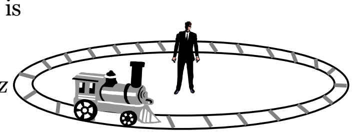
Waves and Sound

SET Self Evaluation Test -17

1. An engine is moving on a circular track with a constant speed. It is blowing a whistle of frequency 500 *Hz*. The frequency received by an observer standing stationary at the centre of the track is



(a) 500 *Hz*
(b) More than 500 *Hz*
(c) Less than 500 *Hz*
(d) More or less than 500 *Hz* depending on the actual speed of the engine

2. In a resonance tube, the first resonance is obtained when the level of water in the tube is at 16*cm* from the open end. Neglecting end correction, the next resonance will be obtained when the level of water from the open end is

(a) 24*cm* (b) 32*cm*
(c) 48*cm* (d) 64*cm*

3. To raise the pitch of a stringed musical instrument the player can

(a) Loosen the string (b) Tighten the string
(c) Shorten the string (d) Both (b) and (c)

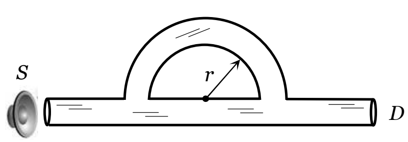
4. A wave travelling along positive *x*-axis is given by $y = A\sin(\omega t - kx)$. If it is reflected from rigid boundary such that 80% amplitude is reflected, then equation of reflected wave is

(a) $y = A\sin(\omega t + kx)$ (b) $y = -0.8A\sin(\omega t + kx)$
(c) $y = 0.8A\sin(\omega t + kx)$ (d) $y = A\sin(\omega t + 0.8\,kx)$

5. The frequency of the first harmonic of a string stretched between two points is 100 *Hz*. The frequency of the third overtone is

(a) 200 *Hz* (b) 300 *Hz*
(c) 400 *Hz* (d) 600 *Hz*

6. A sound wave of wavelength 32 *cm* enters the tube at *S* as shown in the figure. Then the smallest radius *r* so that a minimum of sound is heard at detector *D* is



(a) 7*cm* (b) 14 *cm*
(c) 21*cm* (d) 28 *cm*

7. A stretched wire of length 110 *cm* is divided into three segments whose frequencies are in ratio 1 : 2 : 3. Their lengths must be

(a) 20 *cm* ; 30 *cm* ; 60 *cm*
(b) 60 *cm* ; 30 *cm* ; 20 *cm*
(c) 60 *cm* ; 20 *cm* ; 30 *cm*
(d) 30 *cm* ; 60 *cm* ; 20 *cm*

8. Unlike a laboratory sonometer, a stringed instrument is seldom plucked in the middle. Supposing a sitar string is plucked at about $\frac{1}{4}th$ of its length from the end. The most prominent harmonic would be

(a) Eighth (b) Fourth
(c) Third (d) Second

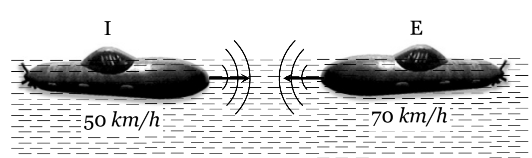
9. If $n_1, n_2, n_3 ....$ are the frequencies of segments of a stretched string, the frequency *n* of the string is given by

(a) $n = n_1 + n_2 + n_3 + ...$ (b) $n = \sqrt{n_1 \times n_2 \times n_3 \times ....}$
(c) $\frac{1}{n} = \frac{1}{n_1} + \frac{1}{n_2} + \frac{1}{n_3} + ...$ (d) None of these

10. The equation of stationary wave along a stretched string is given by $y = 5\sin\frac{\pi x}{3}\cos 40\pi t$ where *x* and *y* are in centimetre and *t* in second. The separation between two adjacent nodes is : **[BHU 2004]**

(a) 6 *cm* (b) 4 *cm*
(c) 3 *cm* (d) 1.5 *cm*

11. An Indian submarine and an enemy submarine move towards each other during maneuvers in motionless water in the Indian ocean. The Indian submarine moves at 50 *km/h*, and the enemy submarine at 70 *km/h*. The Indian sub sends out a sonar signal (sound wave in water) at 1000 *Hz*. Sonar waves travel at 5500 *km/h*. What is the frequency detected by the Indian submarine



(a) 1.02 *kHz* (b) 2 *kHz*
(c) 2.5 *kHz* (d) 4.7 *kHz*

12. Two trains, one coming towards and another going away from an observer both at 4 *m/s* produce whistle simultaneously of frequency 300 *Hz*. Find the number of beats produced **[BHU 1998]**

(a) 5 (b) 6
(c) 7 (d) 12

13. A source of sound emits $200\pi W$ power which is uniformly distributed over a sphere of 10 *m* radius. What is the loudness of sound on the surface of a sphere

(a) 200 *dB* (b) 200 πdB

(c) 120 *dB* (d) 120 πdB

14. When a wave travels in a medium, the particle displacement is given by $y(x,t) = 0.03 \sin \pi(2t - 0.01x)$ where *y* and *x* are meters and *t* in seconds. The phase difference, at a given instant of time between two particle 25 *m*. apart in the medium, is

(a) $\frac{\pi}{8}$ (b) $\frac{\pi}{4}$

(c) $\frac{\pi}{2}$ (d) π

15. A sine wave has an amplitude *A* and wavelength λ. Let *V* be the wave velocity and *v* be the maximum velocity of a particle in the medium. Then

(a) $V = v \text{ if } \lambda = \frac{3A}{2\pi}$ (b) $V = v \text{ if } A = 2\pi\lambda$

(c) $V = v \text{ if } A = \frac{\lambda}{2\pi}$ (d) *V* can not be equal to *v*

16. A pipe open at both ends produces a note of frequency f_1. When the pipe is kept with $\frac{3}{4}$ *th* of its length it water, it produced a note of frequency f_2. The ratio $\frac{f_1}{f_2}$ is

[KCET 1998]

(a) $\frac{3}{4}$ (b) $\frac{4}{3}$

(c) $\frac{1}{2}$ (d) 2

17. A man fires a bullet standing between two cliffs. First echo is heard after 3 seconds and second echo is heard after 5 seconds. If the velocity of sound is 330 *m/s*, then the distance between the cliffs is

(a) 1650 *m* (b) 1320 *m*

(c) 990 *m* (d) 660 *m*

18. The equation for spherical progressive wave is (where *r* is the distance from the source)

(a) $y = a\sin(\omega t - kx)$ (b) $y = \frac{a}{\sqrt{r}}\sin(\omega t - kx)$

(c) $y = \frac{a}{2}\sin(\omega t - kx)$ (d) $y = \frac{a}{r}\sin(\omega t - kx)$

19. A tuning fork *A* produces 4 *beats/sec* with another tuning fork *B* of frequency 320 *Hz*. On filing the fork *A*, 4 *beats/sec* are again heard. The frequency of fork *A*, after filing is

[KCET (Engg./Med.) 1999]

(a) 324 *Hz* (b) 320 *Hz*

(c) 316 *Hz* (d) 314 *Hz*

20. The number of beats produced per second by two vibrations: $x_1 = x_0 \sin 646\pi t$ and $x_2 = x_0 \sin 652\pi t$ is

[UPSEAT 2005]

(a) 2 (b) 3

(c) 4 (d) 6

21. 50 tuning forks are arranged in increasing order of their frequencies such that each gives 4 beats/sec with its previous tuning fork. If the frequency of the last fork is octave of the first, then the frequency of the first tuning fork is

[UPSEAT 2000] **[DPMT 2005]**

(a) 200 *Hz* (b) 204 *Hz*

(c) 196 *Hz* (d) None of these

22. The fundamental frequency of a closed pipe is 220 *Hz*. If $\frac{1}{4}$ of the pipe is filled with water, the frequency of the first overtone of the pipe now is

[KCET 2001] **[EAMCET (Med.) 2000]**

(a) 220 *Hz* (b) 440 *Hz*

(c) 880 *Hz* (d) 1760 *Hz*

23. A glass tube 1.5 *m* long and open at both ends, is immersed vertically in a water tank completely. A tuning fork of 660 *Hz* is vibrated and kept at the upper end of the tube and the tube is gradually raised out of water. The total number of resonances heard before the tube comes out of water, taking velocity of sound air 330 *m/sec* is

[EAMCET (Engg.) 1999]

(a) 12 (b) 6

(c) 8 (d) 4

24. In the 5[th] overtone of an open organ pipe, these are (*N*-stands for nodes and *A*-for antinodes)

(a) 2*N*, 3*A* (b) 3*N*, 4*A*

(c) 4*N*, 5*A* (d) 5*N*, 4*A*

25. An engine approaches a hill with a constant speed. When it is at a distance of 0.9 *km* it blows a whistle, whose echo is heard by the driver after 5 *sec*. If speed of sound in air is 330 *m/s*, the speed of engine is

[AFMC 2000]

[CPMT 2002]

(a) 10 *m/s* (b) 20 *m/s*

(c) 30 *m/s* (d) 40 *m/s*

Answers and Solutions

(SET -17)

1. (a) Since there is no relative motion between the source and listener, So apparent frequency equals original frequency.

2. (c) Next resonance length after the fundamental is $3l_1 = 3\times 16 = 48\,cm$.

3. (d) Higher pitch means higher frequency

Frequency of a stringed system is given by

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

Hence, to get higher frequency (higher pitch) tension should be increase and length should be shorten.

4. (b) On getting reflected from a rigid boundary the wave suffers

Hence if $y_{incident} = A\sin(\omega t - kx)$

then $y_{reflected} = (0.8A)\ \sin\{\omega t - k(-x) + \pi\}$

$= -0.8A\sin(\omega t + kx)$ an additional phase change of π .

5. (c) Third overtone is the fourth harmonic i.e., $n_4 = 4n_1 = 4\times 100 = 400$ Hz

6. (b) Path difference $(\pi r - 2r) = \frac{\lambda}{2} = \frac{32}{2} = 16$,

$$r = \frac{16}{\pi - 2} = 14\,cm\ .$$

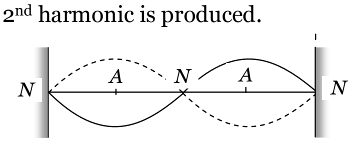
7. (b) $l_1 + l_2 + l_3 = 110\ cm$ and $n_1l_1 = n_2l_2 = n_3l_3$

$n_1 : n_2 : n_3 :: 1 : 2 : 3$

$\because\ \frac{n_1}{n_2} = \frac{1}{2} = \frac{l_2}{l_1} \Rightarrow l_2 = \frac{l_1}{2}$ and $\frac{n_1}{n_3} = \frac{1}{3} = \frac{l_3}{l_1} \Rightarrow l_3 = \frac{l_1}{3}$

$\therefore\ l_1 + \frac{l_1}{2} + \frac{l_1}{3} = 110$ so $l_1 = 60\,cm, l_2 = 30\,cm, l_3 = 20\,cm$.

8. (d) When plucked at one fourth it gives two loops, and hence 2nd harmonic is produced.



9. (c) For a vibrating string

$n_1l_1 = n_2l_2 = n_3l_3.....$ = constant = k (say) = nl

Also $l_1 + l_2 + l_3 + l_4 + ...= 1$

$$\frac{k}{n_1} + \frac{k}{n_2} + \frac{k}{n_3} + \frac{k}{n_4} + ... = \frac{k}{n} \Rightarrow \frac{1}{n} = \frac{1}{n_1} + \frac{1}{n_2} + \frac{1}{n_3} + ...$$

10. (c) Given $y = 5\sin\frac{\pi x}{3}\cos 40\,\pi t$

Comparing with $y = 2a\cos\frac{2\pi vt}{\lambda}\sin\frac{2\pi x}{\lambda} \Rightarrow \lambda = 6\,cm.$

$\therefore$ The separation between adjacent nodes $= \frac{\lambda}{2} = 3\,cm.$

11. (a) Frequency detected by Indian submarine

$$n' = n\left[\frac{v + v_{sub}}{v - v_{sub}}\right] = 1000\left[\frac{5500 + 50}{5500 - 50}\right] \approx 1.02\,kHz.$$

12. (c) $\Delta n = \left[\frac{v}{v-u} - \frac{v}{v+u}\right]n = \frac{2uv}{v^2 - u^2}n$

$$= \frac{2\times 4\times 332}{(332)^2 - (4)^2}\times 300 \approx 7$$

13. (c) Intensity = $\frac{\text{power}}{\text{area}} = \frac{200\,\pi}{2\pi\times 10^{-2}}$ = 1 Watt/m²

Now $L = 10\log_{10}\frac{I}{I_0} = 10\log_{10}\left(\frac{1}{10^{-12}}\right)$

$= 10\log_{10}10^{12} = 120\ dB$

14. (b) $y(x,t) = 0.03\sin\pi(2t - 0.01x) = 0.03\sin(2\pi t - 0.01\pi x)$

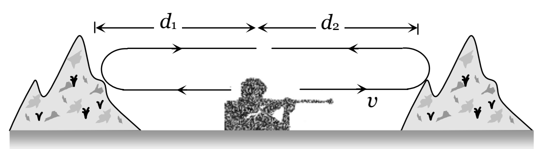
$$k = 0.01\pi = \frac{2\pi}{\lambda} \Rightarrow \Delta\phi = \frac{2\pi}{\lambda}\Delta x = 0.01\pi\times 25 = \frac{\pi}{4}$$

15. (c)Let wave velocity (V) = maximum particle velocity $\Rightarrow$ $n\lambda = \omega A = 2\pi\ nA \Rightarrow A = \frac{\lambda}{2\pi}$

16. c) For open pipe $f_1 = \frac{v}{2l}$ and for closed pipe

$$f_2 = \frac{v}{4\times\left(\frac{l}{4}\right)} = \frac{v}{l} = 2f_1 \Rightarrow \frac{f_1}{f_2} = \frac{1}{2}$$

17. (b)



$$2(d_1 + d_2) = v(t_1 + t_2) \Rightarrow d_1 + d_2 = \frac{330\times(3+5)}{2} = 1320\ m$$

18. (d) For spherical wave intensity $(I) \propto \frac{1}{(\text{Distance } r)^2}$

also $I \propto a^2 \Rightarrow a \propto \frac{1}{r}$. Hence equation of a cylindrical wave is $y = \frac{1}{r}\sin(\omega t - kx)$

19. (a) n_A = ?, n_B = Known frequency = 320 *Hz*

x = 4 *bps*, which remains same after filing.

Unknown fork A is filed so $n_A \uparrow$

Hence $n_A\uparrow - n_B = x \longrightarrow$ Wrong

$n_B - n_A\uparrow = x \longrightarrow$ Correct

$\Rightarrow \quad n_A = n_B - x = 320 - 4 = 316$ *Hz*.

This is the frequency before filing.

But in question frequency after filing is asked which must be greater than 316 *Hz*, such that it produces 4 *beats per sec*. Hence it is 324 *Hz*.

20. (b) From the given equation $\omega_1 = 2\pi n_1 = 646\pi \Rightarrow n_1 = 323$

and $\omega_2 = 2\pi n_2 = 652\pi \Rightarrow n_2 = 326$

Hence, beat frequency $= 326 - 323 = 3$

21. (c) Frequencies of tuning forks is given by

$$n_{\text{last}} = n_{\text{first}} + (N-1)x$$

$$2n = n + (50-1) \times 4 \Rightarrow n = 196\ Hz.$$

22. (c) Fundamental frequency of closed pipe

$n = \frac{v}{4l} = 220\ Hz \Rightarrow v = 220 \times 4l$

If $\frac{1}{4}$ of the pipe is filled with water then remaining length of air column is $\frac{3l}{4}$

Now fundamental frequency = $\frac{v}{4\left(\frac{3l}{4}\right)} = \frac{v}{3l}$ and

First overtone = $3\times$ fundamental frequency

$$= \frac{3v}{3l} = \frac{v}{l} = \frac{220 \times 4l}{l} = 880\ Hz.$$

23. (b) Suppose N resonance occurred before tube coming out.

Hence by using $l = \frac{(2N-1)v}{4n}$

$\Rightarrow 1.5 = \frac{(2N-1) \times 330}{4 \times 660} \Rightarrow N \approx 6$.

24. (c) In open organ pipe 5th overtone corresponds to 4th harmonic mode.

Also in open pipe, Number of nodes = Order of mode of vibration and number of antinodes = (Number of nodes + 1). Here number of nodes = 4, Number of antinodes = 4 + 1 =5.

25. (c) If the speed of engine is v, the distance traveled by engine in 5 *sec* will be $5v$, and hence the distance traveled by sound in reaching the hill and coming back to the moving driver = 900 + (900 – $5v$) = 1800 – $5v$

So the time interval between original sound and it's echo $t = \frac{(1800 - 5v)}{330} = 5 \Rightarrow v = 30\ m/s$.

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