Exercise - 1

1. The elevation of a cloud is 60° above the horizon. A thunder is heard 8 s after the observation of lightning. The speed of sound is 330 ms⁻¹. The vertical height of cloud from ground is

(A) 2826 m  
(B) 2682 m  
(C) 2286 m  
(D) 2068 m  

Sol.

2. The ratio of speed of sound in neon to that in water vapours at any temperature (when molecular weight of neon is 2.02 x 10⁻² kg mol⁻¹ and for water vapours is 1.8 x 10⁻² kg mol⁻¹)

(A) 1.06  
(B) 1.60  
(C) 6.10  
(D) 15.2  

Sol.

3. A Firecracker exploding on the surface of a lake is heard as two sounds a time interval t apart by a man on a boat close to water surface. Sound travels with a speed u in water and a speed v in air. The distance from the exploding firecracker to the boat is

(A) \( \frac{uvt}{u + v} \)  
(B) \( \frac{u + v}{uv} \)  
(C) \( \frac{uvt}{u - v} \)  
(D) \( \frac{uvt}{u + v} \)  

4. The energy per unit area associated with a progressive sound wave will be doubled if:
   (A) the amplitude of the wave is doubled
   (B) the amplitude of the wave is increased by 50%
   (C) the amplitude of the wave is increased by 41%  
   (D) None of these  

Sol.

5. A sound level I is greater by 3.0103 dB from another sound of intensity 10 nW cm⁻². The absolute value of intensity of sound level I in Wm⁻² is:

(A) 2.5 x 10⁻⁴  
(B) 2 x 10⁻⁴  
(C) 2 x 10⁻⁷  
(D) 2.5 x 10⁻⁷  

Sol.

6. A wave travels uniformly in all directions from a point source in an isotropic medium. The displacement of the medium at any point at a distance r from the source may be represented by (A is a constant representing strength of source)

(A) \( \frac{A}{r} \) \( \sin \) (kr - at)  
(B) \( \frac{A}{r} \) \( \sin \) (kr - at)  
(C) \( \frac{A}{r} \) \( \sin \) (kr - at)  
(D) \( \frac{A}{r^2} \) \( \sin \) (kr - at)  

Sol.
7. How many times more intense is 90 dB sound than 40 dB sound?
(A) 5  (B) 50  (C) 500  (D) 10

8. When two waves with same frequency and constant phase difference interfere,
(A) there is a gain of energy
(B) there is a loss of energy
(C) the energy is redistributed and the distribution changes with time
(D) the energy is redistributed and the distribution remains constant in time

9. Sound waves from a tuning fork F reach a point P by two separate routes FAP and FBP (when FBP is greater than FAP by 12 cm there is silence at P). If the difference is 24 cm the sound becomes maximum at P but at 36 cm there is silence again and so on. If velocity of sound in air is 330 ms\(^{-1}\), the least frequency of tuning fork is:
(A) 1537 Hz  (B) 1735 Hz
(C) 1400 Hz  (D) 1375 Hz

10. \( S_1 \) and \( S_2 \) are two sources of sound emitting sine waves. The two sources are in phase. The sound emitted by the two sources interfere at point F. The waves of wavelength:

\[ S_1 \quad 2m \quad S_2 \quad 4m \quad F \]

(A) 1 m will result in constructive interference
(B) \( \frac{2}{5} \) m will result in constructive interference
(C) 4 m will result in destructive interference
(D) All the above

11. The ratio of intensities between two coherent sound sources is 4:1. The difference of loudness in dB between maximum and minimum intensities when they interfere in space is:
(A) 10 \( \log 2 \)  (B) 20 \( \log 3 \)
(C) 10 \( \log 3 \)  (D) 20 \( \log 2 \)
12. In Quincke's tube a detector detects minimum intensity. Now one of the tube is displaced by 5 cm. During displacement detector detects maximum intensity 10 times, then finally a minimum intensity (when displacement is complete). The wavelength of sound is:
(A) 10/9 cm  (B) 1 cm  
(C) 1/2 cm  (D) 5/9 cm

13. Two waves of sound having intensities I and 4I interfere to produce interference pattern. The phase difference between the waves is $\frac{\pi}{2}$ at point A and $\pi$ at point B. Then the difference between the resultant intensities at A and B is
(A) 2I  (B) 4I  (C) 5I  (D) 7I

15. Sound waves of frequency 660 Hz fall normally on a perfectly reflecting wall. The shortest distance from the wall at which the air particle has maximum amplitude of vibration is (velocity of sound in air is 330 m/s)
(A) 0.125 m  (B) 0.5 m  
(C) 0.25 m  (D) 2 m

16. At the closed end of an organ pipe :
(A) the displacement is zero  
(B) the displacement is maximum  
(C) the wave pressure is zero  
(D) None of these

14. A cylindrical tube, open at one end and closed at the other, is in acoustic unison with an external source of frequency held at the open end of the tube, in its fundamental note. Then
(A) the displacement wave from the source gets reflected with a phase change of $\pi$ at the closed end  
(B) the pressure wave from the source get reflected without a phase change at the closed end  
(C) the wave reflected from the closed end again gets reflected at the open end  
(D) All the above

17. An open organ pipe of length L vibrates in its fundamental mode. The pressure variation is maximum
(A) at the two ends  
(B) at the middle of the pipe  
(C) at distance L/4 inside the ends  
(D) at distance L/8 inside the ends
18. The effect of making a hole exactly at \((1/3)^{\text{rd}}\) of the length of the pipe from its closed end is such that:
(A) its fundamental frequency is an octave higher than the open pipe of same length
(B) its fundamental frequency is thrice that before making a hole
(C) the fundamental alone is changed while the harmonics expressed as ratio of fundamentals remain the same
(D) All the above

19. An open organ pipe of length \(L\) vibrates in second harmonic mode. The pressure vibration is maximum
(A) At the two ends
(B) at a distance \(L/4\) from either end inside the tube
(C) At the mid-point of the tube
(D) None of these

20. An open organ pipe of length \(l\) is sounded together with another organ pipe of length \(l + x\) in their fundamental tones \((x < < l)\). The beat frequency heard will be (speed of sound is \(v\)):
(A) \(\frac{vx}{4l}\) 
(B) \(\frac{v^2}{2l}\) 
(C) \(\frac{vx}{2l}\) 
(D) \(\frac{v^2}{2l}\)

21. A sufficiently long close organ pipe has a small hole at its bottom. Initially the pipe is empty. Water is poured into the pipe at a constant rate. The fundamental frequency of the air column in the pipe
(A) Continuously increasing
(B) First increases and then becomes constant
(C) Continuously decreases
(D) First decreases and then become constant

22. A tuning fork of frequency 340 Hz is vibrated just above a cylindrical tube of length 120 cm. Water is slowly poured in the tube. If the speed of sound is 340 m/s then the minimum height of water required for resonance is:
(A) 95 cm 
(B) 75 cm 
(C) 45 cm 
(D) 25 cm

23. An organ pipe \(P_1\) closed at one end vibrating in its first overtone. Another pipe \(P_2\) open at both ends is vibrating in its third overtone. They are in a resonance with a given tuning fork. The ratio of the length of \(P_1\) to that of \(P_2\) is:
(A) 8/3 
(B) 3/8 
(C) 1/2 
(D) 1/3
24. A pipe’s lower end is immersed in water such that the length of air column from the top open end has a certain length 25 cm. The speed of sound in air is 350 m/s. The air column is found to resonate with a tuning fork of frequency 1750 Hz. By what minimum distance should the pipe be raised in order to make the air column resonate again with the same tuning fork? 
(A) 7 cm (B) 5 cm (C) 35 cm (D) 10 cm

25. In case of closed organ pipe which harmonic the p^{th} overtone will be.
(A) 2p + 1 (B) 2p - 1
(C) p + 1 (D) p - 1

26. A closed organ pipe has length ‘l’. The air in it is vibrating in 3^{rd} overtone with maximum displacement amplitude ‘a’. The displacement amplitude at distance l/7 from closed end of the pipe is:
(A) 0 (B) a
(C) a/2 (D) none of these

27. The number of beats heard per second if there are three sources of frequencies (n - 1), n and (n + 1) of equal intensities sounded together is:
(A) 2 (B) 1 (C) 4 (D) 3

28. A tuning fork of frequency 280 Hz produces 10 beats per sec when sounded with a vibrating sonometer string. When the tension in the string increases slightly, it produces 11 beats per sec. The original frequency of the vibrating sonometer string is:
(A) 269 Hz (B) 291 Hz
(C) 270 Hz (D) 290 Hz

29. The speed of sound in a gas, in which two waves of wavelength 1.0 m and 1.02 m produce 6 beats per second, is approximately:
(A) 350 m/s (B) 300 m/s
(C) 380 m/s (D) 410 m/s
30. Consider two sound sources $S_1$ and $S_2$ having same frequency 100 Hz and the observer $O$ located between them as shown in the figure. All the three are moving with same velocity in the same direction. The beat frequency of the observer is

(A) 50 Hz (B) 5 Hz (C) zero (D) 2.5 Hz

Sol.

31. A source $S$ of frequency $f_s$ and an observer $O$, moving with speeds $v_1$ and $v_2$ respectively, are moving away from each other. When they are separated by distance $a$ ($t = 0$), a pulse is emitted by the source. This pulse is received by $O$ at time $t_1$ then $t_2$, is equal to

(A) $\frac{a}{v_s + v_2}$ (B) $\frac{a}{v_1 + v_s}$

(C) $\frac{a}{v_s - v_2}$ (D) $\frac{a}{v_1 + v_2 + v_s}$

Sol.

32. A detector is released from rest over a source of sound of frequency $f_s = 10^4$ Hz. The frequency observed by the detector at time $t$ is plotted in the graph. The speed of sound in air is $v = 10$ m/s.

(A) 300 m/s (B) 350 m/s (C) 300 m/s (D) 310 m/s

Sol.

33. An observer starts moving with uniform acceleration 'a' towards a stationary sound source of frequency $f$. As the observer approaches the source, the apparent frequency $f'$ heard by the observer varies with time $t$ as:

(A) (B) (C) (D)

Sol.

34. A source of sound $S$ having frequency $f$. Wind is blowing from source to observer $O$ with velocity $u$. If speed of sound with respect to air is $C$, the wavelength of sound detected by $O$ is:

(A) $\frac{C + u}{f}$ (B) $\frac{C - u}{f}$

(C) $\frac{C(u)}{f}$ (D) $\frac{C}{f}$

Sol.
Exercise - II

SINGLE CORRECT

1. In a test of subsonic jet flies over head at an altitude of 100 m. The sound intensity on the ground as the jet passes overhead is 160 dB. At what altitude should the plane fly so that the ground noise is not greater than 120 dB.
   (A) above 10 km from ground
   (B) above 1 km from ground
   (C) above 5 km from ground
   (D) above 8 km from ground

Sol.

2. Three coherent waves of equal frequencies having amplitude 10 μm, 4 μm and 7 μm respectively, arrive at a given point with successive phase difference of $\pi/2$. the amplitude of the resulting wave in μm is given by
   (A) 5
   (B) 6
   (C) 3
   (D) 4

Sol.

3. A person standing at a distance of 6 m from a source of sound receives sound wave in two ways, one directly from the source and other after reflection from a rigid boundary as shown in figure. The maximum wavelength for which, the person will receive maximum sound intensity, is
   (A) 4 m
   (B) $\frac{16}{3}$ m
   (C) 2 m
   (D) $\frac{8}{3}$ m

Sol.

4. The ratio of maximum to minimum intensity due to superposition of two waves is $\frac{40}{9}$. Then the ratio of the intensity of component waves is
   (A) $\frac{25}{4}$
   (B) $\frac{16}{25}$
   (C) $\frac{4}{49}$
   (D) $\frac{9}{49}$

Sol.

5. The displacement sound wave in a medium is given by the equation $y = A \cos (ax + bt)$ where A, a and b are positive constants. The wave is reflected by an obstacle situated at $x = 0$. The intensity of the reflected wave is 0.64 times that of the incident wave. Tick the statement among the following that is incorrect.
   (A) the wavelength and frequency of the wave are $2\pi/a$ and $b/2\pi$ respectively
   (B) the amplitude of the reflected wave is 0.8 A
   (C) the resultant wave formed after reflection is $y = A \cos (ax + bt) + [-0.8 A \cos (ax - bt)]$ and $v_{\text{max}}$ (maximum particle speed) is 1.8 bA
   (D) the equation of the standing wave so formed is $y = 1.6 A \sin ax \cos bt$

Sol.
6. A tube of diameter \( d \) and of length \( l \) unit is open at both ends. Its fundamental frequency of resonance is found to be \( v_f \). The velocity of sound in air is \( 330 \text{ m/sec} \). One end of tube is now closed. The lowest frequency of resonance of tube is \( v_f \). Taking into consideration the end correction, \( \frac{v_f}{v_c} \) is:

\[
\begin{align*}
\text{(A)} & \quad \frac{1}{2} \left( \frac{d + 0.6d}{l + 0.3d} \right) \\
\text{(B)} & \quad \frac{1}{2} \left( \frac{d + 0.3d}{l + 0.3d} \right) \\
\text{(C)} & \quad \frac{1}{2} \left( \frac{d + 0.6d}{l + 0.6d} \right) \\
\text{(D)} & \quad \frac{1}{2} \left( \frac{d + 0.3d}{l + 0.6d} \right)
\end{align*}
\]

**Sol.**

7. In a closed end pipe of length 105 cm, standing waves are set up corresponding to the third overtone. What distance from the closed end, amongst the following, is a pressure node?

(A) 20 cm  (B) 60 cm  (C) 85 cm  (D) 45 cm

**Sol.**

8. A closed organ pipe of radius \( r_1 \) and an open organ pipe of radius \( r_2 \) and having same length 'L' resonate when excited with a given tunning fork. Closed organ pipe resonates in its fundamental mode where as open organ pipe resonates in its first overtone, then

\[
\begin{align*}
\text{(A)} & \quad r_2 - r_1 = L \\
\text{(B)} & \quad r_2 - r_1 = L/2 \\
\text{(C)} & \quad r_2 - 2r_1 = 2.5L \\
\text{(D)} & \quad 2r_2 - r_1 = 2.5L
\end{align*}
\]

**Sol.**

9. First overtone frequency of a closed organ pipe is equal to the first overtone frequency of an open organ pipe. Further nth harmonic of closed organ pipe is also equal to the mth harmonic of open pipe, where \( n \) and \( m \) are :

(A) 5, 4  (B) 7, 5  (C) 9, 6  (D) 7, 3.

**Sol.**

10. If \( l_1 \) and \( l_2 \) are the lengths of air column for the first and second resonance when a tuning fork of frequency \( n \) is sounded on a resonance tube, then the distance of the displacement antinode from the top end of the resonance tube is :

\[
\begin{align*}
\text{(A)} & \quad 2(l_2 - l_1) \\
\text{(B)} & \quad \frac{1}{2}(2l_1 - l_2) \\
\text{(C)} & \quad \frac{l_2 - 3l_1}{2} \\
\text{(D)} & \quad \frac{l_2 - l_1}{2}
\end{align*}
\]

**Sol.**

11. The first resonance length of a resonance tube is 40 cm and the second resonance length is 122 cm. The third resonance length of the tube will be

(A) 200 cm  (B) 202 cm  (C) 203 cm  (D) 204 cm

**Sol.**
12. The tuning forks A & B produce notes of frequencies 256 Hz & 262 Hz respectively. An unknown note sounded at the sametime as A produces beats. When the same note is sounded with B, beat frequency is twice as large. The unknown frequency could be:
(A) 268 Hz   (B) 250 Hz
(C) 260 Hz   (D) none of these

13. A closed organ pipe and an open pipe of same length produce 4 beats when they are set into vibrations simultaneously. If the length of each of them were twice their initial lengths, the number of beats produced will be:
(A) 2     (B) 4     (C) 1     (D) 8

14. Two trains move towards each other with the same speed. Speed of sound is 340 ms$^{-1}$. If the pitch of the tone of the whistle of one when heard on the other changes by 9/8 times, then the speed of each train is:
(A) 2 ms$^{-1}$  (B) 40 ms$^{-1}$
(C) 20 ms$^{-1}$  (D) 100 ms$^{-1}$
16. A small source of sound moves on a circle as shown in fig. and an observer is sitting at O. Let at \( v_1, v_2, v_3 \), be the frequencies heard when the source is at A, B, and C respectively.

(A) \( v_1 > v_2 > v_3 \)  
(B) \( v_1 = v_2 > v_3 \)  
(C) \( v_2 > v_3 > v_1 \)  
(D) \( v_1 > v_2 > v_3 \)

**Sol.**

17. The frequency changes by 10% as a sound source approaches a stationary observer with constant speed \( v_s \). What would be the percentage change in frequency as the source recedes the observer with the same speed. Given that \( v_s < v \). \( (v = \text{speed of sound in air}) \)

(A) 14.3%  
(B) 20%  
(C) 10.0%  
(D) 8.5%

**Sol.**

18. An engine whistling at a constant frequency \( n_0 \) and moving with a constant velocity goes past a stationary observer. As the engine crosses him, the frequency of the sound heard by him changes by a factor \( f \). The actual difference in the frequencies of the sound heard by him before and after the engine crosses him is

(A) \( \frac{1}{2} n_0 (1 - f^2) \)  
(B) \( \frac{1}{2} n_0 \left( \frac{1 - f^2}{1 + f} \right) \)  
(C) \( n_0 \left( \frac{1 - f}{1 + f} \right) \)  
(D) \( \frac{1}{2} n_0 \left( \frac{1 - f}{1 - f} \right) \)

**Sol.**

19. A stationary sound source 's' of frequency 334 Hz and a stationary observer 'O' are placed near a reflecting surface moving away from the source with velocity 2m/sec as shown in the figure. If the velocity of the sound waves in air is \( V = 330 \text{ m/sec} \), the apparent frequency of the echo is

(A) 332 Hz  
(B) 326 Hz  
(C) 334 Hz  
(D) 330 Hz

**Sol.**

20. A sounding body of negligible dimension emitting a frequency of 150 Hz is dropped from a height. During its fall under gravity it passes near a balloon moving up with a constant velocity of 2m/s one second after it started to fall. The difference in the frequency observed by the man in balloon just before and just after crossing the body will be: (Given that - velocity of sound = 300m/s; \( g = 10 \text{ m/s}^2 \))

(A) 12  
(B) 6  
(C) 8  
(D) 4

**Sol.**
21. Two sound sources each emitting sound of wavelength λ are fixed some distance apart. A listener moves with a velocity u along the line joining the two sources. The number of beats heard by him per second is -

(A) \( \frac{2u}{\lambda} \)  
(B) \( \frac{u}{\lambda} \)  
(C) \( \frac{u}{3\lambda} \)  
(D) \( \frac{2\lambda}{u} \)

Sol.

25. The maximum displaced points are
(A) a   (B) e   (C) g   (D) i

Sol.

26. The points of maximum compression are
(A) c   (B) g   (C) e   (D) k

Sol.

27. The points of maximum rarefaction are
(A) a   (B) e   (C) g   (D) i

Sol.

28. Which of the following graphs is/are correct.

(A)  
(B)  
(C)  
(D)  

Sol.
29. Which of the following statements are wrong about the velocity of sound in air:
(A) decreases with increases in temperature
(B) increases with decrease in temperature
(C) decreases as humidity increases
(D) independent of density of air.
Sol

30. Two interfering waves have the same wavelength, frequency, and amplitude. They are traveling in the same direction but are 90° out of phase. Compared to the individual waves, the resultant wave will have the same.
(A) amplitude and velocity but different wavelength
(B) amplitude and wavelength but different velocity
(C) wavelength and velocity but different amplitude
(D) amplitude and frequency but different velocity.
Sol

31. If a maxima is formed at the detector then, the magnitude of wavelength \( \lambda \) of the wave produced is given by
(A) \( \pi R \)
(B) \( \frac{\pi R}{2} \)
(C) \( \frac{\pi R}{4} \)
(D) \( \frac{2\pi R}{3} \)
Sol

32. If the minima is formed at the detector then, the magnitude of wavelength \( \lambda \) of the wave produced is given by
(A) \( 2\pi R \)
(B) \( \frac{3\pi R}{2} \)
(C) \( \frac{2\pi R}{3} \)
(D) \( \frac{2\pi R}{5} \)
Sol.

33. The maximum intensity produced at D is given by
(A) \( 4I_o \)
(B) \( 2I_o \)
(C) \( I_o \)
(D) \( 3I_o \)
Sol

34. The maximum value of \( \lambda \) to produce a maxima at D is given by
(A) \( \pi R \)
(B) \( 2\pi R \)
(C) \( \frac{\pi R}{2} \)
(D) \( \frac{3\pi R}{2} \)
35. The maximum value of λ to produce a minima at D is given by

(A) \( \pi R \)  
(B) \( 2\pi R \)  
(C) \( \frac{\pi R}{2} \)  
(D) \( \frac{3\pi R}{2} \)

Sol

36. The second overtone of an open organ pipe A and a closed pipe B have the same frequency at a given temperature. If it follows that the ratio of the

(A) length of A and B is 4 : 3 
(B) fundamental frequencies of A & B is 5 : 6 
(C) lengths of B to that of A is 5 : 6 
(D) frequencies of first overtone of A & B is 10 : 9

Sol

37. Four open organ pipes of different lengths and different gases at same temperature as shown in figure. Let \( f_A, f_B, f_C \) and \( f_D \) be their fundamental frequencies then : [Take \( \gamma_{CO_2} = 7/5 \)]

\[(A) \frac{f_A}{f_B} = \sqrt{2} \quad (B) \frac{f_B}{f_C} = \sqrt{72/28} \]
\[(C) f_C/f_D = \sqrt{11/28} \quad (D) f_D/f_A = \sqrt{78/11}\]

Sol

38. A gas is filled in an organ pipe and it is sounded with an organ pipe in fundamental mode. Choose the correct statement(s) : (T = constant)

(A) If gas is changed from H₂ to O₂, the resonant frequency will increase
(B) If gas is changed from O₂ to N₂, the resonant frequency will increase
(C) If gas is changed from N₂ to He, the resonant frequency will decrease
(D) If gas is changed from He to CH₄, the resonant frequency will decrease

Sol

39. A closed organ pipe of length 1.2 m vibrates in its first overtone mode. The pressure variation is maximum at:

(A) 0.8m from the open end 
(B) 0.4 m from the open end 
(C) at the open end 
(D) 1.0 m from the open end

Sol

40. For a certain organ pipe three successive resonance frequencies are observed at 425 Hz, 595 Hz and 765 Hz respectively. If the speed of sound in air is 340 m/s, then the length of the pipe is

(A) 2.0 m  
(B) 0.4 m  
(C) 1.0 m  
(D) 0.2 m

Sol
41. In an organ pipe whose one end is at $x = 0$, the pressure is expressed by $p = p_0 \cos \frac{3ax}{2}$ where $x$ is in meter and $t$ in sec. The organ pipe can be 
(A) closed at one end, open at another with length = 0.5 m 
(B) open at both ends, length = 1m 
(C) closed at both ends, length = 2m 
(D) closed at one end, open at another with length = $\frac{2}{3}$ m

**Sol**

42. Two whistles A and B each have a frequency of 500 Hz. A is stationary and B is moving towards the right (away from A) at a speed of 50 m/s. An observer is between the two whistles moving towards the right with a speed of 25 m/s. The velocity of sound in air is 350 m/s. Assume there is no wind. Then which of the following statements are true. 
(A) The apparent frequency of whistle B as heard by A is 444 Hz approximately 
(B) The apparent frequency of whistle B as heard by A is 469 Hz approximately 
(C) The difference in the apparent frequencies of A and B as heard by the observer is 4.5 Hz 
(D) The apparent frequencies of the whistles of each other as heard by A and B are the same

**Sol**

43. A source of sound moves towards an observer 
(A) the frequency of the source is increased 
(B) the velocity of sound in the medium is increased 
(C) the wavelength of sound in the medium towards the observer is decreased 
(D) the amplitude of vibration of the particles is increased

44. A car moves towards a hill with speed $v_i$. It blows a horn of frequency $f$ which is heard by an observer following the car with speed $v_e$. The speed of sound in air is $v$.

(A) the wavelength of sound reaching the hill is $\frac{v}{f}$ 
(B) the wavelength of sound reaching the hill is $\frac{v - v_e}{f}$ 
(C) the beat frequency observed by the observer is $\frac{v + v_e}{v - v_e}$ 
(D) the beat frequency observed by the observer is $\frac{2v_e(v + v_e)f}{v^2 - v_e^2}$

**Sol**
1. A sound wave of frequency 100 Hz is travelling in air. The speed of sound in air is 350 m/s. (a) By how much is the phase changed at a given point in 2.5 ms? (b) What is the phase difference at a given instant between two points separated by a distance of 10.0 cm along the direction of propagation?  

Sol.

2. The equation of a travelling sound wave is \( y = 6.0 \sin(600t - 1.8x) \) where \( y \) is measured in \( 10^{-4} \) m, \( t \) in second and \( x \) in metre. (a) Find the ratio of the displacement amplitude of the particles to the wavelength of the wave. (b) Find the ratio of the velocity amplitude of the particles to the wave speed.  

Sol.

3. A man stands before a large wall at a distance of 100.0 m and claps his hands at regular intervals. In such way that echo of a clap merges with the next clap. If he has to clap 5 times during every 3 seconds, find the velocity of sound in air.  

Sol.

4. Calculate the speed of sound in oxygen from the following data. The mass of 22.4 litre of oxygen at STP (\( T = 273 \) K and \( p = 1.0 \times 10^5 \) N/m\(^2\)) is 32 g, the molar heat capacity of oxygen at constant volume is \( C_v = 2.5 R \) and that at constant pressure is \( C_p = 3.5 R \).  

Sol.

5. In a mixture of gases, the average number of degrees of freedom per molecule is 6. The rms speed of the molecules of the gas is \( c \). Find the velocity of sound in the gas.  

Sol.

6. Find the intensity of sound wave whose frequency is 250 Hz. The displacement amplitude of particles of the medium at this position is \( 1 \times 10^{-4} \) m. The density of the medium is 1 kg/m\(^3\), bulk modulus of elasticity of the medium is 400 N/m\(^2\).  

Sol.

7. Two identical sounds A and B reach a point in the same phase. The resultant sound is C. The loudness of C is \( n \) dB higher than the loudness of A. Find the value of \( n \).  

Sol.
8. The loudness level at a distance R from a long linear source of sound is found to be 40dB. At this point, the amplitude of oscillations of air molecules is 0.01 cm. Then find the loudness level & amplitude at a point located at a distance '10R' from the source.

Sol.

9. Two point sound sources A and B each of power 25W and frequency 850 Hz are 1 m apart.
(a) Determine the phase difference between the waves emitting from A and B received by detector D as in figure. B
(b) Also determine the intensity of the resultant sound wave as recorded by detector D. Velocity of sound = 340 m/s.

Sol.

10. Two identical loudspeakers are located at points A & B, 2 m apart. The loudspeakers are driven by the same amplifier. A small detector is moved out from point B along a line perpendicular to the line connecting A & B. Taking speed of sound in air as 332 m/s. Find the frequency below which there will be no position along the line BC at which destructive interference occurs.

Sol.

11. A source of sound S and a detector D are placed at some distance from one another. A big cardboard is placed near the detector and perpendicular to the line SD as shown in figure. It is gradually moved away and it is found that the intensity changes from a maximum to a minimum as the board is moved through a distance of 20 cm. Find the frequency of the sound emitted. Velocity of sound in air is 336 m/s.

Sol.

12. Sound of wavelength \( \lambda \) passes through a Quincke's tube, which is adjusted to give a maximum intensity \( I_m \). Find the distance through the sliding tube should be moved to give an intensity \( I/2 \).

Sol.

13. The stationary wave \( y = 2a \sin kx \cos \omega t \) in a closed organ pipe is the result of the superposition of \( y = a \sin \omega (t - kx) \) &

Sol.

14. The equation of a longitudinal standing wave due to superposition of the progressive waves produced by Two sources of sound is \( s = -20 \sin kx \sin 100 \) at where \( s \) is the displacement from mean position measured in mm, \( x \) is in metres and \( t \) in seconds. The specific gravity of the medium is \( 10^3 \). Density of water = \( 10^3 \) kg/m³. Find:
(a) Wavelength, frequency and velocity of the progressive waves.
(b) Bulk modulus of the medium and the pressure amplitude.
(c) Minimum distance between pressure antinode and a displacement antinode.
(d) Intensity at the displacement nodes.
15. A tube 1.0 m long is closed at one end. A wire of length 0.3 m and mass $1 \times 10^{-7}$ kg is stretched between two fixed ends and is placed near the open end. When the wire is plucked at its mid point the air column resonates in its 1st overtone. Find the tension in the wire if it vibrates in its fundamental mode.

$[V_{\text{sound}} = 330 \text{ m/s}]$

**Sol.**

16. A closed organ pipe of length $l = 100 \text{ cm}$ is cut into two unequal pieces. The fundamental frequency of the new closed organ pipe piece is found to be same as the frequency of first overtone of the open organ pipe piece. Determine the length of the two pieces and the fundamental tone of the open pipe piece. Take velocity of sound = 320 m/s.

**Sol.**

17. Find the number of possible natural oscillations of air column in a pipe whose frequencies lie below $v_1 = 1250 \text{ Hz}$. The length of the pipe is $l = 85 \text{ cm}$. The velocity of sound is $v = 340 \text{ m/s}$.

Consider the two cases:
(a) the pipe is closed from one end
(b) the pipe is opened from both ends.

The open ends of the pipe are assumed to be the antinodes of displacement.

**Sol.**

18. The first overtone of a pipe closed at one end resonates with the third harmonic of a string fixed at its ends. The ratio of the speed of sound to the speed of transverse wave travelling on the string is 2 : 1. Find the ratio of the length of pipe to the length of string.

**Sol.**

19. In a resonance-column experiment, a long tube, open at the top, is clamped vertically. By a separate device, water level inside the tube can be moved up or down. The section of the tube from the open end to the water level act as a closed organ pipe. A vibrating tuning fork is held above the open end, first and the second resonances occur when the water level is 24.1 cm and 74.1 cm respectively below the open end. Find the diameter of the tube. [Hint: end correction is 0.3d]

**Sol.**

20. An open organ pipe filled with air has a fundamental frequency 500 Hz. The first harmonic of another organ pipe closed at one end and filled with carbon dioxide has the same frequency as that of the first harmonic of the open organ pipe. Calculate the length of each pipe. Assume that the velocity of sound in air and in carbondioxide to be 330 and 264 m/s respectively.

**Sol.**
21. Two identical piano wires have a fundamental frequency of 600 vib/sec, when kept under the same tension. What fractional increase in the tension of one wire will lead to the occurrence of six beats per second when both wires vibrate simultaneously.
   **Sol.**

22. A metal wire of diameter 1 mm, is held on two knife edges separated by a distance of 50 cm. The tension in the wire is 100 N. The wire vibrating in its fundamental frequency and a vibrating tuning fork together produces 5 beats per sec. The tension in the wire is then reduced to 81 N. When the two are excited, beats are again at the same rate. Calculate (a) the frequency of the fork (b) the density of the material of the wire.
   **Sol.**

23. Two stationary sources A and B are sounding notes of frequency 680 Hz. An observer 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
   **Sol.**

24. Tuning fork A when sounded with a tuning fork B of frequency 480 Hz gives 5 beats per second. When the prongs of A are loaded with wax, it gives 3 beats per second. Find the original frequency of A.
   **Sol.**

25. A, B and C are three tuning forks. Frequency of A is 350 Hz. Beats produced by A and B are 5 per second and by B and C are 4 per second. When a wax is put on A beat frequency between A and B is 2 Hz and between A and C is 6 Hz. Then, find the frequency of B and C respectively.
   **Sol.**

26. S, O & W represent source of sound (of frequency f), observer & wall respectively. \( V_o, V_w, V_p, V \) are velocity of observer, source, wall & sound (in still air) respectively. \( V_w \) is the velocity of wind. They are moving as shown. Find

   (i) The wavelength of the waves coming towards the observer from source.
   (ii) The wavelength of the waves incident on the wall.
   (iii) The wavelength of the waves coming towards observer from the wall.
   (iv) Frequency of the waves (as detected by O) coming from wall after reflection.
27. S is source R is receiver. R and S are at rest. Frequency of sound from S is \( f \). Find the beat frequency registered by R. Velocity of sound is \( v \).

![Diagram](https://via.placeholder.com/150)

29. The loudness level at a distance \( R \) from a long linear source of sound is found to be 40dB. At this point, the amplitude of oscillations of air molecules is 0.01 cm. Then find the loudness level & amplitude at a point located at a distance ‘10R’ from the source.

28. A car moving towards a vertical wall sounds a horn. The driver hears that the sound of the horn reflected from the cliff has a pitch half-octave higher than the actual sound. Find the ratio of the velocity of the car and the velocity of sound.

30. A fixed source of sound emitting a certain frequency appears as \( f' \), when the observer is approaching the source with speed \( v \) and frequency \( f \), when the observer recedes from the source with the same speed. Find the frequency of the source.

31. The first overtone of an open organ pipe beats with the first overtone of a closed organ pipe with a beat frequency of 2.2 Hz. The fundamental frequency of the closed organ pipe is 110 Hz. Find the lengths of the pipes. Velocity of sound = 330 m/s
1. The displacement of the medium in a sound wave is given by the equation \( y = A \cos(ax + bt) \) where \( A \), \( a \) & \( b \) are positive constants. The wave is reflected by an obstacle situated at \( x = 0 \). The intensity of the reflected wave is 0.64 times that of the incident wave.
(a) what are the wavelength & frequency of the incident wave.
(b) write the equation for the reflected wave.
(c) in the resultant wave formed after reflection, find the maximum & minimum values of the particle speeds in the medium.

2. (a) A standing wave in second overtone is maintained in a open organ pipe of length \( l \). The distance between consecutive displacement node and pressure node is ____________.
(b) Two consecutive overtones produced by a narrow air column closed at one end and open at the other are 750 Hz and 1050 Hz. Then the fundamental frequency from the column is ____________.
(c) A standing wave of frequency 1100 Hz in a column of methane at 20°C produces nodes that are 20 cm apart. What is the ratio of the heat capacity at constant pressure to that at constant volume.

3. Two speakers are driven by the same oscillator with frequency of 200 Hz. They are located 4 m apart on a vertical pole. A man walks straight towards the lower speaker in a direction perpendicular to the pole, as shown in figure.

(a) How many times will he hear a minimum in sound intensity, and
(b) how far is he from the pole at these moments?
Take the speed of sound to be 330 m/s, and ignore any sound reflections coming off the ground.

4. A cylinder ABC consists of two chambers 1 and 2 which contains two different gases. The wall C is rigid but the walls A and B are thin diaphragms. A vibrating tuning fork approaches the wall A with velocity \( u = 30 \) m/s and air columns in chamber 1 and 2 vibrates with minimum frequency such that there is node (displacement) at B and antinode (displacement) at A. Find
(i) the fundamental frequency of air column.
(ii) Find the frequency of tuning fork.
Assume velocity of sound in the first and second chamber be 1100 m/s and 300 m/s respectively. Velocity of sound in air 330 m/s.

5. A source emits sound waves of frequency 1000 Hz. The source moves to the right with a speed of 32 m/s relative to ground. On the right a reflecting surface moves towards left with a speed of 64 m/s relative to the ground. The speed of sound in air is 332 m/s. Find
(a) the wavelength of sound in air incident on reflecting surface
(b) the number of waves arriving per second which meet the reflecting surface.
(c) the speed of reflected waves.
(d) the wavelength of reflected waves.

6. A supersonic jet plane moves parallel to the ground at speed \( v = 0.75 \) mach (1 mach = speed of sound). The frequency of its engine sound is \( v_e = 2k \)Hz and the height of the jet plane is \( h = 1.5 \) km. At some instant an observer on the ground hears a sound of frequency \( v = 2v_e \) Find the instant prior to the instant of hearing when the sound wave received by the observer was emitted by the jet plane. Velocity of sound wave in the condition of observer \( = 340 \) m/s.

7. A train of length \( l \) is moving with a constant speed \( v \) along a circular track of radius \( R \). The engine of the train emits a whistle of frequency \( f \). Find the frequency heard by a guard at the rear end of the train. Make suitable assumption.

8. A bullet travels horizontally at 660 m/s at a height of 5 m from a man. How far is the bullet from the man when he hears its whistle? Velocity of sound in air = 340 m/s.
### Exercise - IV

#### PREVIOUS YEAR QUESTIONS

#### LEVEL - I

1. A tuning fork arrangement (pair) produces 4 beats per second with one fork of frequency 288 cps. A little wax is placed on the unknown fork and it then produces 2 beats per second. The frequency of the unknown fork is **[AIEEE 2002]**

   (a) 286 cps  
   (b) 292 cps  
   (c) 294 cps  
   (d) 288 cps  
   **Sol.**

   4. A tuning fork of known frequency 256 Hz makes 5 beats per second with the vibrating string of a piano. The beat frequency decreases to 2 beats per second when the tension in the piano string is slightly increased. The frequency of the piano string before increasing the tension was **[AIEEE 2003]**

   (a) (256 + 2) Hz  
   (b) (256 - 2) Hz  
   (c) (256 - 5) Hz  
   (d) (256 + 5) Hz  
   **Sol.**

2. Tube A has both ends open while tube B has one end closed, otherwise they are identical. The ratio of fundamental frequency of tubes A and B is **[AIEEE 2002]**

   (a) 1 : 2  
   (b) 1 : 4  
   (c) 2 : 1  
   (d) 4 : 1  
   **Sol.**

3. When temperature increases, the frequency of a tuning fork **[AIEEE 2002]**

   (a) increases  
   (b) decreases  
   (c) remains same  
   (d) increases or decreases depending on the material  
   **Sol.**

5. An observer moves towards a stationary source of sound, with a velocity one-fifth of the velocity of sound. What is the percentage increase in the apparent frequency? **[AIEEE 2005]**

   (a) zero  
   (b) 0.5%  
   (c) 5%  
   (d) 20%  
   **Sol.
6. When two tuning forks (forks 1 and forks 2) are sounded simultaneously, 4 beats per second are heard. Now, some tape is attached on the prong of the fork 2. When the tuning forks are sounded again, 6 beats per second are heard. If the frequency of fork is 200 Hz, then what was the original frequency of fork 2? [AIEEE 2005]
(a) 200 Hz  (b) 202 Hz  
(c) 196 Hz  (d) 204 Hz  
Sol.

7. A whistle producing sound waves of frequencies 9500 Hz and above is approaching a stationary person with speed v ms⁻¹. The velocity of sound in air is 300 ms⁻¹. If the person can hear frequencies up to a maximum of 10,000 Hz, the maximum value of v up to which he can hear the whistle is [AIEEE 2006]
(a) 15√2 ms⁻¹  (b) 15/√2 ms⁻¹  
(c) 15 ms⁻¹  (d) 30 ms⁻¹  
Sol.

8. A sound absorber attenuates the sound level by 20 db. The intensity decreases by a factor of [AIEEE 2007]
(a) 1000  (b) 10000  
(c) 10  (d) 100  
Sol.

9. While measuring the speed of sound by performing a resonance column experiment, a student gets the first resonance condition at a column length of 18 cm during winter. Repeating the same experiment during summer she measures the column length to be x cm for the second resonance. Then [AIEEE 2008]
(a) 18 > x  (b) x > 54  
(c) 54 > x > 36  (d) 36 > x > 18  
Sol.

10. The speed of sound in oxygen (O₂) at a certain temperature is 460 ms⁻¹. The speed of sound in helium (He) at the same temperature will be (assume both gases to be ideal) [AIEEE 2008]
(a) 1420 ms⁻¹  (b) 500 ms⁻¹  
(c) 650 ms⁻¹  (d) 330 ms⁻¹  
Sol.

11. Three sound waves of equal amplitudes have frequencies (ν - 1), ν, (ν + 1). They superpose to give beat. The number of beats produced per second will be [AIEEE 2009]
(a) 4  (b) 3  (c) 2  (d) 1  
Sol.
12. A motor cycle starts from rest & accelerates along a straight path at 2 m/s². At the starting point of the motor cycle there is a stationary electric siren. How far has the motor cycle gone when the driver hears the frequency of the siren at 94% of its value when the motor cycle was at rest? (speed of sound = 330 m/s) 
[AIEEE 2009]
(a) 49 m  (b) 98 m  (c) 147 m  (d) 196 m 
Sol.

14. A sonometer wire of length 1.5 m is made of steel. The tension in it produces an elastic strain of 1%. What is the fundamental frequency of steel if density and elasticity of steel are $7.7 \times 10^3$ kg/m³ and $2.2 \times 10^{11}$ N/m² respectively? 
[JEE MAIN 2013]
(A) 200.5 Hz  (B) 770 Hz  (C) 188.5 Hz  (D) 178.2 Hz 
Sol.

13. A cylindrical tube, open at both ends, has a fundamental frequency, $f$, in air. The tube is dipped vertically in water so that half of it is in water. The fundamental frequency of the air-column is now 
[AIEEE 2012]
Sol.
(a) $f$  (b) $\frac{f}{2}$  (c) $\frac{3f}{4}$  (d) $2f$
1. A siren placed at a railway platform is emitting sound of frequency 5 kHz. A passenger sitting in a moving train A records a frequency of 5.5 kHz while the train approaches the siren. During his return journey in a different train B he records a frequency of 6.0 kHz, while approaching the same siren. The ratio of the velocity of train B to that of train A is

\[ \text{[JEE-2002 (Scr), 3]} \]

(A) 242/252  
(B) 2  
(C) 5/6  
(D) 11/6  
Sol.

2. Two narrow cylindrical pipes A and B have the same length. Pipe A is open at both ends and is filled with a monoatomic gas of molar mass \( M_1 \). Pipe B is open at one end and closed at the other end, and is filled with a diatomic gas of molar mass \( M_2 \). Both gases are at the same temperature.

(a) If the frequency of the second harmonic of the fundamental mode in pipe A is equal to the frequency of the third harmonic of the fundamental mode in pipe B, determine the value of \( M_1 / M_2 \).

(b) Now the open end of pipe B is also closed (so that the pipe is closed at both ends). Find the ratio of the fundamental frequency in pipe A to that in pipe B.

\[ \text{[JEE-2002, 3 + 2]} \]

Sol.

3. A police van moving with velocity 22 m/s and emitting sound of frequency 176 Hz, follows a motor cycle in turn is moving towards a stationary car and away from the police van. The stationary car is emitting frequency 165 Hz. If motorcyclist does not hear any beats then his velocity is

\[ \text{[JEE-2003 (Scr)]} \]

(A) 22 m/s  
(B) 24 m/s  
(C) 20 m/s  
(D) 18 m/s  
Sol.

4. A cylindrical tube when sounded with a tuning fork gives, first resonance when length of air column is 0.1 and gives second resonance when the length of air column is 0.35 m. Then end correction is

\[ \text{[JEE-2003 (Scr)]} \]

(A) 0.025 m  
(B) 0.020 m  
(C) 0.018 m  
(D) 0.012 m  
Sol.

5. A tuning fork of frequency 480 Hz resonates with a tube closed at one end of length, 16 cm and diameter 5 cm in fundamental mode. Calculate velocity of sound in air.

\[ \text{[JEE-2003]} \]

Sol.
6. A closed organ pipe of length $L$ and an open organ pipe contain gases of densities $\rho_1$ and $\rho_2$ respectively. The compressibility of gases are equal in both the pipes. Both the pipes are vibrating in their first overtone with same frequency. The length of the open organ pipe is 

\[ \text{Sol.} \]

(A) $\frac{L}{3}$  \hspace{1cm} (B) $\frac{4L}{3}$ \\
(C) $\frac{4L}{3} \sqrt{\frac{\rho_1}{\rho_2}}$  \hspace{1cm} (D) $\frac{4L}{3} \sqrt{\rho_1}$

9. A whistling train approaches a junction. An observer standing at junction observes the frequency to be $2.2$ KHz and $1.8$ KHz of the approaching and the receding train. Find the speed of the train (speed sound = 300 m/s).

\[ \text{Sol.} \]

7. A source of sound of frequency 600 Hz is placed inside water. The speed of sound in water is 1500 m/s and in air it is 300 m/s. The frequency of sound recorded by an observer who is standing in air is

\[ \text{Sol.} \]

(A) 200 Hz  \hspace{1cm} (B) 3000 Hz \\
(C) 120 Hz  \hspace{1cm} (D) 600 Hz

10. How many times does an observer hear maximum intensity in one second?

\[ \text{Sol.} \]

(A) 4  \hspace{1cm} (B) 10  \hspace{1cm} (C) 6  \hspace{1cm} (D) 8

8. In a resonance column method, resonance occurs at two successive level of $l_1 = 30.7$ cm and $l_2 = 63.2$ cm using a tuning fork of $f = 512$ Hz. What is the maximum error in measuring speed of sound using relations $v = f \lambda$ & $\lambda = 2(l_1 - l_2)$

\[ \text{Sol.} \]

(A) 256 cm/sec  \hspace{1cm} (B) 92 cm/sec \\
(C) 128 cm/sec  \hspace{1cm} (D) 102.4 cm/sec

11. What is the speed of the second?

\[ \text{Sol.} \]

(A) 200 m/s  \hspace{1cm} (B) 180 m/s \\
(C) 192 m/s  \hspace{1cm} (D) 96 m/s

12. At $x = 0$ how many times the amplitude of $y_1 + y_2$ is zero in one second?

\[ \text{Sol.} \]

(A) 192  \hspace{1cm} (B) 48  \hspace{1cm} (C) 100  \hspace{1cm} (D) 96
Passage (Q.13 to 15)
Two trains A and B are moving with speeds 20 m/s and 30 m/s respectively in the same direction on the same straight track, with B ahead of A. The engines are at the front ends. The engine of train A blows a long whistle.

Assume that the sound of the whistle is composed of components varying in frequency from $f_1 = 800$ Hz to $f_2 = 1120$ Hz, as shown in the figure. The spread in the frequency (highest frequency–lowest frequency) is thus 320 Hz. The speed of sound in air is 340 m/s.

13. The speed of sound of the whistle is:
(A) 340 m/s for passengers in A and 310 m/s for passengers in B.
(B) 360 m/s for passengers in A and 310 m/s for passengers in B.
(C) 310 m/s for passengers in A and 360 m/s for passengers in B.
(D) 340 m/s for passengers in both the trains.

Sol.

14. The distribution of the sound intensity of the whistle as observed by the passengers in train A is best represented by:

(A) ![](Image)
(B) ![](Image)
(C) ![](Image)
(D) ![](Image)

Sol.

15. The spread of frequency as observed by the passengers in train B is:
(A) 310 Hz  
(B) 330 Hz  
(C) 350 Hz  
(D) 290 Hz

16. A vibrating string of certain length l under a tension T resonates with a mode corresponding to the first overtone (third harmonic) of an air column of length 75 cm inside a tube closed at one end. The string also generates 4 beats/s when excited along with a tuning fork of frequency n. Now when the tension of the string is slightly increased the number of beats reduces to 2 per second. Assuming the velocity of sound in air to be 340 m/s, the frequency n of the tuning fork in Hz is:
(A) 344  
(B) 336  
(C) 117.3  
(D) 109.3

Sol.

17. A student performed the experiment to measure the speed of sound in air using resonance air column method. Two resonances in the air column were obtained by lowering the water level. The resonance with the shorter air column is the first resonance and that with the longer air column is the second resonance. Then,

(A) the intensity of the sound heard at the first resonance was more than that at the second resonance
(B) the prongs of the tuning fork were kept in a horizontal plane above the resonance tube
(C) the amplitude of vibration of the ends of the prongs is typically around 1 cm
(D) the length of the air column at the first resonance was somewhat shorter than $\frac{1}{4}$ of the wavelength of the sound in air

Sol.
18. A stationary source is emitting sound at a fixed frequency $f_s$, which is reflected by two cars approaching the source. The difference between the frequencies of sound reflected from the cars is 1.2% of $f_s$. What is the difference in the speeds of the cars (in km per hour) to the nearest integer? The cars are moving at constant speeds much smaller than the speed of sound which is 330 ms$^{-1}$. [JEE 2010]

Sol.

19. A hollow pipe of length 0.8 m is closed at one end. At its open end a 0.5 m long uniform string is vibrating in its second harmonic and it resonates with the fundamental frequency of the pipe. If the tension in the wire is 50 N and the speed of sound is 320 ms$^{-1}$, the mass of the string is:

[JEE 2010]

(A) 5 g  (B) 10 g  (C) 20 g  (D) 40 g

Sol.

20. Column I shows four systems, each of the same length $L$, for producing standing waves. The lowest possible natural frequency of a system is called its fundamental frequency, whose wavelength is denoted as $\lambda_s$. Match each system with statement given in column II describing the nature and wavelength of the standing waves. [JEE 2011]

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) Pipe closed at one end</td>
<td>(P) Longitudinal waves</td>
</tr>
<tr>
<td>(B) Pipe open at both ends</td>
<td>(Q) Transverse waves</td>
</tr>
<tr>
<td>(C) Stretched wire clamped at both ends</td>
<td>(R) $\lambda_s = L$</td>
</tr>
<tr>
<td>(D) Stretched wire clamped at both ends and at mid point</td>
<td>(T) $\lambda_s = 4L$</td>
</tr>
</tbody>
</table>

Sol.

21. A police car with a siren of frequency 8 kHz is moving with uniform velocity 36 km/hr towards a tall building which reflects the sound waves. The speed of sound in air is 320 m/s. The frequency of the siren heard by the car driver is [JEE 2011]

(A) 8.50 kHz  (B) 8.25 kHz  
(C) 7.75 kHz  (D) 7.50 kHz
23. Two vehicles, each moving with speed $u$ on the same horizontal straight road, are approaching each other. Wind blows along the road with velocity $w$. One of these vehicles blows a whistle of frequency $f_s$. An observer in the other vehicle hears the frequency of the whistle of be $f'_s$. The speed of sound in still air is $V$. The correct statement(s) is (are) [JEE 2013]
(A) If the wind blows from the observer to the source, $f'_s > f_s$.
(B) If the wind blows from the source to the observer, $f'_s > f_s$.
(C) If the wind blows from observer to the source, $f'_s < f_s$.
(D) If the wind blows from the source to the observer, $f'_s < f_s$.
Sol.

22. A person blows into open-end of a long pipe. As a result, a high-pressure pulse of air travels down the pipe. When this pulse reaches the other end of the pipe,
(A) a high-pressure pulse starts travelling up the pipe, if the other end of the pipe is open.
(B) a low-pressure pulse starts travelling up the pipe, if the other end of the pipe is open.
(C) a low-pressure pulse starts travelling up the pipe, if the other end of the pipe is closed.
(D) a high-pressure pulse starts travelling up the pipe, if the other end of the pipe is closed. [JEE 2012]
Sol.
### Exercise - I

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### Exercise - II

|   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 42. | C | 43. | C | 44. | B, D |

### Exercise - III

#### (JEE ADVANCED)

#### LEVEL - I

<p>| | | | | | | |</p>
<table>
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</thead>
<tbody>
<tr>
<td>1. (a) ( \frac{\pi}{2} )  (b) ( \frac{2\pi}{35} )</td>
<td>2. (a) ( 1.7 \times 10^{-3} )  (b) ( 1.08 \times 10^{-4} )</td>
<td>3. ( 333 \text{ m/s} )</td>
<td>4. ( 310 \text{ m/s} )</td>
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<tr>
<td>5. 2c/3 6. ( \frac{\pi^2 \times 10^{-9}}{4} ) W/m²</td>
<td>7. 6</td>
<td>8. ( 30 \text{ dB, } 10\sqrt{10} \text{ mm} )</td>
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</tr>
</tbody>
</table>
| 9. (a) p  (b) \( L = (\sqrt{\frac{1}{4}} - \sqrt{\frac{1}{5}})^2 = (25/312)^2 \) 10. \( 83 \text{ Hz} \) | 11. \( 420 \text{ Hz} \) | 12. \( \lambda/8 \)
| 13. a \([\sin(kx + \omega t) + 2 \sin(kx - \omega t)]\) | 14. (a) \( f = 50 \text{ Hz, } \lambda = 0.2 \text{ m, } v = 10 \text{ ms}^{-1} \)  (b) \( P_e = 62.8 \text{ Nm}^2 = 20 \pi \text{ Nm}^2, B = 100 \text{ Nm}^2 \)  (c) \( \lambda/4 = 0.05 \text{ m} \)  (d) \( L = 20 n^2 \times 200 \text{ watt}^{-1} \) |
| 15. \( 735 \text{ N} \) | 16. \( 20, 80 \text{ cm, } 200 \text{ Hz} \) |
| 17. (a) \( v_s = \frac{V}{4\pi} (2n + 1) \); six oscillations  (b) \( v_n = \frac{V}{2\pi} (n+1) \), also six oscillations; Here \( n = 0, 1, 2, \ldots \) |
| 18. \( 1:1 \)  19. \( 3 \text{ cm} \)  20. \( 33 \text{ cm and } 13.2 \text{ cm} \)  21. \( 2 \% \) |
| 22. (a) \( 95\% \)  (b) \( \frac{40}{\pi} \times 10^3 \text{ kg/m}^3 \)  23. \( 2.5 \text{ ms}^{-1} \)  24. \( 485 \text{ Hz} \) |
| 25. \( 345, 341 \text{ or } 349 \text{ Hz} \) | 26. (i) \( (V - V_m + V_n) / f \)  (ii) \( (V + V_m - V_n) / f \) (iii) \( (V - V_m - V_n) / f \); where \( f = (V + V_m + V_n) / V + V_m - V_n \) f  (iv) \( (V - V_m - V_n) / V - V_m - V_n \) f |
| 27. \( f_o = \frac{2f}{V - u} \)  28. \( 1:5 \)  29. \( 30 \text{ dB, } 10\sqrt{10} \text{ mm} \)  30. \( \frac{L_f / 2}{L} \) |
| 31. \( L_s = 0.75 \text{ m, } L_s = \frac{150}{151} \text{ m, } 1.006 \text{ m} \) |
### Level - II

1. (a) \( \frac{2 \pi}{a} \), (b) \( b/2 \), (c) \( y = \pm 0.8 A \cos (ax - bt) \), (c) max. \( \pm 1.8 \) \( A \), min \( = 0 \),
2. (a) \( f/6 \); (b) 150 Hz; (c) 1.28
3. (a) 2; (b) 9.28 m and 1.99 m
4. 1650 Hz, 1500 Hz
5. (a) 0.3 m, (b) 1320, (c) 332 m/s, (d) 0.2 m
6. 5.9 sec
7. \( f \)
8. 9.7 m

### Exercise - IV

### Previous Year Questions

### Level - I

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### Level - II

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<tbody>
<tr>
<td>1.</td>
<td>B</td>
<td>2.</td>
<td>(a) 2.116, (b) 3/4</td>
<td>3.</td>
<td>A</td>
<td>4.</td>
<td>A</td>
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<tr>
<td>5.</td>
<td>336 m/s</td>
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<td>6.</td>
<td>C</td>
<td>7.</td>
<td>D</td>
<td>8.</td>
<td>D</td>
<td>9.</td>
<td>( V_1 = 30 ) m/s</td>
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<tr>
<td>14.</td>
<td>A</td>
<td>15.</td>
<td>A</td>
<td></td>
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<tr>
<td>20.</td>
<td>A ( \rightarrow PT ); B ( \rightarrow PS ); C ( \rightarrow QS ); D ( \rightarrow QR )</td>
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SOUND WAVES

Exercise - I

OBJECTIVE PROBLEMS (JEE MAIN)

1. C
   QQ = 8 x 330 = 2640 m
   \[ PQ = \text{QQ} \sin 60^\circ \]
   PQ = 2640 \times \frac{\sqrt{3}}{2} = 2286 m

2. A
   \[ v = \sqrt{\frac{\gamma RT}{M}} \]
   \[ \gamma \text{ for monoatomic} = 1.67 \]
   \[ \gamma \text{ for triatomic} = 1.3 \]
   \[ \frac{\frac{\gamma_1}{M_1} \frac{M_2}{\gamma_2}}{\frac{\gamma_1}{M_1} \frac{M_2}{\gamma_2}} = \sqrt{\frac{1.67 \times 1.8 \times 10^{-2}}{1.3 \times 2.02 \times 10^{-2}}} = 1.067 \]

3. D
   \[ \left( \frac{d - d}{\text{v} - \text{u}} \right) = \text{t}, \ \text{d} \left( \frac{1}{\text{v}} - \frac{1}{\text{u}} \right) = \text{t} \Rightarrow \text{d} = \left( \frac{\text{uv}}{\text{u} - \text{v}} \right) \text{t} \]

4. C
   \[ \frac{E}{A} = 1 \]
   \[ \frac{I}{r} = 21 \]
   \[ A^2 = \sqrt{2} A \ (1 \times A^2) \]
   \[ \Delta A = \sqrt{2} A - A = A (\sqrt{2} - 1) \]
   \[ \Delta A \% = (\sqrt{2} - 1) \times 100 = 41\% \]

5. B
   \[ L_1 - L_2 = 10 \log \frac{I_1}{I_2} \]
   \[ 0.30103 = 10 \log \frac{I_1}{I_2} \quad \Rightarrow \quad 2 = \frac{I_1}{I_2} \]
   \[ \log 2 = 0.30103 = I_1 = 2 \times 10^{-4} \text{Wm}^{-2} \]

6. B
   \[ I = \frac{A}{r} \text{(Amplitude)} \]
   \[ I = \frac{1}{r} \Rightarrow A = \frac{1}{r} \text{ Amplitude} = \frac{A}{r} \]
   \[ \Rightarrow A \sin (kr - wt) \]

7. D
   \[ (90 - 40) = 10 \log \frac{I_1}{I_2} \]
   \[ 5 = \log \frac{I_1}{I_2} \quad \Rightarrow \quad \frac{I_1}{I_2} = 10^5 \]

8. D
   \[ \text{frequency is same} \]
   \[ \text{energy remains conserved} \]
   \[ \Rightarrow \text{Redistribution is stable with time.} \]

9. D
   \[ \Delta x = 12 = \frac{\lambda}{2}, \quad \lambda = 24 \text{ cm} \]
   \[ f = \frac{\nu}{\lambda} = \frac{330}{24 \times 10^{-2}} = 1375 \text{ Hz} \]

10. D
    \[ \Delta x = 2 \text{ m for constructive interference} \]
    \[ 2 = n\lambda \]
    for Destructive \[ 2 = 2(n + 1) \frac{\lambda}{2} \]

11. B
    \[ \frac{I_1}{I_2} = 4 \quad \frac{I_3}{I_2} = 4 \]
    \[ I_{\text{max}} = \left( \sqrt{4} \times \sqrt{4} \right) = 9, \quad I_{\text{min}} = \left( \sqrt{4} - \sqrt{4} \right) = 1 \]
    \[ \Delta I = 10 \log I_{\text{max}} - 10 \log \frac{I_{\text{max}}}{I_{\text{min}}} = 10 \log \frac{9}{1} = 20 \log 3 \]

12. B
    \[ 11^{\text{th}} \text{ minima from the current minima} \]
    \[ \Delta x = 10\lambda \]

13. B
    \[ I_1 = I \quad I_2 = 4 \]
    \[ I_1 = I_1 + I_2 = 5I \]
    \[ I_2 = 1 \quad I = 9I \]
    \[ \Delta I = (I_2 - I_1) = 4I \]

14. D
    For displacement → Phase change π at close end
    For pressure → No phase change at close end

15. A
    \[ \lambda = \frac{330}{600} = \frac{1}{2} \]
    \[ \Rightarrow \frac{\lambda}{4} = \frac{1}{8} \Rightarrow 0.125 \text{ m} \]

16. A
    Pr node
    displacement = zero (node)

17. B
    at the middle of the pipe
18. D
How
\( \frac{\lambda}{4} = \frac{f}{3} \) \quad \lambda = \frac{4f}{3} \quad \text{Fundamental freq.} = \frac{3v}{4}\epsilon \quad \text{initially} = \frac{v}{4\epsilon} \Rightarrow \text{trice} \\
19. B
20. C
\[ f = \frac{v}{2l} \]
\[ f' = \frac{v}{2l + x} \]
\[ |f_i - f_a| = \frac{v}{2l} - \frac{v}{2l + x} \]
\[ = \frac{v}{2l} \left( \frac{x}{2l + x} \right) = \frac{vx}{2l^2} \]
21. B
f = \frac{v}{\lambda}
water poured into pipe then
\( \lambda \downarrow \) so f ↑
then Input water = output water
Hence f constant.
22. C
340 = \frac{340}{4(r-h)}
\[ 4r - 4h = 1 \]
\[ \lambda = \frac{3.8}{4} = 0.95 \text{ m} \]
23. B
\[ \frac{\lambda_1}{\lambda_2} = \frac{3.1/4}{2.2} = \frac{3}{8} \]
24. D
1750 = \frac{350}{\lambda}
\[ \lambda = \frac{1}{5} = 20 \text{ cm} \]
should be raised by \( \frac{\lambda}{2} = 10 \text{ cm} \).
25. A
\[ f_0 = \frac{\lambda}{4\epsilon} \]
\[ f = \frac{(2n+1)v}{4\epsilon} \quad (2n + 1) \text{overtone} \]
\[ \Rightarrow (2P + 1) \text{overtone} \]
26. B
\[ \frac{7\lambda}{4} = f \]
\[ \frac{\lambda}{4} = \frac{f}{7} \]
\[ \therefore \text{Amplitude} = a \]
27. B
\[ (n-1) \quad n \quad (n+1) \]
common beat = 1.
28. D
280 ± 10
\[ f = \frac{v}{2l} = \frac{1}{2l} \frac{T}{\mu} \]
\[ \Rightarrow T \uparrow, v \downarrow, f \uparrow \Rightarrow \therefore 290 \text{ Hz} \]
29. B
\[ \frac{v}{\lambda_1} = \frac{v}{\lambda_2} = 6 \Rightarrow \frac{v}{1.02} = 6 \]
\[ \lambda_1 = \frac{6v}{1.02} \quad \lambda_2 = \frac{6v}{1.00} \]
\[ v = \frac{306 \times 300 \text{ m/s}}{0.02} \]
30. C
30 m/s \rightarrow S \rightarrow O \rightarrow S',
\[ f = 100 \text{ Hz} \]
\[ f'_{s1} = \left( \frac{v - v_0}{v} \right) 100 = 100 \]
\[ f'_{s2} = \left( \frac{v + v_0}{v} \right) 100 = 100 \]
No Beat.
31. C
\[ v_s - v \rightarrow \text{Relative velocity} \Rightarrow t = \frac{a}{v_s - v_2} \]
32. C
\[ f' = \left( \frac{v + gt}{v} \right) f \]
\[ f' = f + \frac{gt}{v} \cdot t \Rightarrow f' = 1000 + 9 \times \frac{1000}{v} \cdot t \]
\[ t = 30 \text{ s} \]
\[ f' = 2000 \text{ Hz} \Rightarrow v = 300 \text{ m/s} \]
33. A
\[ f' = \left( \frac{v + at}{v} \right) f \]
\[ f' = f + \frac{at}{v} \cdot t \]
34. A
\[ \lambda = \frac{c + u}{f} \]
1. A

\[ 160 - 120 = 10 \log \frac{I_1}{I_2} \]

\[ 10^t = \frac{I_1}{I_2}, \quad I = \frac{1}{t^2} \]

\[ 10^t = \left( \frac{r_2}{r_1} \right)^2, \quad \frac{r_2}{r_1} = 100 \]

\[ r_1 = 10^t \text{ m}. \]

2. A

\[ \begin{align*}
\lambda_x &= 10 - 6 = 4 = n \lambda \\
\frac{\lambda}{n} &= \frac{4}{n}
\end{align*} \]

for \( \lambda \rightarrow \max \)

\[ n \rightarrow \min = 1 \]

\[ \lambda = 4 \]

3. A

\[ \text{V.A.} = 10 - 6 = 4 = n \lambda \]

\[ \frac{\lambda}{n} = \frac{4}{n} \]

for \( \lambda \rightarrow \max \)

\[ n \rightarrow \min = 1 \]

\[ \lambda = 4 \]

4. A

\[ \frac{I_{\text{max}}}{I_{\text{min}}} = \frac{1}{\sqrt{1 - \frac{r_2}{r_1}}} = \frac{49}{9} \]

\[ \Rightarrow \sqrt{\frac{I_1}{I_2}} = \frac{7}{3} \]

\[ \Rightarrow \frac{I_1}{I_2} = \frac{49}{9} \]

5. B

\[ y = A \cos (ax + bt) \]

\[ I_1 = 1 \]

\[ I_2 = 0.64I \]

\[ I \times A_\text{tot} = 0.64 I = A_\text{tot} \]

\[ A_\text{tot} = \sqrt{1} = 0.8 A \]

6. C

At point P so = zero

\[ t = (t_2 - 3t_1) \]

7. D

\[ \begin{align*}
v_1 &= \frac{v}{2(t + 0.6d)} \\
v_2 &= \frac{v}{2(t + 0.3d)} \\
v_1 &= \frac{v}{2(t + 0.3d)}
\end{align*} \]

\[ l = 105 \text{ cm} \]

\[ \frac{7l}{4} = 105 \]

for Pressure node

\[ \frac{\lambda_1}{4} \]

\[ \frac{105}{7} = 15 \text{ cm} \]

\[ \frac{3b}{4} = 45 \text{ cm} \]

8. \[ f_1 = \frac{v}{4(L + 0.6r_1)} \]

\[ f_2 = \frac{v}{(L - 0.6 \times 2r_2)} \]

\[ f_1 = \frac{v}{4(L + 0.6r_1)} = \frac{v}{(L - 1.2r_3)} \]

\[ 0.8 r_1 - 0.4 r_2 = -L \]

\[ r_1 - 2r_2 = 2.5 L \]

9. C

\[ \begin{align*}
\frac{3v_1}{4} &= \frac{v}{2} \\
v_1 &= \frac{v}{2}
\end{align*} \]

\[ \Rightarrow \frac{nv_1}{4} = \frac{mv_2}{2} \]

\[ \Rightarrow 2n = 3m \]

check the options

\[ n = 9, m = 6. \]

10. C

At point P so = zero

\[ t = (t_2 - 3t_1) \]
11. D

\( t_1 + e = \frac{\lambda}{4} \Rightarrow 40 + e = \frac{\lambda}{4} \) ........... (1)
\( t_2 + e = \frac{3\lambda}{4} \Rightarrow 122 + e = \frac{3\lambda}{4} \) ........... (2)
\( t_3 + e = \frac{5\lambda}{4} \)
\( (2) - (1) \)
\( 82 = \frac{\lambda}{2} \)
\( \lambda = 164, e = 1 \Rightarrow t_3 = \frac{5}{4} \times 164 - 1 = 205 - 1 = 204 \text{ cm.} \)

12. B

a is the +ve const.
(I) 256 + a = 262 - 2a = \( f_0 \) \( \Rightarrow a = 2 \)
\( f_0 = 258 \text{ Hz} \)
(II) 256 + a = 262 + 2a = \( f_0 \)
Not Possible
(III) 256 + a = 262 + 2a = \( f_0 \)
Not possible a have -ve value
(IV) 256 - a = 262 - 2a = \( f_0 \) \( \Rightarrow a = 6 \)
\( f_0 = 250 \text{ Hz} \)

13. A

\( f = \frac{v}{4\tau} \)
\( \frac{v_2}{f_2} = \frac{v}{2\tau} \)
\( |f_1 - f_2| = 4 \)
\( \Rightarrow \frac{v}{2} \left( \frac{1}{f_1} - \frac{1}{f_2} \right) = 4 \) ........ (1)
\( \Rightarrow \frac{v}{4} \left( \frac{1}{2f_1} - \frac{1}{f_2} \right) = n \) ........ (2)
from eq. (1) and (2)
\( n = 2 \)

14. C

\( f_1 = \frac{9}{8} \)
\( f_2 = \frac{9}{8} \)
\( f_3 = \left( \frac{v - v_2}{v - v_3} \right) f_1 \) \( (\therefore v_4 = v_3) \)
\( \Rightarrow \frac{v_3}{v - v_3} = 17 v = -v \)
\( \Rightarrow v_3 = 20 \text{ m/s} \) \( \Rightarrow v_3 = 20 \text{ m/s}. \)

15. B

\( f' = \left( \frac{v - v_2 \sin \theta}{v - 2v_2 \cos \theta} \right) f \)
\( f' = \left( \frac{v - v_2 / \sqrt{3}}{v - 2v_2} \right) f \) constant.

16. D

\( \frac{M}{f} = \left( \frac{v}{v - v_2} \right) - 1 = \frac{1}{10} \)
\( \Rightarrow v = \frac{v - v_2}{10} \) \( \Rightarrow v = \frac{1}{11} \)
\( \Rightarrow \frac{M}{f} = \frac{v}{v + v_2} - 1 = \frac{11v}{12} - 1 = \frac{1}{12} \)
\( \cdot 100 = 8.33 \% \)

17. D

\( f = \left( \frac{v}{v - v_2} \right) n_3 \)
\( f = \frac{v}{v - v_2} \)
\( f_3 = \left( \frac{v}{v + v_2} \right) n_3 \) \( \Rightarrow f = \left( \frac{v - v_2}{v + v_2} \right) \)
\( \Rightarrow v_3 = \left( \frac{1 - f}{1 + f} \right) v \) \( \Rightarrow f - f_3 = \frac{\sqrt{n_3(v_2^2)}}{v^2 - v_3^2} \)
\( \Rightarrow \frac{1}{f} = 2 \left( \frac{1}{f_3} - \frac{1}{f} \right) \)

18. B

\( f = \left( \frac{v}{v - v_2} \right) f_1 \)
\( f_1 = \frac{v}{v - v_2} \)
\( f_1 = f \)
\( f = \left( \frac{v - v_2}{v + v_2} \right) \)
\( \Rightarrow v_2 = \left( \frac{1 - f}{1 + f} \right) v \)
\( \Rightarrow f - f_2 = \frac{\sqrt{n_3(v_2^2)}}{v^2 - v_3^2} \)

19. D

\( f = \left( \frac{v - v_2}{v} \right) \)
\( f = \left( \frac{v}{v + v_2} \right) f \)
\( f = \left( \frac{v - v_2}{v + v_2} \right) f \) \( (\therefore v_3 = v) \)
\( = \left( \frac{330 - 2}{330 - 2} \right) \times 334 = 330 \text{ Hz} \)
20. A
\[ f' = \left( \frac{v - v_0}{v - v_s} \right) f \quad t = 1 \text{ s} \Rightarrow v_s = 10 \text{ m/s} \]
\[ f' = \left( \frac{v - v_0}{v + v_s} \right) f \quad v_0 = 2 \text{ m/s} \]
\[ f' = \left( \frac{300 + 2}{300 - 10} \right) \times 150 = 156 \]
\[ f' = \left( \frac{300 - 2}{300 + 10} \right) \times 150 = 144 \]
\[ \Rightarrow f' - f = 12 \text{ beat} \]

21. A
\[ f' = \left( \frac{v + u}{v} \right) f \]
\[ f' = \left( \frac{v - u}{v} \right) f \quad s_1, \quad u, \quad s_2. \]
\[ (f' - f) = \frac{1}{v} (24) f \]
\[ f_s = \frac{2u}{\lambda} \quad \lambda = \frac{v}{f} \]

22. B (Sol. of 22 to 27)
\[ \frac{\partial v}{\partial x} = -v = \frac{\partial x}{\partial t}, \quad v = \text{ve} \]
\[ \frac{\partial v}{\partial x} = -v = \frac{\partial y}{\partial t} = -v = \text{ve} \]

23. C
Stationary point or Max Displacement point.
\[ \frac{\partial y}{\partial x} = 0, \quad \frac{\partial y}{\partial t} = 0. \]

24. A

25. ABD

26. AD

27. C

29. A, B, C, D
\[ v = \sqrt{T}, \quad v \uparrow \text{ T} \uparrow \]
v is humid air.

30. C
\[ \lambda_1 = \lambda_2, \quad f_r = f_r \]
\[ A_1 = A_2 \quad \Delta \phi = \frac{\pi}{2} \]
\[ A_{max} = \sqrt{A_1^2 - A_2^2 + 2A_1A_2 \cos \frac{\pi}{2}} = \sqrt{A_1^2 + A_2^2} \]
\[ v = f \lambda = f_1 \lambda_1 = f_2 \lambda_2 \]

31. A, B, C
\[ \Delta x = nR = n\lambda \]
\[ \lambda = \frac{nR}{n} \]
\[ n = 1 \quad \lambda = nR \]
\[ n = 2 \quad \lambda = \frac{nR}{2} \]
\[ n = 3 \quad \lambda = \frac{nR}{3} \]
\[ n = 4 \quad \lambda = \frac{nR}{4} \]

32. A, C, D
\[ \Delta x = \frac{3}{4} (2\pi r) - \frac{2\pi r}{4} \]
\[ = \pi r = (2n + 1) \lambda \]
\[ n = 0 \quad \lambda = \frac{2\pi r}{3} \]
\[ n = 1 \quad \lambda = \frac{2\pi r}{5} \]
\[ n = 2 \quad \lambda = \frac{2\pi r}{5} \]

33. B
\[ I_{max} = 4I_0 \cos^2 \left( \frac{\pi}{4} \right) \]
\[ = 4I_0 \cos^2 \left( \frac{\pi}{4} \right) = 2I_0 \]

34. A
\[ \lambda x = nR = n\lambda \]
\[ \lambda = \frac{nR}{n} \]
\[ \text{for} \lambda \text{ max} n = 1 \]

35. B
\[ \Delta x = nR = (2n + 1) \lambda \]
\[ \lambda = \frac{2nR}{2n + 1} \]
\[ \text{for} \lambda_{max} \quad n = 0 \]
\[ \lambda = \frac{2nR}{2n + 1} \]

36. C, D
\[ f_1 = \frac{3\lambda_1}{2} \quad (r_2 = \frac{5\lambda_2}{4}) \]
\[ \lambda_1 = \frac{2\lambda_1}{3} \quad \lambda_2 = \frac{4\lambda_2}{5} \]
37. C

\[ f = \frac{3\nu}{2l_1} = \frac{5\nu}{4l_2} \quad \Rightarrow \quad \frac{l_1}{l_2} = 6 \]

Fundamental

\[ f_a = \frac{\nu}{2l_1}, \quad f_b = \frac{\nu}{4l_2} \]

\[ \frac{f_a}{f_b} = \frac{2/1}{4/2} = \frac{10}{6} \quad \text{(B)} \]

1st Overtone

\[ f_a = \frac{\nu}{l_1}, \quad f_b = \frac{3\nu}{4l_2} \]

\[ \frac{f_a}{f_b} = \frac{4/2}{3/1} = \frac{20}{18} = \frac{10}{9} \]

38. B, D

\[ f = \frac{\nu}{2l} = \sqrt{\frac{\alpha R T}{M}}, \quad f = \frac{1}{\sqrt{m}} \quad \text{M ↓ f ↑} \]

39. B

\[ \frac{3\lambda}{4} = 1.2, \quad \frac{\lambda}{4} = \frac{1.2}{3} = 0.4 \text{ from open end.} \]

40. C

Open organ pipe

\[ f = \frac{n\nu}{2l} = \frac{1.25}{2l} \quad \text{(1)} \]

\[ \frac{n - 1}{2l} = 1.75 \quad \text{(2)} \]

\[ \frac{n - 2}{2l} = 2.25 \quad \text{(3)} \]

from (1) and (2) \( \frac{2.5l + 1}{2l} = 1.75 \)

Close organ pipe

\[ f = \frac{(2n - 1)\nu}{4l} \]

\[ f = \frac{2n + 1}{4l} = 1.75 \quad \text{(2)} \]

\[ \frac{2n + 3}{4l} = 2.25 \quad \text{(3)} \]

from eq. (1) and (2)

\[ 2n - 1 = 5/l \]

\[ 2n + 1 = 7/l \]

41. C

\[ \frac{-2 = -2r}{l = 1 \text{ m.}} \]

\[ P = P_0 \cos \frac{3\pi x}{2} \times \sin 300 \pi t \]

at close end \( P_0 \rightarrow \text{Antinode} \)

at open end \( P_0 \rightarrow \text{node} \)

(A) at \( x = 0 \)

\[ P = P_0 \cos 0 = P_0 \quad \text{Antinode} \]

at \( x = 0.5 \text{ m} \)

\[ P = P_0 \cos 3\pi = -P_0 \quad \text{Antinode} \]

(c) at \( x = 0 \) antinode - close end.

at \( x = 2 \text{ m} \).

\[ P_0 \cos 3x = \text{antinode - close end.} \]

(D) \( x = 0 \) antinode - close end.

\[ x = \frac{2}{3} \quad \text{Antinode - close end.} \]

42. C

(A) \( f = \frac{\nu}{\nu - \nu_b} \times 500 \)

\[ \frac{350}{350 + 50} \times 500 = 437.5 \]

(B) \( f = \frac{\nu + \nu_2}{\nu + \nu_b} \times 500 \)

\[ \frac{350 + 25}{350 + 50} \times 500 = 468.7 \times 469 \text{ Hz.} \]

(C) \( f = \frac{\nu - \nu_0}{\nu - \nu_b} \times 500 = 464.3 \text{ Hz} \)

\[ (f_a - f_b) = 4.5 \text{ Hz} \]

(D) \( a = \frac{\nu}{\nu - \nu_b} \times 500 = 437.5 \text{ Hz} \)

\[ f_b = \frac{\nu - \nu_b}{\nu} \times 500, \quad = 428.6 \text{ Hz} \]

43. C

\[ \frac{1}{\nu} \quad \text{A} \]

44. B, D

\[ f' = \frac{\nu + \nu_0}{\nu - \nu_c} \rightarrow f' = \frac{\nu}{\nu - \nu_c} \]

(B) \( \lambda = \frac{\nu}{f} = \frac{\nu - \nu_c}{f} \)

(D) Beat frequency

\[ = \frac{2\nu_c(\nu + \nu_0)}{(\nu - \nu_c)(\nu - \nu_c)} \]

\[ = \frac{2\nu_c(\nu + \nu_0)}{(\nu - \nu_c)^2} \cdot f \]
Exercise - III

(JEE ADVANCED)

LEVEL - I

1. (a) \( f = 100 \text{ Hz} \).
\( v = 350 \text{ m/s} \)
\( t = 2.5 \times 10^{-1} \text{s} \)
\( \Delta x = 350 \times 2.5 \times 10^{-3} \) = 0.875
\( \Delta \phi = \frac{2\pi}{\lambda} \cdot \Delta x \\
= \frac{2\pi}{350} \times 100 \times 0.875 = \frac{\pi}{2} \)
(b) \( \Delta x = 10 \times 10^{-2} \text{ m} \).
\( \Delta \phi = \frac{2\pi}{350} \times 100 \times 10 \times 10^{-2} = \frac{2\pi}{35} \)

2. \( y = 6 \sin (600t - 1.8x) \)
(a) \( K = \frac{2\pi}{\lambda} = 1.8 \)
\( \lambda = \frac{10\pi}{9} \)
\( A = 6 \times 10^{-5} \text{ m} \)
\( \Rightarrow \frac{A}{\lambda} = \frac{6 \times 10^{-5} \times 9}{10\pi} = 1.7 \times 10^{-5} \)
(b) \( \omega = 600 \)
\( v = \frac{\omega}{k} = \frac{600}{1.8} = 333.33 \text{ m/s} \)
\( (v_p)_{max} = (6.0) \times 10^{-5} \times 600 = 36 \times 10^{-3} \)
\( (v_a)_{max} = 36 \times 10^{-3} \times 1.8 = 10.8 \times 10^{-3} \)

3. freq. = \( \frac{5}{3} \)
Time period of one clap to go to wall and come to man.
\( T = \frac{3}{5} \text{ s} \)
\( v = 200 \times 5 = 333.33 \text{ m/s} \)

4. 310 m/s
5. 2ε/3
6. \( f = 250 \text{ Hz} \).
\( A = 1 \times 10^{-14} \text{ m} \).
\( r = 1 \text{ kg/m}^3 \)
\( b = 400 \text{ N/m}^2 \)
\( v = \sqrt{\frac{r}{P}} = \sqrt{\frac{400}{1}} = 20 \text{ m/s} \)

1 = \( 2p^2 \pi A^2 \cdot rv \\
= 2p^2 \pi (250)^2 \times (10^{-4})^2 \times 1 \times 20 \\
= \frac{\pi^2}{4} \times 10^{-4} \text{ W/m}^2 \\

7. \( I_a = I_b = 1 \)
\( I_c = 41 \)
\( 10 \log \frac{I_a}{I_0} = n + 10 \log \frac{1}{I_0} \)
\( 10 \log 4 = n \)
\( n = 20 \log 2 \)
\( = 20 \times 0.3010 = 6 \)

8. 30 dB, 10\sqrt{10} \text{ mm} \)

9. (a) \( P = 25p \)
\( f = 850 \text{ Hz} \).
\( \Delta x = 2.6 \times 2.4 = 0.2 \)
\( \lambda = \frac{340}{850} = 0.4 \)
\( \Delta \phi = \frac{2\pi}{\lambda} \) \( (0.2) \)
\( = 2\pi \times 0.2 = \pi \)
(b) \( I = (\sqrt{I_a} - \sqrt{I_b})^2 \)
\( I_a = \frac{P}{\text{Area}} = \frac{25\pi}{4\pi(2.4)^2} = \frac{25}{23} \)
\( I_b = \frac{25\pi}{4\pi(2.6)^2} = \frac{25}{27} \)
\( I = \left( \sqrt{\frac{25}{23}} - \sqrt{\frac{25}{27}} \right) ^2 \)
\( = (1.04 - 0.96)^2 \)
\( = 6.4 \times 10^{-3} \text{ W/m}^2 \)

10. \( n = 332 \text{ m/s} \)
At point B
\( \Delta x = 2 \frac{\lambda}{2} \)
\( \lambda = 4 \)
\( f = \frac{v}{\lambda} = \frac{332}{4} = 83 \text{ Hz} \)

11. \[ I = I_1 + I_2 + 2\sqrt{I_1 \cdot I_2} \]

\[ \text{Diagram} \]
1. \( I_{\text{net}} = (\sqrt{I_1} + \sqrt{I_2})^2 \quad n = 336 \text{ m/s} \)

2. \( I_{\text{net}} = (\sqrt{I_1} - \sqrt{I_2})^2 \quad f = 7 \)

At position a, \( \Delta \phi = 0, 2\pi, 4\pi \)

\( \Rightarrow \Delta x = 0, \lambda, 2\lambda \)

At position b, \( \Delta \phi = \pi, 3\pi, 5\pi \)

\( \Rightarrow \Delta x = \frac{\lambda}{2}, \frac{3\lambda}{2}, \frac{5\lambda}{2} \)

It at position a, \( \Delta \phi = 2\pi \)

\( \Delta x_i = \lambda \)

\( \Delta x_j = \frac{3\lambda}{2} \)

\( \Delta x = \Delta x_j - \Delta x_i = \frac{\lambda}{2} \)

\( \frac{\lambda}{2} = 2 \times (20 \times 10^{-2}) \quad \Rightarrow \lambda = 80 \times 10^{-2} \)

\( f = \frac{v}{\lambda} = \frac{336}{80 \times 10^{-2}} = 420 \text{ Hz} \)

12. \( l = \frac{l_1 + l_2}{2} \quad l_1 = 41 \cos^2 \frac{\lambda}{2} \quad l_2 = \frac{l_0 \cos^2 \frac{\lambda}{2}}{2} \)

\( \frac{\lambda}{2} = \frac{\pi}{4} \)

\( \Rightarrow \Delta \phi = \frac{\pi}{2} \)

\( \frac{2\pi}{\lambda} \Delta x = \Delta \phi \)

\( \Delta x = \frac{\lambda}{2\pi} \Delta \phi = \frac{\lambda}{4} \quad \Rightarrow \quad x = \frac{\Delta x}{2} = \frac{\lambda}{8} \)

13. \( y = 2a \sin kx \cos \omega t \)

\( y = a \sin (\omega t - kx) \quad \text{......... (1)} \)

\( y = a[\sin(kx + \omega t) + 2 \sin (kx - \omega t)] \)

14. \( s = -20 \sin 10\pi x \sin 100\pi t \)

(a) \( k = 10\pi \)

\( \lambda = \frac{2\pi}{10\pi} = \frac{1}{5} \text{ m} \)

\( n = \frac{100\pi}{10\pi} = 10 \text{ m/s} \)

\( f = \frac{10}{1} \times 5 = 50 \text{ Hz} \)

(b) \( n = \frac{v}{\omega r} \)

15. \( \beta = n^2 \quad \beta r = 10^{-3} \times 10^3 \times 100 = 100 \)

\( \Delta P = \beta S \quad \Delta = 100 \times (10\pi) \)

\( (20 \times 10^{-3}) \quad 20\pi \)

\( c \quad \frac{\lambda}{4} = \frac{1}{20} \text{ m} \)

16. \( \frac{\lambda}{4} = \frac{x}{2} \quad \lambda = 4x \)

\( f = \frac{320}{4x} \)

\( (1 - x) = \lambda \)

\( f = \frac{320}{(1 - x)} \)

\( x = \frac{1}{5} \)

Length of close organ pipe

\( \frac{1}{5} = 20 \text{ cm} \)

Length of open organ pipe

\( 80 \text{ cm} \)

Fundamental tone of open organ pipe

\( = \frac{v}{2} = \frac{320}{2 	imes 0.8} = 200 \text{ Hz} \)

17. \( v = 1250 \text{ Hz} \)

\( f = 85 \text{ cm} = 0.85 \text{ m} \)

\( v = 340 \text{ m/s} \)

(a) \( f = \frac{(2n+1)v}{4r} \)

\( n = 0 \quad f = 100 \)

\( n = 1 \quad f = 300 \)

\( n = 2 \quad f = 500 \)

\( n = 3 \quad f = 700 \)
18. First Overtone

\[ \lambda_1 = \frac{4 \ell_1}{3} \]

\[ \frac{v_1}{v_w} = \frac{2}{1} \]

3rd harmonic

\[ \lambda_2 = \frac{2 \ell_2}{3} \]

\[ f_2 = \frac{v_x}{\lambda_2} = \frac{3v}{2 \ell_2} \]

\[ f_2 = \frac{v_2}{\lambda_2} = \frac{3v_2}{4 \ell_2} \]

given \( f_1 = f_3 \)

\[ \frac{3v_1}{4 \ell_1} = \frac{3v_2}{4 \ell_2} \]

\[ \frac{f_1}{f_2} = \frac{v_1}{2v_2} = \frac{2}{2(1)} = 1 \]

19. 

\[ \ell_1 = 24.1 \text{ cm} \]

\[ \ell_2 = 74.1 \text{ cm} \]

20. 

\[ f_0 = 500 \text{ Hz} = \frac{v}{2\ell} \]

\( r = 33 \text{ cm.} \)

\( l = 4r' \)

\[ f_0 = \frac{v}{\lambda} = \frac{v}{4r} \]

\[ \Rightarrow \frac{v}{4r} = 500 \]

\[ r' = \frac{4 \times 500}{13.2 \text{ cm}} \]

21. 

\[ f_0 = 600 \text{ Hz} = \frac{1}{2\ell} \sqrt{\frac{\mu}{T}} \]

\[ f' = 606 = \frac{1}{2r} \sqrt{\frac{T}{\mu}} \]

\[ 6 = \frac{1}{2r} \sqrt{\frac{T}{\mu}} \left[ \frac{T'}{T} - 1 \right] \]

\[ 6 = 600 \left[ \frac{T'}{T} - 1 \right] \]

\[ \left( \frac{\ell}{100} + 1 \right)^2 = \frac{T'}{T} = \frac{T + \Delta T}{T} \]

\[ \Delta T = \left( \frac{1}{100} - 1 \right)^2 - 1 \]

\[ \Delta T \% = \frac{0.02}{T} \]

22. 

\[ D = 1 \text{ mm} \]

\[ T_1 = 100 \text{ N} \]

\[ f_1 = 50 \text{ cm.} \]

\[ T_2 = 81 \text{ N} \]

\[ f_i = \frac{v}{2\ell} \]
23. \( f = 680 \text{ Hz.} \quad v = 340 \text{ m/s} \)

A \( \longrightarrow \) 10 Beats \( \longrightarrow \) B

\( f_u = \left( \frac{v - u}{v} \right) 680 \)

\( \Rightarrow \left| f_u - f_1 \right| = 10 \)

\( \Rightarrow v + u \times 680 - \left( \frac{v - u}{v} \right) \times 680 = 10 \)

\( \frac{680}{2[2u]} = 10 \)

\( u = \frac{10}{4} = 2.5 \text{ m/s.} \)

24. \( f = 480 \text{ Hz.} \)

\( \left| f - f_1 \right| = 5 \text{ Hz} \Rightarrow f_u = 485 \text{ or } 475 \)

\( \left| f - f_1 \right| = 3 \)

But after max. freq. induced
So, correct Ans is 485 Hz.

25. \( f = 350 \text{ Hz.} \)

\( \left| f - f_1 \right| = 5 \text{ Hz} \)......... (1)

\( \left| f - f_1 \right| = 2 \)......... (2)

\( \left| f - f_1 \right| = 6 \text{ Hz} \)......... (3)

\( f_u = f_1 - 5 = 345 \text{ Hz.} \)

\( f_u = 348 \text{ Hz.} \)

\( 345 - f_u = 4 \)

\( f_1 = 349 \text{ Hz.} \)

Or

\( 348 - f_u = 6 \)

\( f_1 = 342 \text{ Hz.} \)

26.(i)

\( \lambda = (v - v_u) T + v_u T \)

\( = \frac{f}{f} \quad \lambda \)

\( = \frac{f}{f} \quad \lambda \)

\( \lambda = (v + v_u) T - v_u T \)

\( = \frac{f}{f} \quad \lambda \)

\( = \frac{f}{f} \quad \lambda \)

\( \lambda = \frac{v + v_u - v_u}{f} \)

\( f' = \frac{v + v_u - v_u}{f} \quad f' \)

\( f' = \frac{v + v_u - v_u}{f} \quad f' \)

\( f' = \frac{v + v_u - v_u}{f} \quad f' \)
27. \( S \xrightarrow{f} R \)  

\[ f' = \frac{v-v_0}{v}, f \]

\[ f'' = \frac{v-u}{v+u}, f \]

Beat = \( |f'' - f'| \)

\[ f = f \left[ \frac{v-u-v-u}{v+u} \right] \]

\[ = \begin{bmatrix} -2u \\ u \end{bmatrix} \]

29. 30 dB, \( 10\sqrt{10} \) mm

30. \( f_c = \frac{v'-v}{v'} \cdot f \)

\[ f_c = \frac{v'-v}{v'} \cdot f \]

\[ f_c + f = f \left[ \frac{v'+v'-v'}{v'} \right] \]

\[ = \frac{2v'}{v'} \]

\[ f = \frac{f_c + f}{2} \]

31. \( f = \frac{v}{l_1} \)

\[ f = \frac{v}{4r_2} = 110 \]

\[ \Rightarrow l_2 = \frac{330}{4 \times 110} = \frac{3}{4} \text{ m.} \]

\[ \frac{v}{l_1} \cdot \frac{3v}{4r_2} = 2.2 \]

\[ \frac{1}{l_1} - \frac{3}{4} \times \frac{3}{4} = 2.2 \]

\[ \frac{v}{l_1} = 2.2 + 330 \]

\[ l_1 = \frac{330}{332.2} \]
1. \( y = A \cos (ax + bt) \)
   (a) \( \frac{2\pi}{\lambda} = \frac{a}{b} \Rightarrow \lambda = \frac{2\pi}{a} \)
   \( 2\pi f = b \Rightarrow f = \frac{b}{2\pi} \)
   (b) \( v_r = 0.8A \cos (ax - bt + \pi) \)
      \( v_i = -0.8A \cos (ax - bt) \)
      since \( A' = \left[ \frac{f'}{f} \right] A \)
      \( A' = 0.8A \)
   (c) Reflected & incidence from a wave of \( A_{inc} = A + 0.8A \)
   \( = 1.8A \)
   and \( A_{max} = A - 0.8A = 0.2A \)
   so \( V_{max} = 1.8Aw \) & \( V_{min} = 0.2Aw \)

2. (a)
   \( l = \frac{3}{2} \Rightarrow \lambda = \frac{2}{3}L \)
   disp. node to pressure
   node
   \[ \frac{\lambda}{2} = \frac{2f}{3x4} = \frac{f}{6} \]
   (b) \( 750 = (2n + 1)f \)
      \( 1050 = [2(n + 1) + 1]f = 750 + 2f \)
      \( 2f_s = 300 \Rightarrow f_s = 150Hz \)
   (c) \( \frac{\lambda}{2} = 20cm \)
      \( \Rightarrow \lambda = 0.4m \)
      \( v = f_s = 1100 \times 0.4 = 440m/s \)
      \( 440 = \sqrt{RT} \Rightarrow r = 8.31 \times 293 \times \left[ \frac{16}{1000} \right] = 1.28 \)

3. (a) \( \lambda = \frac{v}{f} = \frac{330}{200} = 1.65m \)
   \( d = 4m \)
   max. path difference = \( 4m = 2.42\lambda \)
   So minima at path difference \( \lambda x = 0.5\lambda, 1.5\lambda \)
   (b)
   \( \lambda x = \sqrt{\frac{l}{4} + 16} - \lambda = 0.5\lambda, 1.5\lambda \)
   where \( \lambda = 1.65m \)
   solving \( l = 9.28m \) & 1.99m

4. \begin{array}{c}
      AB \hspace{1cm} BC \\
      1100m/s \hspace{1cm} 300m/s \\
   \end{array}
   In AB \( f_i = \text{odd} \times \frac{V}{4l} = \text{odd} \times \frac{1100}{4 \times 0.5} = 550; 1650, 2750... \)
   In BC \( f_j = \frac{v}{2l} = n \times 150 = 150; 300; 450... \)
   common & last frequency = 1650 Hz
   (a) 1650n
   (b) \( f' = \frac{v}{v_v} f \)
   \( 1650 = \frac{330}{330 - 30} \times f \)
   \( f = \frac{1650 \times 30}{33} = 1500Hz \)

5. (a) \( l' = \frac{v - v_v}{f} = \frac{332 - 32}{1000} = 0.3m \)
   (b) \( f'' = \frac{v + v_v}{v - v_v} \times f = \frac{332 + 64}{332 - 32} \times 1000 = 1320Hz \)
   (c) \( \lambda' = \frac{v - v_v}{f} - \frac{332 - 32}{1320} = 0.2m \)

6. \( f = \frac{V}{V - v_v} f \)
   \( 2f_s = \frac{V}{V - v_v} f_0 \Rightarrow 2v - 2v_v = v \)
   \( \Rightarrow v_v = \frac{V}{2} = 170m/s \)
   \( = 1500 m \)
   \( \Rightarrow v_v = \frac{V}{2} = 170m/s \)

So, \( 0.75v \cos \theta = \frac{V}{2} \)
\( \cos \theta = \frac{1}{1.5} = \frac{2}{3} \)
Now, \( \frac{1500}{\sin \theta} = \frac{1500}{\sqrt{3}} = \frac{4500}{\sqrt{3}} = 900\sqrt{3} \)
\( t = \frac{900\sqrt{3}}{\sqrt{3}} = 20/12 \times 340 = 5.95 \)

7. \( V \cos \theta \)
\( f' = f \)
\( f' = f \)

8. \begin{array}{c}
      \text{5m} \hspace{1cm} \text{Distance} \\
      \text{660 m/s} \\
   \end{array}
   = 165 \times 9.7 \ m
Exercise - IV

PREVIOUS YEAR QUESTIONS

LEVEL - I

1. B

The tuning fork of frequency 288 Hz is producing 4 beats per second with the unknown tuning fork, i.e., the frequency difference between them is 4. Therefore, the frequency of unknown tuning fork.

\[ n = 288 \div 4 = 292 \text{ or } 284 \]

On placing a little wax on unknown tuning fork, its frequency decreases but now the number of beats produced per second is 2 i.e., the frequency difference now decrease. It is possible only when before placing the wax, the frequency of unknown fork is greater than the frequency of given tuning fork. Hence, the frequency of unknown tuning fork = 292 Hz.

2. C

Let the tubes A and B have equal length called as I. Since, tube A is opened at both the ends, therefore, its fundamental frequency

\[ n_A = \frac{v}{2A} \text{ ... (i)} \]

Since, tube B is closed at one end, therefore, its fundamental frequency

\[ n_B = \frac{v}{4I} \text{ ... (ii)} \]

From Eqs. (i) and (ii), we get

\[ \frac{n_A}{n_B} = \frac{\frac{v}{2A}}{\frac{v}{4I}} = 2 : 1 \]

3. B

4. C

\[ f_1 = 256 \text{ Hz} \]

For tuning fork \( f_1 - f_i = \pm 5 \),

\[ f_1 = \text{frequency of piano} \]

\[ f_2 = (256+5)\text{Hz}, \text{ or } (256-5)\text{Hz}, \]

When tension is increased, the beat frequency decreases to 2 beats per second. If we assume that the frequency of piano string is 261 Hz, then on increasing tension, frequency, more than 261 Hz. But it is given that beat frequency decreases to 2, therefore 261 Hz is not possible.

Hence, 251 Hz i.e., (256-5) was the frequency of piano string before increasing tension.

5. D

\[ v = \frac{v}{5}, \Rightarrow v = \frac{320}{5} = 64 \text{ ms}^{-1} \]

When observer moves towards the stationary source, then

\[ n' = \frac{v + v_a}{v} \]

\[ = (\frac{320 + 64}{320}) \text{ or } \frac{n'}{n} = \frac{384}{320} \]

Hence, percentage increase

\[ \frac{n' - n}{n} = \left( \frac{384 - 320}{320} \times 100 \right)\% = 20\% \]

6. C

The frequency of fork 2

\[ = 200 \div 4 = 196 \text{ or } 204 \text{ Hz} \]

Since, on attaching the tape on the prong of fork 2, its frequency decreases, but now the number of beats per second is 6 i.e., the frequency difference now increase. It is possible only when before attaching the tape, the frequency of fork 2 is less than the frequency of tuning fork 1. Hence, the frequency of fork 2 is 196 Hz.

7. C

Velocity of sound in air = 300 m/s

If a source of sound is moving towards a stationary listener, the frequency heard by the listener would be different from the actual frequency of the source, this apparent frequency is given by

\[ f_{\text{app}} = \left( \frac{v_{\text{source}}}{v_{\text{sound in air}}} \right) \text{, where symbols have their usual meanings.} \]

In the denominator +ve sign would be taken when source is receding away from the listener, while -ve sign would be taken when source is approaching the listener.

Let \( v \) be the maximum value of source velocity for which the person is able to hear the sound, then

\[ 10000 = f_{\text{app}} = \left( \frac{300}{300 - v} \right) \times 9500 \]

or

\[ v = 15 \text{ m/s} \]
8. D
Let intensity of sound be I and I'.
Loudness of sound initially
\[ \beta_1 = 10 \log \left( \frac{I}{I_0} \right) \]
Later, \( \beta_2 = 10 \log \left( \frac{I'}{I_0} \right) \)
\[ \beta_1 - \beta_2 = 20 \]
\[ 20 = 10 \log \left( \frac{1}{1} \right) \text{ or } \Gamma = \frac{1}{100} \]
Therefore, intensity decreases by a factor of 100.

9. B
\[ l_1 = 18 \text{ cm} \]
\[ f = \frac{v}{4l_1} \]
\[ f = \frac{3v}{4l_1} \]
where \( l_1 = x \) according to given situation and also \( v < v_s \) as during summer temperature would be higher
\[ \Rightarrow \frac{3v}{4l_1} = v_1 \]
or \[ l_2 = 3l_1 \]
\[ \Rightarrow x = 54 \times \left( \text{A quantity greater than 1} \right) \]
So, \( x > 54 \)

10. A
Speed of sound is given by,
\[ v = \sqrt{\frac{\gamma RT}{M}} \]
\[ v_{w} = \sqrt{\frac{7RT}{32}} \text{ and } v_{nc} = \sqrt{\frac{5RT}{4}} \]
\[ \therefore \frac{v_{w}}{v_{nc}} = \sqrt{\frac{3 \times 4}{5 \times 32 \times 5}} \]
or \[ v_{nc} = 460 \times \sqrt{\frac{32 \times 5}{7 \times 3 \times 4}} = 1420 \text{ ms}^{-1} \]
No option is matching with the real solution.

11. C
Maximum number of beats = \( v + 1 - (v-1) = 2 \)

12. B
Motor cycle, \( u = 0, a = 2 \text{ m/s}^2 \)
observer is in motion and source is at rest
\[ \Rightarrow n' = n \frac{v - v_s}{v - v_s} \]
\[ \Rightarrow 94 = n \frac{330 - v_s}{330} \]
\[ \Rightarrow 330 - v_s = \frac{330 \times 94}{100} \]
\[ \Rightarrow v_s = 330 - \frac{94 \times 33}{10} = \frac{33 \times 6}{10} \text{ ms}^{-1} \]
\[ s = \frac{v^2 - u^2}{2a} = \frac{9 \times 33 \times 33}{100} = \frac{9 \times 1089}{100} = 98 \text{ m} \]

13. A
Initially for open organ pipe, fundamental frequency.
\[ v_s = \frac{v}{2} = \frac{f}{2} \]
But when it is half dipped in water, then it becomes closed organ pipe of length \( \frac{l}{2} \). In this case fundamental frequency
\[ v_s = \frac{v}{4} - \frac{f}{2} \]

14. D
Strain = \( \frac{1}{100} \)
Stress = (strain)\( y = \frac{1}{100} \times 2.2 \times 10^{11} \)
\[ = 2.2 \times 10^{9} \]
\[ \frac{T}{A} = \text{Stress} = 2.2 \times 10^{9} \]
\[ T = 2.2 \times 10^{9} A \]
\[ v = \sqrt{\frac{T}{M}} = \sqrt{\frac{T}{\rho A}} = \sqrt{\frac{2.2 \times 10^{9}}{\rho A}} \]
\[ v = \sqrt{\frac{2.2 \times 10^{9}}{7.7 \times 10^{4}}} = \frac{2}{\sqrt{7}} \times 10^{4} \]
\[ f = \frac{v}{2L} = \frac{2}{\sqrt{7}} \times 10^{4} \times \frac{1}{2} \times 1.5 = 178.2 \text{ Hz} \]
1. \( f_A = \frac{5.5}{A} = \frac{V + V_A}{V_A} \times 5 \)
   \( v_A = \frac{5.5V - 5V}{5} \)
   \( f' = 6000 \text{KHz} = \frac{V}{V_A} \times 5 \)
   \( v_A = \frac{6V - 5V}{5} \)
   \( v_A = 2 \)
   \( v_A \)

2. \( \lambda_1 = \frac{2\lambda}{4} = \frac{\lambda}{4} \)
   \( \frac{3\lambda}{2} = \frac{2\lambda}{4} \)
   \( \lambda = \frac{2\lambda}{3} \)
   \( f = \frac{v}{2\lambda} \)
   \( 2v = \frac{3v}{4\lambda} \)

3. \( \lambda = \frac{2\lambda}{2} \)
   \( \lambda = 4\lambda \)

4. \( \lambda = \frac{2\lambda}{3} \)
   \( \lambda = 4\lambda \)

5. \( f = \frac{RT}{M_A} = \frac{3RT}{M_b} \)
   \( \frac{5}{3M_A} = \frac{7}{5M_b} \)
   \( 16 \times 5 = \frac{9 \times 7}{3 \times 9 \times 7} = \frac{400}{189} = 2.116 \)

6. \( f_A = \frac{V_A}{2\lambda} = \frac{\frac{5RT}{3M_A}}{2\lambda} \)
   \( f_B = \frac{\frac{7RT}{5M_b}}{2\lambda} \)

3. \( \lambda = 2\lambda \)

4. \( \lambda = \frac{1}{2.116} \)

5. \( \lambda = \frac{3}{4} \)

6. \( L = \frac{3\lambda}{4} \)

5. \( \lambda = \frac{3}{4} \)

6. \( f = \frac{\frac{\pi}{L}}{1 + \frac{L}{L'}} \)
\[ \lambda = \frac{4L}{3} \]

\[ f = \frac{\beta}{\sqrt{T_i / 4L}} \Rightarrow \frac{3}{4L} \sqrt{\frac{\beta}{T_i}} \sqrt{\frac{\beta}{T_i}} \]

\[ L' = \frac{4L}{3} \sqrt{T_i} \]

7. D
Frequency remain constant in different mediums.

8. D
Related to error

9.
\[ 2200 = \frac{v}{v - v_s} f \quad 1800 = \frac{v}{v - v_s} f \]
\[ \frac{22}{18} = \frac{v + v_s}{v - v_s} \]

11. \[ v - v_1 = v \]
\[ v - v_2 = v \]
\[ v_1 - v_2 = v \times \frac{1.2}{100} = \frac{198}{100} \]
\[ v_1 - v_2 = v \times \frac{1.2}{100} = \frac{198}{100} = 7 \text{ km/hr} \]

12. A
\[ f_{\text{av}} = \left( \frac{v + v_s}{v - v_s} \right) \times f \]
\[ = \left( \frac{320 - 10}{320 - 10} \right) \times 8 \text{ kHz} = 8.5 \text{ kHz} \]

13. B,D
At closed end pressure doesn't change phase and at open end the phase is reversed.

14. AB
Observer to source
\[ f_s = f_t \left( v - w - u \right) \] \[ f_s > f_t \]
source to observer
\[ f_t = f_s \left( v - w + u \right) \] \[ f_s > f_t \]