed of sound in water ($v_w$) = 1450 m $s^{-1}$
Since the reflected wave travels in air, its wavelength is

$$\lambda_a = \frac{v_a}{\nu} = \frac{340}{10^5} = 3.4\times 10^{-3}\,\text{m} = 3.4\,\text{mm}$$

Since the transmitted wave travels in water, its wavelength is

$$\lambda_w = \frac{v_w}{\nu} = \frac{1450}{10^5} = 1.45\times 10^{-2}\text{ m}$$

$$= 1.45 \text{ cm}$$

Q21. The formula for the time period T for a loaded spring, $T = 2\pi\sqrt{\frac{\text{displacement}}{\text{acceleration}}}$

Does the time period depend on length of the spring?

Sol. Although length of the spring does not appear in the expression for the time period, yet the time period depends on the length of the spring. It is because; force constant of the spring depends on the length of the spring.

Q22. One end of a long string of linear mass density $8.0 \times 10^{-3}$ kg $m^{-1}$ is connected to an electrically driven turning folk of frequency 256 $H_2$. The other end passes over a pulley and is tied to a pan containing a mass of 90 kg. The pulley end absorbs all the incoming energy so that reflected waves at this end have negligible amplitude. At t = 0, the left end of the string x =0 has zero transverse displacement (y = 0) and is moving along positive x direction. The amplitude of wave is 5.0 cm. Write down the transverse displacement y as function of x and t that describes the wave on the string.

Sol.

Solu : The wave is travelling along x-axis and its equation is given by

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

$$y = a\sin(2\pi\upsilon t - kx) = a\sin(\omega t - kx) \qquad \text{(i)}$$

To determine a, ω and k :

$$a = 5.0 \text{ cm} = 0.05 \text{ m},\ \upsilon = 256\ H_z$$

$$w = 2\pi v = 2\pi \times 256 = 1.61 \times 10^3\ s^{-1}$$

$$m = 8.0 \times 10^{-3}\ \text{kg m}^{-1},\ T = 90 \times 9.8\ \text{N}$$

$$v = \sqrt{\frac{T}{m}} = \sqrt{\frac{90 \times 9.8}{8.0 \times 10^{-3}}} = 332\ \text{ms}^{-1}$$

$$\therefore \quad \lambda = \frac{v}{\upsilon} = \frac{332}{256} = 1.297\ \text{m}$$

and $$k = \frac{2\pi}{\lambda} = \frac{2\pi}{1.297} = 4.84\ \text{m}^{-1}$$

substituting for a, ω and k in equ (i) we have

$$y = 0.05\sin(1.61 \times 10^3\ t - 4.84\ x)$$

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Q23. The transverse displacement of a string (clamped at its two ends) is given by

$$Y(x, t) = 0.06 \sin \frac{2\pi}{3} \times \cos(120\pi t)$$

Where x, y are in m and t is in s. The length of the string is 1.5 m and its mass is $3.0 \times 10^{-2}$ kg. Answer the following.

a. Does the function represent a travelling or a stationary wave?
b. Interpret the wave as a superposition of two waves travelling in opposite directions. What are the wavelength frequency and speed of propagation of each wave?
c. Determine the tension in the string.

Sol. $Y(x, t) = 0.06 \sin \frac{2\pi}{3} \times \cos 120\pi t$

(a) The displacement which involves harmonic functions of x and t separately represents a stationary wave and the displacement, which is harmonic function of the form $(vt \pm x)$, represent a travelling wave. Hence, the equation given above represents a stationary wave.

(b) When a wave pulse $y_1 = a \sin \frac{2\pi}{\lambda}(vt - x)$ travelling along x-axis is superimposed by the reflected pulse.

$y_2 = -a \sin \frac{2\pi}{\lambda}(vt + x)$ from the other end, a stationery wave is formed and is given by

$y = y_1 + y_2 = -2a \sin \frac{2\pi}{\lambda} \times \cos \frac{2\pi}{\lambda} vt$ (ii)

comparing the eqs (i) and (ii) we have

$\frac{2\pi}{\lambda} = \frac{2\pi}{3}$ or $\lambda = 3\,m$

and $\frac{2\pi}{\lambda} v = 120\pi$ or $v = 60\lambda = 60 \times 3 = 180\ ms^{-1}$

Now frequency $\gamma = \frac{v}{\lambda} = \frac{180}{3} = 60\ H_z$

(c) Velocity of transverse wave in a string is given by

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

Here $m = \frac{3 \times 10^{-2}}{1.5} = 2 \times 10^{-2}\ kgm^{-1}$

Also $v = 180\ ms^{-1}$

$\therefore$ $T = v^2 m = (180)^2 \times 2 \times 10^{-2} = 648N$

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Q24. Differentiate between closed pipe and open pipe at both ends of same length for frequency of fundamental note harmonics.

Sol. (a) In a pipe open at ends, the frequcney of fundamental note produced is twice as that produced by a closed pipe of same length.

(b) An open pipe producces all the harnmonics, while in a closed pipe, the even harmonics are absent.

Q25. Why can the transerse waves not be produced in air?

Sol. For air, moduls of rigidity is zero or it does not passes property of cohession. Therefore transeverse waves can not be produced.

Q26. Frequency is the most fundamental property of wave, why?

Sol. When a wave passes through different media, velocity and wavelength change but frewquency does not change.

Q27. A transverse wave travels along x-axis. The particles of the medium mustg move in which direction?

Sol. In the y – z plane or in plane perpendicualr to x – axis.