Waves

1. The ratio of frequencies of fundamental harmonic produced by an open pipe to that of a closed pipe having the same length is **(2023)**
   (a) 3 : 1
   (b) 1 : 2
   (c) 2 : 1
   (d) 1 : 3

2. If the initial tension on a stretched string is doubled, then the ratio of the initial and final speeds of a transverse wave along the string is: **(2022)**
   (a) Options not available
   (b) $\frac{1}{\sqrt{2}}$
   (c) Options not available
   (d) Options not available

3. In a guitar, two strings A and B made of same material are slightly out of tune and produce beats of frequency 6 Hz. When tension in B is slightly decreased, the beat frequency increases to 7 Hz. If the frequency of A is 530 Hz, the original frequency of B will be : **(2020)**
   (a) 524 Hz
   (b) 536 Hz
   (c) 537 Hz
   (d) 523 Hz

4. The length of the string of a musical instrument is 90 cm and has a fundamental frequency of 120 Hz. Where should it be pressed to produce fundamental frequency of 180 Hz? **(2020 Covid Re-NEET)**
   (a) 60 cm
   (b) 45 cm
   (c) 80 cm
   (d) 75 cm

5. The fundamental frequency in an open organ pipe is equal to the third harmonic of a closed organ pipe. If the length of the closed organ pipe is 20 cm, the length of the open organ pipe is: **(2018)**
   (a) 12.5 cm
   (b) 8 cm
   (c) 13.2 cm
   (d) 16 cm

6. A tuning fork is used to produce resonance in a glass tube. The length of the air column in this tube can be adjusted by a variable piston. At room temperature of 27°C two successive resonances are produced at 20 cm and 73 cm of column length. If the frequency of the tuning fork is 320 Hz, the velocity of sound in air at 27°C is:
   (a) 350 m/s
   (b) 339 m/s
   (c) 330 m/s
   (d) 350 m/s

7. The two nearest harmonics of a tube closed at one end and open at other end are 220 Hz. What is the fundamental frequency of the system? **(2017-Delhi)**
   (a) 20 Hz
   (b) 30 Hz
   (c) 40 Hz
   (d) 10 Hz

8. Two cars moving in opposite directions approach each other with speed of 22 m/s and 16.5 m/s respectively. The driver of the first car blows a horn having a frequency 400 Hz. The frequency heard by the driver of the second car is [velocity of sound 340 m/s]: **(2017-Delhi)**
   (a) 361 Hz
   (b) 411 Hz
   (c) 448 Hz
   (d) 350 Hz

9. Due to Doppler effect, the shift in wavelength observed is 0.1Å, for a star producing a wavelength 6000Å. The velocity of recession of the star will be: **(2017-Gujrat)**
   (a) 20 kms^{-1}
   (b) 2.5 kms^{-1}
   (c) 10 kms^{-1}
   (d) 5 kms^{-1}

10. A metal rod of 1 m length, is dropped exact vertically on to a hard metal floor. Plate capacitor is to be designed, it is determined that the impact produces a longitudinal wave of 1.2 kHz frequency. The speed of sound in the metal rod is: **(2017-Gujrat)**

(a) 600 m/s
(b) 2400 m/s
(c) 1800 m/s
(d) 1200 m/s

11. Two open organ pipes of fundamental frequencies n_1 and n_2 are joined in series. The fundamental frequency of the new pipe so obtained will be: **(2017-Gujrat)**
(a) $(n_1 + n_2)$
(b) $\frac{n_1+n_2}{2}$
(c) $\sqrt{n_1^2 + n_2^2}$
(d) $\frac{n_1 n_2}{n_1+n_2}$

12. Three sound waves of equal amplitudes have frequencies $(n-1), n, (n+1)$. They superimpose to give beats. The number of beats produced per second will be: **(2016-II)**
(a) 3
(b) 2
(c) 1
(d) 4

13. The second overtone of an open organ pipe has the same frequency as the first overtone of a closed pipe L meter long. The length of the open pipe will be: **(2016-II)**
(a) $\frac{L}{2}$
(b) 4L
(c) L
(d) 2L

14. A body of mass m is attached to the lower end of a spring whose upper end is fixed. The spring has negligible mass. When the mass m is slightly pulled down and released, it oscillates with a time period of 3 s. When the mass m is increased by 1 kg, the time period of oscillations becomes 5 s. The value of m in kg is: **(2016-II)**
(a) $\frac{16}{9}$
(b) $\frac{9}{16}$
(c) $\frac{3}{4}$
(d) $\frac{4}{3}$

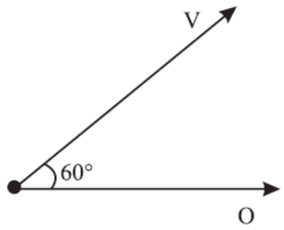
15. An air column, closed at one end and open at the other, resonates with a tuning fork when the smallest length of the column is 50 cm. The next larger length of the column resonating with the same tuning fork is: **(2016-I)**
(a) 66.7 cm
(b) 100 cm
(c) 150 cm
(d) 200 cm

16. A uniform rope of length L and mass m_1 hangs vertically from a rigid support. A block of mass m_2 is attached to the free end of the rope. A transverse pulse of wavelength λ_1 is produced at the lower end of the rope. The wavelength of the pulse when it reaches the top of the rope is λ_2. The ratio λ_2/λ_1 is: **(2016-I)**
(a) $\sqrt{\frac{m_1}{m_2}}$
(b) $\sqrt{\frac{m_1+m_2}{m_2}}$
(c) $\sqrt{\frac{m_2}{m_2}}$
(d) $\sqrt{\frac{m_1+m_2}{m_1}}$

17. A siren emitting a sound of frequency 800 Hz moves away from an observer towards a cliff at a speed of $15 ms^{-1}$. Then, the frequency of sound that the observer hears in the echo reflected from the cliff is:
(Take velocity of sound in air = 330 ms^{-1}) **(2016-I)**
(a) 765 Hz
(b) 800 Hz
(c) 838 Hz
(d) 885 Hz

18. The fundamental frequency of a closed organ pipe of length 20 cm is equal to the second overtone of an organ pipe open at both the ends. The length of organ pipe open at both the ends is: **(2015)**
(a) 100 cm
(b) 120 cm
(c) 140 cm
(d) 80 cm

19. A source of sound S emitting waves of frequency 100 Hz and an observer O are located at some distance from each other. The source is moving with a speed of 19.4 ms^{-1} at an angle of 60° with the source observer line as shown in the figure. The observer is at rest. The apparent frequency observed by the observer (velocity of sound in air 330 ms^{-1}) is: **(2015 Re)**



(a) 106 Hz
(b) 97 Hz
(c) 103 Hz
(d) 100 Hz

20. The number of possible natural oscillations of air column in a pipe closed at one end of length 85 cm whose frequencies lie below 1250 Hz are (velocity of sound = 340 ms^{-1}): **(2014)**
(a) 4
(b) 5
(c) 7
(d) 6

21. If n_1, n_2 and n_3 are the fundamental frequencies of three segments into which a string is divided, then the original fundamental frequency n of the string is given by: **(2014)**
(a) $\frac{1}{n} = \frac{1}{n_1} + \frac{1}{n_2} + \frac{1}{n_3}$
(b) $\frac{1}{\sqrt{n}} = \frac{1}{\sqrt{n_1}} + \frac{1}{\sqrt{n_2}} + \frac{1}{\sqrt{n_3}}$
(c) $\sqrt{n} = \sqrt{n_1} + \sqrt{n_2} + \sqrt{n_3}$
(d) $n = n_1 + n_2 + n_3$

22. A speeding motorcyclist sees traffic jam ahead him. He slows down to 36 km hour–1. He finds that traffic has eased and a car moving ahead of him at 18 km hour^{-1} is honking at a frequency of 1392 Hz. If the speed of sound is 343 ms^{-1}, the frequency of the honk as heard by him will be **(2014)**
(a) 1332 Hz
(b) 1372 Hz
(c) 1412 Hz
(d) 1454 Hz

23. If we study the vibration of a pipe open at both ends, then the following statement is not true: **(2013)**
(a) Pressure change will be maximum at both ends
(b) Open end will be anti-node
(c) Odd harmonics of the fundamental frequency will be generated
(d) All harmonics of the fundamental frequency will be generated

24. A source of unknown frequency gives 4 beats/s, when sounded with a source of known frequency 250 Hz. The second harmonic of the source of unknown frequency gives five beats per second, when sounded with a source of frequency 513 Hz. The unknown frequency is: **(2013)**
(a) 260 Hz
(b) 254 Hz
(c) 246 Hz
(d) 240 Hz

25. A wave travelling in the +ve x-direction having displacement along y-direction as 1m, wavelength 2π m and frequency of $1/\pi$ Hz is represented by:
(a) $y = \sin(2\pi x + 2\pi)$
(b) $y = \sin(x - 2t)$
(c) $y = \sin(2\pi x - 2\pi t)$
(d) $y = \sin(10\pi x - 20\pi)$

Answer Key

S1. Ans. (c)

S2. Ans. (b)

S3. Ans. (a)

S4. Ans. (a)

S5. Ans. (c)

S6. Ans. (b)

S7. Ans. (a)

S8. Ans. (c)

S9. Ans. (d)

S10. Ans. (b)

S11. Ans. (d)

S12. Ans. (b)

S13. Ans. (d)

S14. Ans. (b)

S15. Ans. (c)

S16. Ans. (b)

S17. Ans. (c)

S18. Ans. (b)

S19. Ans. (c)

S20. Ans. (d)

S21. Ans. (a)

S22. Ans. (c)

S23. Ans. (a)

S24. Ans. (b)

S25. Ans. (b)

Solutions

S1. Ans.(c)

Fundamental harmonic frequency open pipe $= \frac{v}{4L} = v_2$ (say)

$\Rightarrow \frac{v_1}{v_2} = \frac{\frac{v}{2L}}{\frac{v}{4L}}$ 2: 1

S2. Ans.(b)

$v \propto \sqrt{\text{Tension}}$

$\frac{v_i}{v_f} = \sqrt{\frac{T_i}{T_f}}$

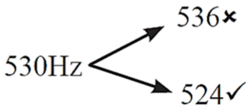
$\frac{v_i}{v_f} = \sqrt{\frac{T}{2T}}$

$\frac{v_i}{v_f} = \sqrt{\frac{1}{2}} = \frac{1}{\sqrt{2}}$

S3. Ans.(a)

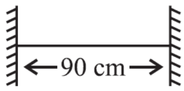
$\upsilon = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$

$|\eta_A - \eta_B| = 6Hz$

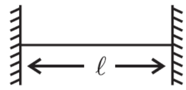


$|\eta_A - \eta_B^1| = 7Hz$

S4. Ans.(a)



$f = 120Hz = \frac{\nu}{2l} \Rightarrow 120 = \frac{\nu}{2(0.9)}$



$f = 180Hz = \frac{\nu}{2l}$

$\Rightarrow 180 = \frac{120\times 0.9}{l} \Rightarrow l = 60cm$

S5. Ans.(c)

Open O.P. $= f_0 = \frac{\nu}{2l_1}$

Closed O.P. $= f_3 = \frac{3\nu}{4l_2}$

$\frac{\nu}{2l_1} = 3\frac{\nu}{4l_2} \Rightarrow \frac{1}{l_1} = \frac{3}{2\times 20}$ $(\because l_2 = 20)$

$l_1 = \frac{40}{3} = 13.33\ cm$

S6. Ans.(b)

$\frac{\lambda}{2} = 73 - 20 = 53cm$

$V = f\lambda = 320 \times (53 \times 2 \times 10^{-2}) = 339.2$

S7. Ans.(a)

In a closed organ pipe

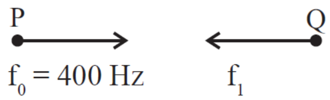
Fundamental frequency $f_0 = \frac{\nu}{4l}$ only odd harmonics produce so difference between any two successive harmonics

$260 - 220 = \frac{2\nu}{4l}$

$40 = \frac{2\nu}{4l}$

$40 = 2f_0 \Rightarrow f_0 = 20\ Hz$

S8. Ans.(c)



$v_0 = 22m/s$ $\quad v_0 = 16.5\ m/s$

$f_1 = f_0\left[\frac{v+v_0}{v-v_s}\right]$

$f_1 = 400\left[\frac{340+16.5}{340-22}\right]$

$f_1 = \frac{44}{8.4}Hz$

S9. Ans.(d)

Shifting in wavelength $\Delta\lambda = 0.1$Å

$\lambda = 6000$ Å

$\frac{V}{C} = \frac{\Delta\lambda}{\lambda}$

$V = \frac{\Delta\lambda\ C}{\lambda}$

$= \frac{0.1\times 10^{-10}\times 3\times 10^{8}}{6000\times 10^{-10}}$

$= 0.5 \times 10^4\ ms^{-1} = 5kms^{-1}$

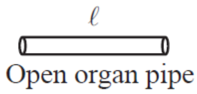
S10. Ans.(b)

$f = \frac{V}{2l}$

$1.2 \times 10^3 Hz = \frac{V}{2\times 1}$

$V = 2.4 \times 10^3\ m/s$

S11. Ans.(d)



$n = \frac{\nu}{2l} \Rightarrow l = \frac{\nu}{2n}$

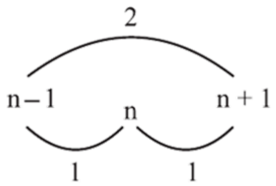
$l_1 = \frac{\nu}{2n_1}$ $\quad l_2 = \frac{\nu}{2n_2}$

$l = l_1 + l_2$

$\frac{v}{2n} = \frac{v}{2n_1} + \frac{v}{2n_2}$

$n = \frac{n_1 n_2}{n_1 + n_2}$

S12. Ans.(b)



Beats: Max difference between two wave frequency. Therefore (n + 1) – (n – 1) = 2

S13. Ans.(d)

For second overtone (3rd harmonic) in open organ pipe,

$\frac{3\lambda}{2} = l_0 \Rightarrow \lambda = \frac{2l_0}{3}$ For first overtone (3rd harmonic) in closed organ pipe,

$\frac{3\lambda}{2} = l_c \Rightarrow \lambda = \frac{4l_c}{3} = \frac{4L}{3}$

So, $\frac{2l_0}{3} = \frac{4L}{3} \Rightarrow l_0 = 2L$

S14. Ans.(b)

$T = 2\pi\sqrt{\frac{m}{k}}$

$3 = 2\pi\sqrt{\frac{m}{k}}$ ...(1)

$5 = 2\pi\sqrt{\frac{m}{k}}$ ...(2)

$\frac{(1)^2}{(2)^2} \Rightarrow \frac{9}{25} = \frac{m}{m+1} \Rightarrow m = \frac{9}{16}$

S15. Ans.(c)

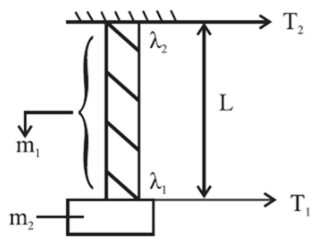
First minimum resonating length for closed organ pipe.

$= \frac{\lambda}{4} = 50\ cm$

Length of the air column

$= \frac{3\lambda}{4} = 150\ cm$

S16. Ans.(b)



$T_1 = m_2 g$

$T_2 = (m_1 + m_2)g$

We know velocity $\propto \sqrt{T}$

Also $\lambda \propto \sqrt{T}$

$\frac{\lambda_1}{\lambda_2} = \frac{\sqrt{T_1}}{\sqrt{T_2}} = \sqrt{\frac{m_2}{m_1 + m_2}}$

$\frac{\lambda_2}{\lambda_1} = \sqrt{\frac{m_1 + m_2}{m_2}}$

S17. Ans.(c)

$f' = \frac{f_0 \mathrm{v}}{\mathrm{v} - \mathrm{v}_{\text{source}}}$

$= \frac{800 \times 330}{330 - 15} = 838\ Hz$

S18. Ans.(b)

Fundamental frequency of closed organ pipe

$a = \frac{v}{4l_c}$

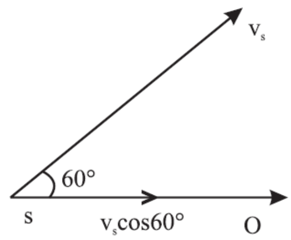
2nd overtone frequency of open organ pipe $= \frac{3v}{2l_0}$ Now,

$\frac{\mathrm{v}}{4l_c} = \frac{3\mathrm{v}}{2l_0} \Rightarrow l_0 = 6l_c = 6(20\ cm) = 120\ cm$

S19. Ans.(c)

$f_0 = f_s\left[\frac{\mathrm{v}}{\mathrm{v} - \mathrm{v}_s \cos 60°}\right]$

$\mathrm{v} = 330\ \mathrm{ms}^{-1}$



$f_0 = f_s\left(\frac{\mathrm{v}}{\mathrm{v} - \mathrm{v}_s}\right) = 100\left(\frac{330}{330 - \frac{19.4}{2}}\right) \approx 103Hz$

S20. Ans.(d)

Frequency COP, $f_n = (2n+1)\frac{\mathrm{v}}{41}$

For n = 0, f_0 = 100 Hz

n = 1, f_1 = 300 Hz

n = 2, f_2 = 500 Hz

n = 3, f_3 = 700 Hz

n = 4, f_4 = 900 Hz

n = 5, f_5 = 1100 Hz

Which are less than1250 Hz.

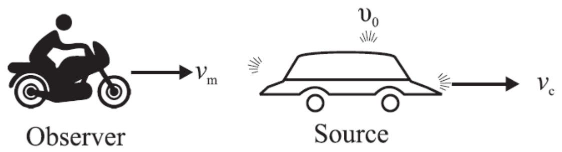
S21. Ans.(a)

Total length of string $l = l_1 + l_2 + l_3$

But frequency $\propto \frac{1}{\text{length}}$

Therefore, $\frac{1}{n} = \frac{1}{n_1} + \frac{1}{n_2} + \frac{1}{n_3}$

S22. Ans.(c)



Here, speed of motorcyclist,

$v_m = 36 \text{ km hour}^{-1} = 36 \times \frac{5}{18} \text{ms}^{-1} = 10\text{ms}^{-1}$

Speed for car,

$v_c = 18 \text{ km hour}^{-1} = 18 \times \frac{5}{18} \text{ms}^{-1} = 5\text{ms}^{-1}$

Frequency of source, $\upsilon_0 = 1392\ Hz$

Speed of sound, v = 343 ms^{-1}

The frequency of the honk heard by the motorcyclist is

$\upsilon' = \upsilon_0 \left(\frac{v + v_m}{v + v_c}\right) = 1392 \left(\frac{343+10}{343+5}\right)$

$= \frac{1392 \times 353}{348} = 1412\ Hz$

S23. Ans.(a)

Pressure change will be minimum at both open ends

S24. Ans.(b)

Frequency of unknown source = 246 Hz or 254 Hz Second harmonic of this source = 429 Hz or 508 Hz Which gives 5 beats per second, when sounded with a source of frequency 513 Hz. Therefore unknown frequency = 254 Hz.

S25. Ans.(b)

$k = \frac{2\pi}{\lambda} = \frac{2\pi}{2\pi} = 1$ and $\omega = 2\pi f = (2\pi)\left(\frac{1}{\pi}\right) = 2$

So equation of wave

$y = \sin(kx - \omega t) = \sin(x - 2t)$