WAVE MOTION

1. A musician using an open flute of length 50 cm produces second harmonic sound waves. A person runs towards the musician from another end of a hall at a speed of 10 km/h. If the wave speed is 330 m/s, the frequency heard by the running person shall be close to :

(1) 753 Hz (2) 500 Hz
(3) 333 Hz (4) 666 Hz

2. Two coherent sources produce waves of different intensities which interfere. After interference, the ratio of the maximum intensity to the minimum intensity is 16. The intensity of the waves are in the ratio:

(1) 4 : 1 (2) 25 : 9
(3) 16 : 9 (4) 5 : 3

3. A heavy ball of mass M is suspended from the ceiling of a car by a light string of mass m (m<<M). When the car is at rest, the speed of transverse waves in the string is 60 ms^{-1}. When the car has acceleration a, the wave-speed increases to 60.5 ms^{-1}. The value of a, in terms of gravitational acceleration g, is closest to :

(1) $\frac{g}{5}$ (2) $\frac{g}{20}$ (3) $\frac{g}{10}$ (4) $\frac{g}{30}$

4. A closed organ pipe has a fundamental frequency of 1.5 kHz. The number of overtones that can be distinctly heard by a person with this organ pipe will be :

(Assume that the highest frequency a person can hear is 20,000 Hz)

(1) 7 (2) 5 (3) 6 (4) 4

5. A string of length 1 m and mass 5 g is fixed at both ends. The tension in the string is 8.0 N. The siring is set into vibration using an external vibrator of frequency 100 Hz. The separation between successive nodes on the string is close to :

(1) 16.6 cm (2) 20.0 cm
(3) 10.0 cm (4) 33.3 cm

6. A train moves towards a stationary observer with speed 34 m/s. The train sounds a whistle and its frequency registered by the observer is f_1. If the speed of the train is reduced to 17 m/s, the frequency registered is f_2. If speed of sound is 340 m/s, then the ratio f_1/f_2 is :

(1) 18/17 (2) 19/18 (3) 20/19 (4) 21/20

7. Equation of travelling wave on a stretched string of linear density 5 g/m is

$y = 0.03 \sin(450\,t - 9x)$

where distance and time are measured is SI units. The tension in the string is :

(1) 10 N (2) 12.5 N (3) 7.5 N (4) 5 N

8. A resonance tube is old and has jagged end. It is still used in the laboratory to determine velocity of sound in air. A tuning fork of frequency 512 Hz produces first resonance when the tube is filled with water to a mark 11 cm below a reference mark, near the open end of the tube. The experiment is repeated with another fork of frequency 256 Hz which produces first resonance when water reaches a mark 27 cm below the reference mark. The velocity of sound in air, obtained in the experiment, is close to:

(1) 328ms^{-1} (2) 322ms^{-1}
(3) 341ms^{-1} (4) 335ms^{-1}

9. A travelling harmonic wave is represented by the equation $y(x, t) = 10^{-3}\sin(50t + 2x)$, where x and y are in meter and t is in seconds. Which of the following is a correct statement about the wave?

The wave is propagating along the

(1) negative x-axis with speed $25ms^{-1}$

(2) The wave is propagating along the positive x-axis with speed $25\ ms^{-1}$

(3) The wave is propagating along the positive x-axis with speed $100\ ms^{-1}$

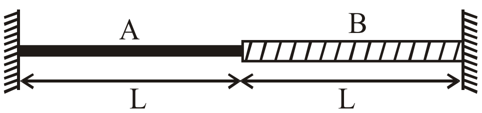
(4) The wave is propagating along the negative x-axis with speed $100\ ms^{-1}$

10. A person standing on an open ground hears the sound of a jet aeroplane, coming from north at an angle 60° with ground level. But he finds the aeroplane right vertically above his position. If υ is the speed of sound, speed of the plane is :

(1) $\frac{2\upsilon}{\sqrt{3}}$ (2) υ

(3) $\frac{\upsilon}{2}$ (4) $\frac{\sqrt{3}}{2}\upsilon$

11. A wire of length 2L, is made by joining two wires A and B of same length but different radii r and 2r and made of the same material. It is vibrating at a frequency such that the joint of the two wires forms a node. If the number of antinodes in wire A is p and that in B is q then the ratio p : q is :



(1) 4 : 9 (2) 3 : 5

(3) 1 : 4 (4) 1 : 2

12. A string 2.0 m long and fixed at its ends is driven by a 240 Hz vibrator. The string vibrates in its third harmonic mode. The speed of the wave and its fundamental frequency is :-

(1) 320m/s, 120 Hz (2) 180m/s, 80 Hz

(3) 180m/s, 120 Hz (4) 320m/s, 80 Hz

13. The pressure wave, $P = 0.01\sin[1000t - 3x]\ Nm^{-2}$, corresponds to the sound produced by a vibrating blade on a day when atmospheric temperature is 0°C. On some other day, when temperature is T, the speed of sound produced by the same blade and at the same frequency is found to be $336\ ms^{-1}$. Approximate value of T is :

(1) 15°C (2) 12°C

(3) 4°C (4) 11°C

14. A string is clamped at both the ends and it is vibrating in its 4th harmonic. The equation of the stationary wave is $Y = 0.3\sin(0.157x)\cos(200\pi t)$. The length of the string is : (All quantities are in SI units.)

(1) 20 m (2) 80 m

(3) 60 m (4) 40 m

15. A source of sound S is moving with a velocity of 50 m/s towards a stationary observer. The observer measures the frequency of the source as 1000 Hz. What will be the apparent frequency of the source when it is moving away from the observer after crossing him ? (Take velocity of sound in air is 350 m/s)

(1) 857 Hz (2) 807 Hz

(3) 750 Hz (4) 1143 Hz

16. A stationary source emits sound waves of frequency 500 Hz. Two observers moving along a line passing through the source detect sound to be of frequencies 480 Hz and 530Hz. Their respective speeds are, in ms^{-1},

(Given speed of sound = 300 m/s)

(1) 16, 14 (2) 12, 18

(3) 12, 16 (4) 8, 18

17. A tuning fork of frequency 480 Hz is used in an experiment for measuring speed of sound (ν) in air by resonance tube method. Resonance is observed to occur at two successive lengths of the air column, $l_1 = 30$ cm and $l_2 = 70$ cm. Then ν is equal to :

(1) 332 ms^{-1} (2) 379 ms^{-1}

(3) 384 ms^{-1} (4) 338 ms^{-1}

18. Two sources of sound S_1 and S_2 produce sound waves of same frequency 660 Hz. A listener is moving from source S_1 towards S_2 with a constant speed u m/s and he hears 10 beats/s. The velocity of sound is 330 m/s. Then, u equals :

(1) 2.5 m/s (2) 15.0 m/s

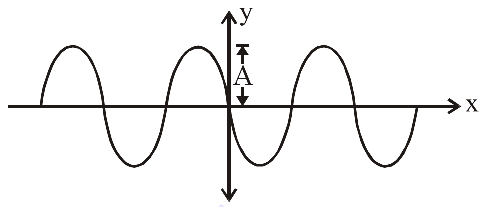
(3) 5.5 m/s (4) 10.0 m/s

19. A small speaker delivers 2 W of audio output. At what distance from the speaker will one detect 120 dB intensity sound ? [Given reference intensity of sound as 10^{-12}W/m^2]

(1) 10 cm (2) 30 cm

(3) 40 cm (4) 20 cm

20. A progressive wave travelling along the positive x-direction is represented by $y(x, t) = A \sin (kx - \omega t + \phi)$. Its snapshot at t = 0 is given in the figure:



For this wave, the phase ϕ is :

(1) 0 (2) $-\frac{\pi}{2}$ (3) π (4) $\frac{\pi}{2}$

21. A submarine (A) travelling at 18 km/hr is being chased along the line of its velocity by another submarine (B) travelling at 27 km/hr. B sends a sonar signal of 500 Hz to detect A and receives a reflected sound of frequency ν. The value of ν is close to :

(Speed of sound in water = 1500 ms^{-1})

(1) 499 Hz (2) 502 Hz

(3) 507 Hz (4) 504 Hz

SOLUTION

1. Ans. (4)

Frequency of the sound produced by flute,

$$f = 2\left(\frac{v}{2\ell}\right) = \frac{2\times 330}{2\times 0.5} = 660\text{Hz}$$

Velocity of observer, $v_0 = 10\times\frac{5}{18} = \frac{25}{9}\text{m/s}$

∴ frequency detected by observer,

$$f' = \left[\frac{v+v_0}{v}\right]f$$

$$\therefore f' = \left[\frac{\frac{25}{9}+330}{330}\right]660$$

= 335.56 × 2 = 671.12

∴ closest answer is (4)

2. Ans. (2)

$$\frac{I_{max}}{I_{min}} = 16$$

$$\Rightarrow \frac{A_{max}}{A_{min}} = 4$$

$$\Rightarrow \frac{A_1 + A_2}{A_1 - A_2} = \frac{4}{1}$$

Using componendo & dividendo.

$$\frac{A_1}{A_2} = \frac{5}{3} \Rightarrow \frac{I_1}{I_2} = \left(\frac{5}{3}\right)^2 = \frac{25}{9}$$

3. Ans. (1)

$$60 = \sqrt{\frac{Mg}{\mu}}$$

$$60.5 = \sqrt{\frac{M\left(g^2+a^2\right)^{1/2}}{\mu}} \Rightarrow \frac{60.5}{60} = \sqrt{\sqrt{\frac{g^2+a^2}{g^2}}}$$

$$\left(1+\frac{0.5}{60}\right)^4 = \frac{g^2+a^2}{g^2} = 1+\frac{2}{60}$$

$$\Rightarrow g^2 + a^2 = g^2 + g^2\times\frac{2}{60}$$

$$a = g\sqrt{\frac{2}{60}} = \frac{g}{\sqrt{30}} = \frac{g}{5.47}$$

$$\simeq \frac{g}{5}$$

4. Ans. (1)

For closed organ pipe, resonate frequency is odd multiple of fundamental frequency.

∴ $(2n + 1)\ f_0 \le 20{,}000$

(f_0 is fundamental frequency = 1.5 KHz)

∴ n = 6

∴ Total number of overtone that can be heared is 6. (1 to 6).

NTA answer is option (1) that is 7 overtones but correct answer is option (3) that is 6 overtones.

5. Ans. (2)

Velocity of wave on string

$$V = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{8}{5}\times 1000} = 40\text{m/s}$$

Now, wavelength of wave $\lambda = \frac{v}{n} = \frac{40}{100}\text{m}$

Separation b/w successive nodes, $\frac{\lambda}{2} = \frac{20}{100}$ m

= 20 cm

6. Ans. (2)

$$f_{app} = f_0\left[\frac{v_2 \pm v_0}{v_2 \mp v_s}\right]$$

$$f_1 = f_0\left[\frac{340}{340-34}\right]$$

$$f_2 = f_0\left[\frac{340}{340-17}\right]$$

$$\frac{f_1}{f_2} = \frac{340-17}{340-34} = \frac{323}{306} \Rightarrow \frac{f_1}{f_2} = \frac{19}{18}$$

7. **Ans. (2)**

y = 0.03 sin(450 t – 9x)

$$v=\frac{\omega}{k}=\frac{450}{9}=50\,m/s$$

$$v=\sqrt{\frac{T}{\mu}}\Rightarrow\frac{T}{\mu}=2500$$

$\Rightarrow$ T = 2500 × 5 × 10^{-3}

= 12.5 N

8. **Ans. (1)**

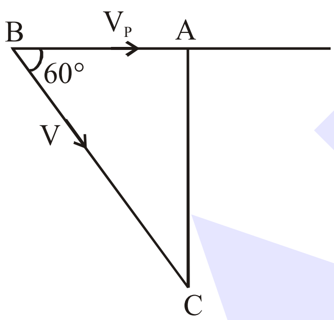
9. **Ans. (1)**

y= a sin(ωt + kx)

$\Rightarrow$ wave is moving along –ve x-axis with speed

$$v=\frac{\omega}{K}\Rightarrow v=\frac{50}{2}=25m/sec.$$

10. **Ans. (3)**



AB = V_p × t

BC = Vt

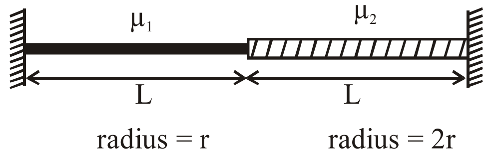
$$\cos 60°=\frac{AB}{BC}$$

$$\frac{1}{2}=\frac{V_p\times t}{Vt}$$

$$V_P=\frac{V}{2}$$

11. **Ans. (4)**

Sol.



Let mass per unit length of wires are μ_1 and μ_2 respectively.

$\because$ Materials are same, so density ρ is same.

$$\therefore\ \mu_1=\frac{\rho\pi r^2L}{L}=\mu\ \text{and}\ \mu_2=\frac{\rho 4\pi r^2L}{L}=4\mu$$

Tension in both are same = T, let speed of wave in wires are V_1 and V_2

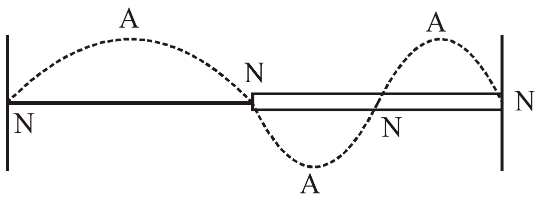
$$V_1=\sqrt{\frac{T}{\mu}}=V\ ;\ V_2=\sqrt{\frac{T}{4\mu}}=\frac{V}{2}$$

So fundamental frequencies in both wires are

$$f_{01}=\frac{V_1}{2L}=\frac{V}{2L}\ \&\ f_{02}=\frac{V_2}{2L}=\frac{V}{4L}$$

Frequency at which both resonate is L.C.M of both frequencies i.e. $\frac{V}{2L}$.

Hence no. of loops in wires are 1 and 2 respectively.



So, ratio of no. of antinodes is 1 : 2.

12. **Ans. (4)**

Sol. $3\left(\frac{v}{2\ell}\right)=240$

$$3\frac{v}{2\times 2}=240$$

v = 320 m/s

$$\text{fundamental frequency}=\frac{v}{2\ell}=\frac{320}{2\times 2}=80\text{ Hz.}$$

13. Ans. (3)

Sol. Speed of wave from wave equation

$$v = -\frac{(\text{coeffecient of } t)}{(\text{coeffecient of } x)}$$

$$v = -\frac{1000}{(-3)} = \frac{1000}{3}$$

since speed of wave $\propto \sqrt{T}$

$$\text{so} = \frac{\frac{1000}{3}}{336} = \sqrt{\frac{273}{T}}$$

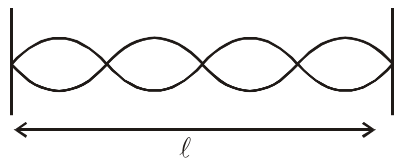
$\Rightarrow$ T = 277.41 K

T = 4.41°C

Option (3)

14. Ans. (2)

Sol. 4[th] harmonic



$$4\frac{\lambda}{2} = \ell$$

$2\lambda = \ell$

From equation $\frac{2\pi}{\lambda} = 0.157$

$\lambda = 40$

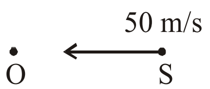
$\ell = 2\lambda$

= 80 m

Option (2)

15. Ans. (3)

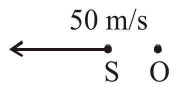
Sol.



$$f_{app} = \left(\frac{V-0}{V-50}\right) f_{source}$$

$$1000 = \left(\frac{350}{300}\right) f_{source}$$

$$f_{source} = \frac{1000 \times 300}{350}$$



$$f_{app} = \left(\frac{V}{V+50}\right) \cdot f_{source}$$

$$= \frac{350}{400} \times 1000 \times \frac{300}{350}$$

= 750 Hz

16. Ans. (2)

Sol. $f = 480 = \frac{300 - v_1}{300} \times 500$

$$\frac{1440}{5} = 300 - v_1$$

$$v_1 = \frac{60}{5} = 12 \text{m/s}$$

$$530 = \frac{300 + v_2}{300} \times 500$$

$1590 = 1500 + 5v_2$

$5v_2 = 90$

$v_2 = 18$ m/s

17. Ans. (3)

Sol. $v = 2f(l_2 - l_1)$

$v = 2 \times 480 \times (70 - 30) \times 10^{-2}$

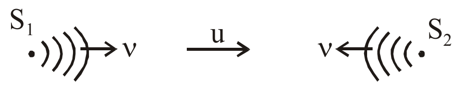
$v = 960 \times 40 \times 10^{-2}$

$v = 38400 \times 10^{-2}$ m/s

$v = 384$ m/s

18. Ans. (1)

Sol. f = 660 Hz, $\nu = 330$ m/s



$$f_1 = f\left(\frac{\nu - u}{\nu}\right)$$

$$f_2 = f\left(\frac{\nu + u}{\nu}\right)$$

$$f_2 - f_1 = \frac{f}{\nu}[\nu + u - (\nu - u)]$$

$$10 = f_2 - f_1 = \frac{f}{\nu}[2u]$$

u = 2.5 m/s

19. **Ans. (3)**

Sol. Loudness of sound is given by

$$dB = 10\log\frac{I}{I_0}\quad\left(\begin{array}{c}\text{I is intensity of sound}\\ I_0\text{ is reference intensity of sound}\end{array}\right)$$

$$\therefore\ 120 = 10\log\left(\frac{I}{I_0}\right)$$

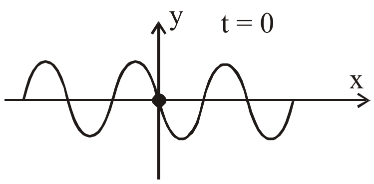
$$\Rightarrow I = 1\ W/m^2$$

Also $I = \frac{P}{4\pi r^2} = \frac{2}{4\pi r^2}$

$$\therefore\ r = \sqrt{\frac{2}{4\pi}} = \sqrt{\frac{1}{2\pi}}\ m = 0.399\ m \approx 40\ cm$$

20. **Ans. (3)**

Sol.



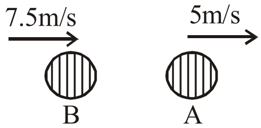
$y = A\sin(kx - wt + \phi)$

at $x = 0$, $t = 0$, $y = 0$ and slope is negative

$\Rightarrow \phi = \pi$

21. **Ans. (2)**

Sol.



$f_0 = 500$ Hz

frequency recieved by A

$$\Rightarrow \left(\frac{1500-5}{1500-7.5}\right)f_0 = f_1$$

and frequency recieved By B again =

$\longleftarrow 1500$

(B) (A) & $\Rightarrow$

7.5 m/s $\longrightarrow$ $\longrightarrow$ 5 m/sec

$$f_2 = \left(\frac{1500+7.5}{1500+5}\right)\times\left(\frac{1500-5}{1500-7.5}\right)f_0 = 502\ Hz$$