arride learning

SOUND WAVES

Contents

Syllabus

Speed of Sound in gases ; Doppler effect (in sound).

Name : ______________________ **Contact No.** ______________________

ARRIDE LEARNING ONLINE E-LEARNING ACADEMY

A-479 indra Vihar, Kota Rajasthan 324005

Contact No. 8033545007

EXERCISE # 1

PART - I : OBJECTIVE QUESTIONS

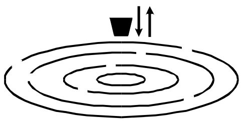
* ***Marked Questions are having more than one correct option.***

SECTION (A): EQUATION OF SOUND WAVE, WAVELENGTH, FREQUENCY, PRESSURE & DISPLACEMENT AMPLITUDE

A-1. When sound wave is refracted from air to water, which of the following will remain unchanged?
(A) wave number (B) wavelength (C) wave velocity (D) frequency

A-2. When we clap our hands, the sound produced is best described by
(A) $p = p_0 \sin (kx - \omega t)$ (B) $p = p_0 \sin kx \cos \omega t$
(C) $p = p_0 \cos kx \sin \omega t$ (D) $p = \Sigma\, p_{on} \sin (k_n x - \omega_n t)$
Here p denotes the change in pressure from the equilibrium value.

A-3. A piece of cork is floating on water in a small tank. The cork oscillates up and down vertically when small ripples pass over the surface of water. The velocity of the ripples being 0.21 ms^{-1}, wave length 15 mm and amplitude 5 mm, the maximum velocity of the piece of cork is ($\pi = \frac{22}{7}$)



(A) 0.44 ms^{-1} (B) 0.24 ms^{-1} (C) 2.4 ms^{-1} (D) 4.4 ms^{-1}

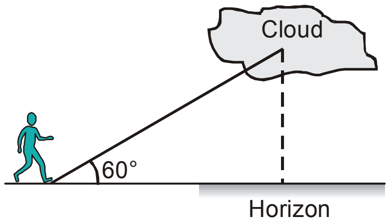
A-4. A light pointer fixed to one prong of a tuning fork touches a vertical plate. The fork is set vibrating and the plate is allowed to fall freely. Eight complete oscillations are counted when the plate falls through 10 cm, then the frequency of the fork is : ($g = 9.8\ m/s^2$)
(A) 65 Hz (B) 56 Hz (C) 46 Hz (D) 64 Hz

A-5. 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) $\frac{t(u+v)}{uv}$ (C) $\frac{t(u-v)}{uv}$ (D) $\frac{uvt}{u-v}$

SECTION (B) : SPEED OF SOUND

B-1. The elevation of a cloud is 60° above the horizon. A thunder is heard 8 s after the observation of lighting. 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

B-2.* A tuning fork is vibrating with constant frequency and amplitude. If the air is heated without changing pressure the following quantities will increase.
(A) Wavelength (B) Frequency (C) Velocity (D) Time period

B-3.* An electrically maintained tuning fork vibrates with constant frequency and constant amplitude. If the temperature of the surrounding air increases but pressure remains constant, the sound produced will have
(A) large wavelength (B) larger frequency (C) larger velocity (D) larger time period

SECTION (C) : INTENSITY OF SOUND, DECIBEL SCALE

C-1. The intensity of a sound wave is directly proportional to :
(A) the frequency (B) the amplitude
(C) the square of the amplitude (D) the square of the speed of sound

C-2.* Two sound waves move in the same direction in the same medium. The pressure amplitude of the waves are equal but the wavelength of the first wave is double that of the second. Let the average power transmitted across a cross section by the two wave be P_1 and P_2 and their displacement amplitudes are s_1 and s_2 then
(A) $P_1/P_2 = 1$ (B) $P_1/P_2 = 2$ (C) $s_1/s_2 = 1/2$ (D) $s_1/s_2 = 2/1$

C-3. 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) 2.5×10^{-4} (B) 2×10^{-4} (C) 2.0×10^{-2} (D) 2.5×10^{-2}

C-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) the frequency of the wave is increased by 41%

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

C-6. A person is talking in a small room and the sound intensity level is 60 dB everywhere within the room. If there are eight people talking simultaneously in the room, what is the sound intensity level ?
(A) 60 dB (B) 69 dB (C) 74 dB (D) 81 dB

C-7. 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

C-8. The ratio of maximum to minimum intensity due to superposition of two waves is $\frac{49}{9}$. Then the ratio of the intensity of component waves is
(A) $\frac{25}{4}$ (B) $\frac{16}{25}$ (C) $\frac{4}{49}$ (D) $\frac{9}{49}$

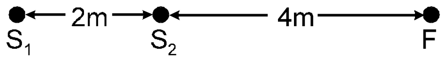
SECTION (D) : INTERFERENCE

D-1. 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

D-2. Three coherent waves of equal frequencies having amplitude 10 μm, 4μm 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

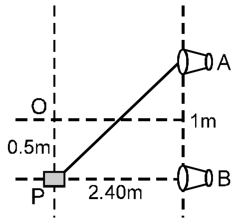
D-3.* S_1 and S_2 are two sources of sound emitting sine waves. The two sources are in phase. The sound emitted by the two sources interfere at point F. The waves of wavelength :



(A) 1 m will result in constructive interference (B) $\frac{2}{3}$ m will result in constructive interference

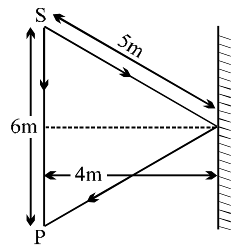
(C) 2m will result in destructive interference (D) 4m will result in destructive interference

D-4. Two speakers A and B, placed 1 m apart, each produce sound waves of frequency1800 Hz in phase. A detector moving parallel to line of speakers distant 2.4 m away detects a maximum intensity at O and then at P. Speed of sound wave is :



(A) 330 ms^{-1} (B) 360 ms^{-1} (C) 350 ms^{-1} (D) 340 ms^{-1}

D-5. 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 the 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

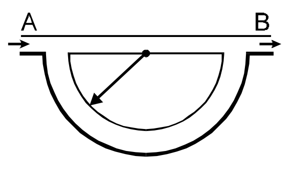
D-6. Two waves of sound having intensities I and 4I interfere to produce interference pattern. The phase difference between the waves is $\pi/2$ at point A and π at point B. Then the difference between the resultant intensities at A and B is

(A) 2I (B) 4I (C) 5I (D) 7I

D-7. 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

D-8. Sound signal is sent through a composite tube as shown in the figure. The radius of the semicircular portion of the tube is r. Speed of sound in air is v. The source of sound is capable of giving varied frequencies in the range of ν_1 and ν_2 (where $\nu_2 > \nu_1$). If n is an integer then frequency for maximum intensity is given by :



(A) $\frac{nv}{r}$ (B) $\frac{nv}{r(\pi-2)}$ (C) $\frac{nv}{\pi r}$ (D) $\frac{nv}{(r-2)\pi}$

SECTION (E) : REFLECTION OF SOUND, EQUATION OF STATIONARY WAVES

E-1. The fundamental frequency of a pipe closed at one end is f_1. How many nodes are present in a standing wave frequency $9f_1$?
(A) 4 (B) 5 (C) 6 (D) 8

E-2.* 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 π 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) the wave reflected from the closed end does not suffer reflection at the open end

E-3. The length of a pipe closed at one end is L. In the standing wave whose frequency is 7 times the fundamental frequency, what is the closest distance between nodes ?
(A) $\frac{1}{14}L$ (B) $\frac{1}{7}L$ (C) $\frac{2}{7}L$ (D) $\frac{4}{7}L$

SECTION (F) : ORGAN PIPES AND RESONANCE

F-1.* 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) the wave pressure is maximum

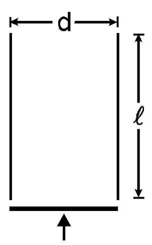
F-2. If λ_1, λ_2, λ_3 are the wavelengths of the waves giving resonance in the fundamental, first and second overtone modes respectively in a open organ pipe, then the ratio of the wavelengths $\lambda_1 : \lambda_2 : \lambda_3$, is :
(A) 1 : 2 : 3 (B) 1 : 3 : 5 (C) 1 : 1/2 : 1/3 (D) 1 : 1/3 : 1/5

F-3. The three lowest resonant frequencies of a system are 50 Hz, 150 Hz and 250 Hz. The system could be:
(A) a tube of air closed at both ends. (B) a tube of air open at one end.
(C) a tube of air open at both ends. (D) a vibrating string with fixed ends

F-4. The fundamental frequency of a closed organ pipe is same as the first overtone frequency of an open pipe. If the length of open pipe is 50 cm, the length of closed pipe is
(A) 25 cm (B) 12.5 cm (C) 100 cm (D) 200 cm

F-5. A cylindrical tube, open at both ends, has a fundamental frequency υ. The tube is dipped vertically in water so that half of its length is inside the water. The new fundamental frequency is
(A) $\upsilon/4$ (B) $\upsilon/2$ (C) υ (D) 2υ

F-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 ν_1. The velocity of sound in air is 330 m/sec. One end of tube is now closed. The lowest frequency of resonance of tube is ν_2. Taking into consideration the end correction, $\frac{\nu_2}{\nu_1}$ is



(A) $\frac{(\ell+0.6d)}{(\ell+0.3d)}$ (B) $\frac{1}{2}\frac{(\ell+0.3d)}{(\ell+0.6d)}$ (C) $\frac{1}{2}\frac{(\ell+0.6d)}{(\ell+0.3d)}$ (D) $\frac{1}{2}\frac{(d+0.3\ell)}{(d+0.6\ell)}$

F-7. 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

F-8. 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) $\frac{vx}{4l^2}$ (B) $\frac{vl^2}{2x}$ (C) $\frac{vx}{2l^2}$ (D) $\frac{vx^2}{2l}$

F-9. 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 ms^{-1} then the minimum height of water required for resonance is:
(A) 95 cm (B) 75 cm (C) 45 cm (D) 25 cm

F-10. 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

F-11. 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

F-12. 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

F-13. 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

F-14. 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:
(A) $2(l_2 - l_1)$ (B) $\frac{1}{2}(2l_1 - l_2)$ (C) $\frac{l_2 - 3l_1}{2}$ (D) $\frac{l_2 - l_1}{2}$

F-15. A closed orgain pipe has length 'l'. The air in it is vibrating in 3rd 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

SECTION (G) : BEATS

G-1. A tuning fork of frequency 512 Hz is vibrated with a sonometer wire and 6 beats per second are heard. The beat frequency reduces if the tension in the string is slightly increased. The original frequency of vibration of the string is
(A) 506 Hz (B) 512 Hz (C) 518 Hz (D) 524 Hz

G-2.* Two tuning forks A & B produce notes of frequencies 256 Hz & 262 Hz respectively. An unknown note sounded at the same time with 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) 258 Hz

G-3. When beats are produced by two progressive waves of nearly the same frequency, which one of the following is correct?

(A) The particles vibrate simple harmonically, with the frequency equal to the difference in the component frequencies.

(B) The amplitude of vibration at any point changes simple harmonically with a frequency equal to the difference in the frequencies of the two waves.

(C) The frequency of beats depends upon the position, where the observer is

(D) The frequency of beats changes as the time progresses

G-4. The number of beats heard per second if there are three sources of sound of frequencies (n – 1), n and (n + 1) of equal intensities sounded together is :

(A) 2 (B) 1 (C) 4 (D) 3

G-5. 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 [Assume same mode of vibration in both cases]

(A) 2 (B) 4 (C) 1 (D) 8

G-6. 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

G-7. 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

SECTION (H) : DOPPLER EFFECT

H-1. A listener is at rest with respect to the source of sound. A wind starts blowing along the line joining the source and the observer. Which of the following quantities do not change?

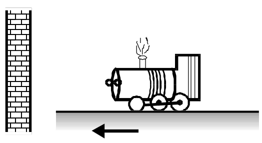
(A) Frequency (B) Velocity of sound (C) Wavelength (D) Time period

H-2. The change in frequency due to Doppler effect does not depend on

(A) the speed of the source (B) the speed of the observer

(C) the frequency of the source (D) separation between the source and the observer

H-3. An engine driver moving towards a wall with velocity of 50 ms^{-1} emits a note of frequency 1.2 kHz. The frequency of note after reflection from the wall as heard by the engine driver when speed of sound in air is 350 ms^{-1} is :



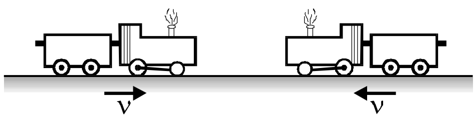
(A) 1 kHz (B) 1.8 kHz (C) 1.6 kHz (D) 1.2 kHz

H-4. A source of sound with frequency 620 Hz is placed on a moving platform that approaches a physics student at speed v, the student hears sound with a frequency f_1. Then the source of sound is held stationary while the student approaches it at the same speed v, the student hears sound with a frequency f_2. Choose the correct statement.

(A) $f_1 = f_2$; both are greater than 620 Hz (B) $f_1 = f_2$; both are less than 620 Hz

(C) $f_1 > f_2 > 620$ Hz (D) $f_2 > f_1 > 620$ Hz

H-5. 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}

H-6. A moving van and a small car are travelling in the same direction on a two-lane road. The van is moving at twice the speed of the car and over-tekes the car. The driver of the car sounds his horn, frequency = 440 Hz, to signal the van that it is safe to return to the lane. Which is the correct statement?

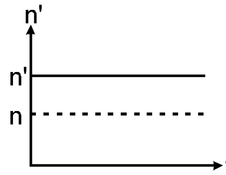
(A) The car driver and van driver both hear the horn frequency as 440 Hz.

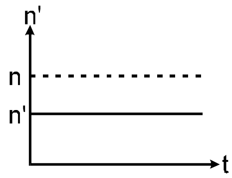
(B) The car driver hears 440 Hz, but the van driver hears a lower frequency.

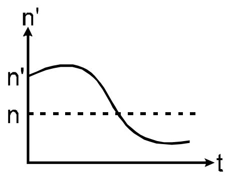
(C) The car driver hears 440 Hz, but the van driver hears a higher frequency.

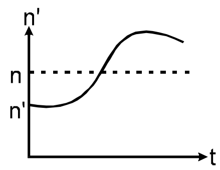
(D) Both driver hear the same frequency and it is lower than 440 Hz.

H-7. Source and observer both start moving simultaneously from origin, one along X-axis and the other along Y-axis with speed of source equal to twice the speed of observer. The graph between the apparent frequency (n') observed by observer and time t would be : (n is the frequency of the source)

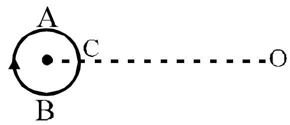
(A)


(B)


(C)


(D)


H-8. A small source of sound moves on a circle as shown in fig. and an observer is sitting at O. Let at $\upsilon_1, \upsilon_2, \upsilon_3$ be the frequencies heard when the source is at A, B, and C respectively.



(A) $\upsilon_1 > \upsilon_2 > \upsilon_3$ (B) $\upsilon_1 = \upsilon_2 > \upsilon_3$ (C) $\upsilon_2 > \upsilon_3 > \upsilon_1$ (D) $\upsilon_1 > \upsilon_3 > \upsilon_2$

PART - II : MISLLANEOUS QUESTIONS

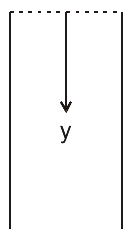
1. COMPREHENSION

COMPREHENSION # 1

In an organ pipe (may be closed or open) of 99 cm length standing wave is setup, whose equation is given by longitudinal displacement

$$\xi = (0.1 \text{ mm}) \cos \frac{2\pi}{80} (y + 1 \text{ cm}) \cos 2\pi(400)\, t$$

where y is measured from the top of the tube in centimeters and t in second. Here 1 cm is the end correction.



1. The upper end and the lower end of the tube are respectively:
(A) open – closed (B) closed – open (C) open – open (D) closed – closed

2. The air column is vibrating in
(A) First overtone (B) Second overtone (C) Third harmonic (D) Fundamental mode

3. Equation of the standing wave in terms of excess pressure is –
(Bulk modulus of air B = 5×10^5 N/m^2)

(A) $P_{ex} = (125\,\pi N/m^2) \sin \frac{2\pi}{80}(y + 1\text{ cm}) \cos 2\pi(400t)$

(B) $P_{ex} = (125\,\pi N/m^2) \cos \frac{2\pi}{80}(y + 1\text{ cm}) \sin 2\pi(400t)$

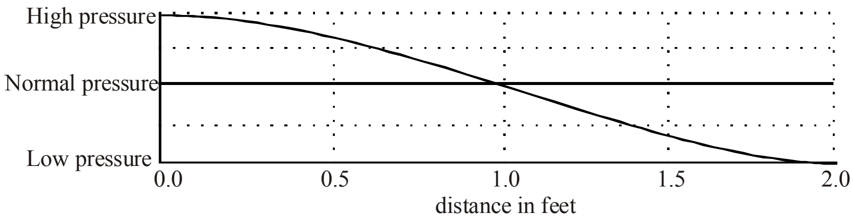
(C) $P_{ex} = (225\,\pi N/m^2) \sin \frac{2\pi}{80}(y + 1\text{ cm}) \cos 2\pi(200t)$

(D) $P_{ex} = (225\,\pi N/m^2) \cos \frac{2\pi}{80}(y + 1\text{ cm}) \sin 2\pi(200t)$

4. Assume end correction approximately equals to (0.3) × (diameter of tube), estimate the approximate number of moles of air present inside the tube (Assume tube is at NTP, and at NTP, 22.4 litre contains 1 mole)
(A) $\frac{10\pi}{36 \times 22.4}$ (B) $\frac{10\pi}{18 \times 22.4}$ (C) $\frac{10\pi}{72 \times 22.4}$ (D) $\frac{10\pi}{60 \times 22.4}$

COMPREHENSION # 2

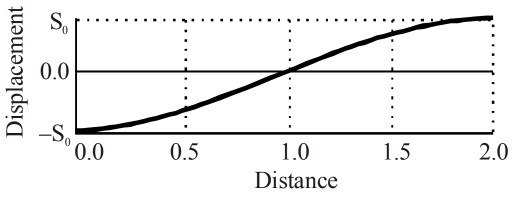
A tube of air 2 feet in length has a pressure versus distance graph as shown at t = 0. It is vibrating in one of its allowed standing wave modes.

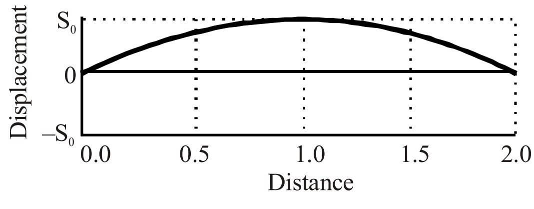


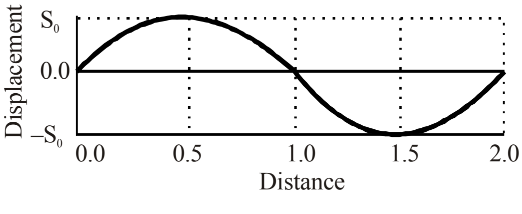
5. The tube has
(A) both ends open (B) both ends closed
(C) left end open, right end closed (D) left end closed, right end open

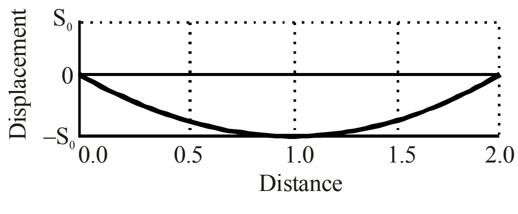
6. Which standing wave is this?
(A) fundamental (B) second harmonic (C) second overtone (D) first overtone

7. Which of the following graphs of molecular displacement vs. horizontal distance corresponds to the above pressure graph?

(A)


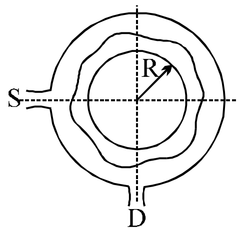
(B)


(C)


(D)


COMPREHENSION # 3

A narrow tube is bent in the form of a circle of radius R, as shown in the figure. Two small holes S and D are made in the tube at the positions right angle to each other. A source placed at S generated a wave of intensity I_0 which is equally divided into two parts : One part travels along the longer path, while the other travels along the shorter path. Both the part waves meet at the point D where a detector is placed



8. If a maxima is formed at the detector then, the magnitude of wavelength λ of the wave produced is given by

(A) πR (B) $\frac{\pi R}{2}$ (C) $\frac{\pi R}{4}$ (D) $\frac{2\pi R}{3}$

9. If the minima is formed at the detector then, the magnitude of wavelength λ of the wave produced is given by

(A) $2\pi R$ (B) $\frac{3\pi R}{2}$ (C) $\frac{2\pi R}{3}$ (D) $\frac{2\pi R}{5}$

10. The maximum intensity produced at D is given by

(A) $4I_0$ (B) $2I_0$ (C) I_0 (D) $3I_0$

11. The maximum value of λ to produce a maxima at D is given by

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

12. The maximum value of λ to produce a minima at D is given by

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

2. MATCH THE COLUMN

13. **Match the Column:**

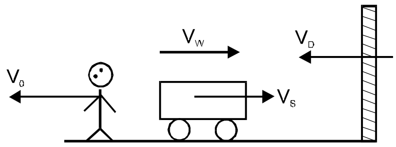
(A) $y = 4 \sin (5x - 4t) + 3 \cos (4t - 5x + \pi/6)$ — (p) Particles at every position are performing SHM

(B) $y = 10 \cos \left(t - \frac{x}{330}\right) \sin (100) \left(t - \frac{x}{330}\right)$ — (q) Equation of travelling wave

(C) $y = 10 \sin (2\pi x - 120t) + 10 \cos (120t + 2\pi x)$ — (r) Equation of standing wave

(D) $y = 10 \sin (2\pi x - 120 t) + 8 \cos (118t - 59/30\pi x)$ — (s) Equation of Beats

14. S, O & W represent source of sound (of frequency f), observer & wall respectively. V_O , V_S, V_D, V are velocity of observer, source, wall & sound (in still air) respectively. V_W is the velocity of wind. They are moving as shown. then match the following : where $f_r = \frac{V + V_w + V_D}{V + V_w - V_S} f$



(A) The wavelength of the waves coming towards the observer from source. (p) $(V - V_W - V_D)/f_r$
(B) The wavelength of the waves incident on the wall. (q) $(V - V_W - V_O)f_r /(V - V_W - V_D)$
(C) The wavelength of the waves coming towards observer from the wall. (r) $(V - V_W + V_S)/f$
(D) Frequency of the waves (as detected by O) coming from wall after reflection. (s) $(V + V_W - V_S)/f$

3 : TRUE OR FALSE

STATE TRUE 'OR' FALSE :

15. As sound propagates in air density of the medium varies but pressure remains constant and is equal to atmospheric pressure

16. Source and observer both are stationary and wind is blowing in a direction from source to observer then observer detects an apparent increase in frequency.

17. Beat frequency is defined as the difference of frequency of two sources.

18. Sound travel faster in water than in air.

19. Pressure node is always a displacement node and pressure antinode is always a displacement antinode

4 : FILL IN THE BLANKS

20. The intensity of sound at a point due to point sound source is 0.2 W/m^2. If the distance of the source is made doubled and power is also doubled then the intensity at the point will become _________ W/m^2.

21. The faintest sound, the human ear can detect at a frequency of 1 k Hz (for which ear is most sensitive) corresponds to an intensity of about 10^{-12} w/m^2. Assuming the density of air $\cong$ 1.5 kg/m^3 & velocity of sound in air $\cong$ 300 m/s, the pressure amplitude and displacement amplitude of the sound will be respectively ______ N/m^2 & ______ m.

22. The stationary wave y = 2a sin kx cos ωt in a closed organ pipe is the result of the superposition of y_1 = a sin (ωt – kx) & _______ .

23. A closed organ pipe of length 83.2 cm and 6 cm diameter is vibrated. The velocity of sound is 340 m/s. The number of overtones in this tube having frequency below 1000 Hz is _______.

EXERCISE # 2

PART - I : MIXED OBJECTIVE

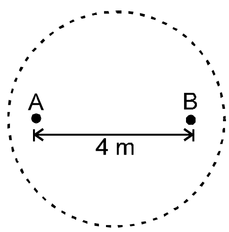
* ***Marked Questions are having more than one correct option.***

SINGLE CORRECT ANSWER TYPE

1. A closed pipe resonates at its fundamental frequency of 300 Hz. Which one of the following statements is wrong?
(A) If the temperature rises, the fundamental frequency increases.
(B) If the pressure rises, the fundamental frequency increases.
(C) The first overtone is of frequency 900 Hz.
(D) An open pipe with the same fundamental frequency has twice the length.

2. Which one of the following statements is incorrect for stable interference to occur between two waves?
(A) The waves must have the same wave length
(B) The waves must have a constant phase difference
(C) The waves must be transverse only
(D) The waves must have equal amplitudes.

3. Two coherent radio point sources separated by 4.0 m are placed at points A and B along a straight line as shown. Both are emitting waves in phase of wavelength λ = 1.0 m. A detector moves in a circular path around the two sources in a plane containing them. The number of maxima counted by the detector in one full cycle is :



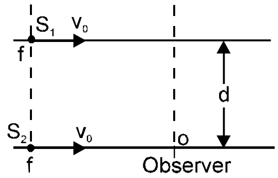
(A) 4 (B) 8 (C) 12 (D) 16

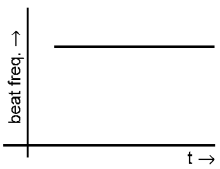
4. In a Hall, a person receives direct sound waves from a source 120m away. He also receives wave from the same source which reach him after being reflected from the 25m high ceiling at a point half way between them. The two waves interfere constructively for wave length (in meters).
(A) 10, 10/2, 10/3, 10/4 (B) 20, 20/3, 20/5, 20/7,...........
(C) 30, 20, 10,............ (D) 10, 10/3, 10/5,10/7...........

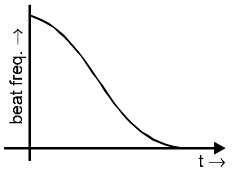
5. Two sound sources produce progressive waves given by y_1 =12 cos 100πt and y_2 = 4 cos 102πt near the ear of an observer. When sounded together, the observer will hear
(A) 2 beats per two sound source with an intensity ratio of maximum to minimum nearly 4 : 1
(B) 1 beat per second with an intensity ratio of maximum to minimum nearly $\sqrt{2}$: 1
(C) 2 beats per second with an intensity ratio of maximum to minimum nearly 9 : 1
(D) 1 beat per second with an intensity ratio of maximum to minimum nearly 4 : 1

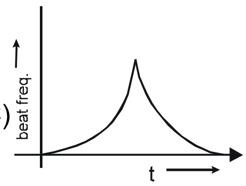
6. The displacement sound wave in a medium is given by the equation Y = A cos(ax + bt) where A, a and b are positive constants. The wave is reflected by an denser obstacle situated at x = 0. The intensity of the reflected wave is 0.64 times that of the incident wave. Tick the statement among the following that is incorrect.
(A) the wavelength and frequency of the wave are 2π/a and b/2π 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_{max} (maximum particle speed) is 1.8 bA
(D) the equation of the standing wave so formed is y = 1.8 A sin ax cos bt

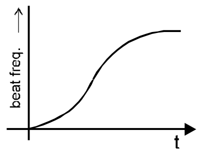
7. Two identical sources moving parallel to each other at separation ' d ' are producing sounds of frequency ' f ' and are moving with constant velocity v_0. A stationary observer ' O ' is on the line of motion of one of the sources. Then the variation of beat frequency heard by O with time is best represented by: (as they come from large distance and go to a large distance)



(A) 

(B) 

(C) 

(D) 

8. There is a set of four tuning forks, one with the lowest frequency vibrating at 550 Hz. By using any two tuning forks at a time, the following beat frequencies are heard: 1, 2, 3, 5, 7, 8. The possible frequencies of the other three forks are:
(A) 552, 553, 560 (B) 557, 558, 560
(C) 552, 553, 558 (D) 551, 553, 558

9. A train blowing its whistle moves with a constant velocity v away from an observer on the ground. The ratio of the natural frequency of the whistle to that measured by the observer is found to be 1.2. If the train is at rest and the observer moves away from it at the same velocity, this ratio would be given by:
(A) 0.51 (B) 1.25 (C) 1.52 (D) 2.05

10. A train moving towards a tunnel in a huge mountain with a speed of 12 m/s sounds its whistle. Sound is reflected from the mountain. If the driver hears 6 beats per second & speed of sound in air is 332 m/s, the frequency of the whistle is
(A) 80 Hz (B) 120 Hz (C) 160 Hz (D) 240 Hz

11. Two sound sources produce progressive waves given by $y_1 = 12 \cos 100\pi t$ and $y_2 = 4 \cos 102\pi t$ near the ear of an observer. When sounded together, the observer will hear
(A) 2 beats per two sound source with an intensity ratio of maximum to minimum nearly 4 : 1
(B) 1 beat per second with an intensity ratio of maximum to minimum nearly $\sqrt{2} : 1$
(C) 2 beats per second with an intensity ratio of maximum to minimum nearly 9 : 1
(D) 1 beat per second with an intensity ratio of maximum to minimum nearly 4 : 1

12. The extension in a string, obeying Hooke's law is x. The speed of sound in the stretched string is v. If the extension in the string is increased to 1.5 x , the speed of sound will be
(A) 1.22 v (B) 0.61 v (C) 1.50 v (D) 0.75 v

13. A train moving towards a tunnel in a huge mountain with a speed of 12 m/s sounds its whistle. If the driver hears 6 beats per second & speed of sound in air is 332 m/s, the frequency of the whistle is
(A) 80 Hz (B) 120 Hz (C) 160 Hz (D) 240 Hz

14. When a train approaches a stationary observer, the apparent frequency of the whistle is n' and when the same train recedes away from the observer, the apparent frequency is n". Then the apparent frequency n when the observer moves with the train is :

(A) $n = \frac{n' + n''}{2}$ (B) $\sqrt{n' n''}$ (C) $n = \frac{2n' n''}{n' + n''}$ (D) $n = \frac{2n' n''}{n' - n''}$

15. 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

16. 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 = speed of sound in air)

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

17. A source which is emitting sound of frequency f is initially at (– r, 0) and an observer is situated initially at (2r, 0). If observer and source both are moving with velocities $\vec{v}_{observer} = -\sqrt{2}V\hat{i} - \sqrt{2}V\hat{j}$ and $\vec{v}_{source} = \frac{V}{\sqrt{2}}\hat{i} + \frac{V}{\sqrt{2}}\hat{j}$, then which of the following is correct option ?

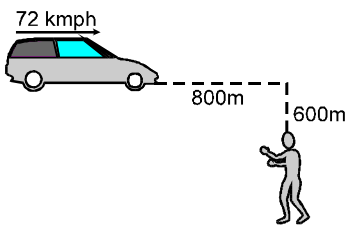
(A) Apparent frequency first increases, then decreases and observer observes the original frequency once during the motion.

(B) Apparent frequency first increases, then decreases and observer observes the original frequency twice during the motion.

(C) Apparent frequency first increases, then decreases during the motion and observer never observes the initial frequency.

(D) Apparent frequency continuously decreases and once during the motion, observer hears the original frequency.

18. A car is approaching a railway crossing at a speed of 72 kmph. It sounds a horn, when it is 800 m away, at 600 Hz. If velocity of sound in air is 330 ms^{-1}, the apparent frequency as received by a man at rest near the railway track perpendicular to the road at a distance of 600 m from the crossing is



(A) 653 Hz (B) 365.5 Hz (C) 630.5 Hz (D) 563.5 Hz

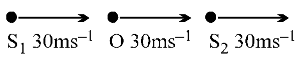
19. In the case of sound waves, wind is blowing from source to receiver with speed U_W. Both source and receiver are stationary. If λ_0 is the original wavelength with no wind and V is speed of sound in air then wavelength as received by the receiver is given by :

(A) λ_0 (B) $\left(\frac{V+U_w}{V}\right)\lambda_0$ (C) $\left(\frac{V-U_w}{V}\right)\lambda_0$ (D) $\left(\frac{V}{V+V_w}\right)\lambda_0$

20. A fixed source of sound emitting a certain frequency appears as f_a when the observer is approaching the source with speed v and frequency f_r when the observer recedes from the source with the same speed. The frequency of the source is

(A) $\frac{f_r+f_a}{2}$ (B) $\frac{f_a-f_r}{2}$ (C) $\sqrt{f_a f_r}$ (D) $\frac{2f_r f_a}{f_r+f_a}$

21. Consider two sound sources S_1 and S_2 having same frequency 100Hz and the observer O located between them as shown in the fig. All the three are moving with same velocity in same direction. The beat frequency of the observer is

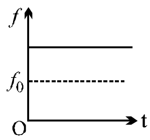


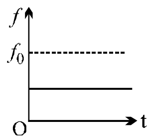
(A) 50Hz (B) 5 Hz (C) zero (D) 2.5 Hz

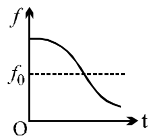
22. An engine whistling at a constant frequency n_0 and moving with a constant velocity goes past a stationary observer. As the engine crosses him, the frequency of the sound heard by him changes by a factor f ($f_{after} = f \times f_{before}$). The actual difference in the frequencies of the sound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

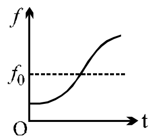
(A) $\frac{1}{2} n_0(1 - f^2)$ (B) $\frac{1}{2} n_0\left(\frac{1-f^2}{f}\right)$ (C) $n_0\left(\frac{1-f}{1+f}\right)$ (D) $\frac{1}{2} n_0\left(\frac{1-f}{1+f}\right)$

23. Source and observer both start moving simultaneously from origin, one along x-axis and the other along y-axis with speed of source = twice the speed of observer. The graph between the apparent frequency observed by observer f and time t would approximately be :

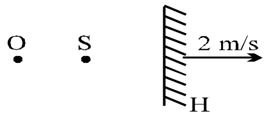
(A) 

(B) 

(C) 

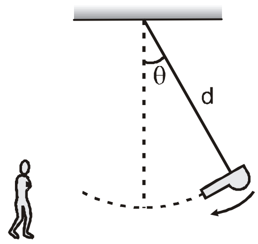
(D) 

24. 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 2 m/sec as shown in the figure. If the velocity of the sound waves in air is V = 330 m/sec, the apparent frequency of the echo is :



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

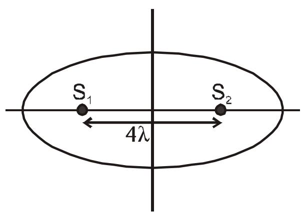
25. A source on a swing which is covering an angle θ from the vertical is producing a frequency ν. The source is distant d from the place of support of swing. If velocity of sound is c, acceleration due to gravity is g, then the maximum and minimum frequency heard by a listener in front of swing is



(A) $\frac{c\nu}{\sqrt{2gd} - c}, \frac{c\nu}{\sqrt{2gd} + c}$ (B) $\frac{c\nu}{\sqrt{2gd(1-\cos\theta)} - c}, \frac{c\nu}{\sqrt{2gd(1-\cos\theta)} + c}$

(C) $\frac{c\nu}{c - \sqrt{2gd(1-\cos\theta)}}, \frac{c\nu}{c + \sqrt{2gd(1-\cos\theta)}}$ (D) $\frac{c\nu}{c - \sqrt{2gd(1-\sin\theta)}}, \frac{c\nu}{c + \sqrt{2gd(1-\sin\theta)}}$

26. S_1, S_2 are two coherent sources (having initial phase difference zero) of sound located along x-axis separated by 4λ where λ is wavelength of sound emitted by them. Number of maxima located on the elliptical boundary around it will be :

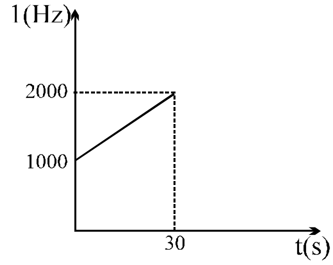


(A) 16 (B) 12 (C) 8 (D) 4

27. A source S of frequency f_0 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_1, 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) $\frac{a}{v_1 + v_2 + v_s}$

28. A detector is released from rest over a source of sound of frequency $f_0 = 10^3$ Hz. The frequency observed by the detector at time t is plotted in the graph. The speed of sound in air is (g = 10 m/s^2)



(A) 330 m/s (B) 350 m/s (C) 300 m/s (D) 310 m/s

29. 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 = 10m/s^2)

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

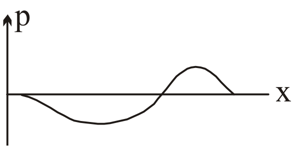
30. A source of sound S having frequency f. Wind is blowing from source to observer O with velocity u. If speed of sound with respect to air is C, the wavelength of sound detected by O is:

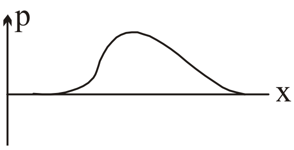
(A) $\frac{C+u}{f}$ (B) $\frac{C-u}{f}$ (C) $\frac{C(C+u)}{(C-u)f}$ (D) $\frac{C}{f}$

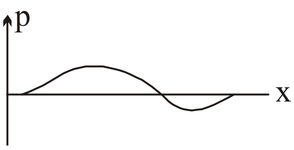
31. The equations of two displacement sound waves propagating in a medium are given by $s_1 = 2\sin(200\pi t)$ and $s_2 = 5\sin(150\pi t)$. The ratio of intensities of sound produced is :

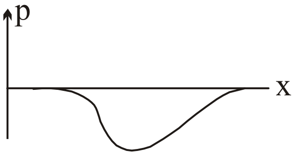
(A) 4 : 25 (B) 9 : 100 (C) 8 : 15 (D) 64 : 225

32. For displacement(s)-x graph shown for a sound wave, select appropriate excess pressure(p)-x graph.

(A)


(B)


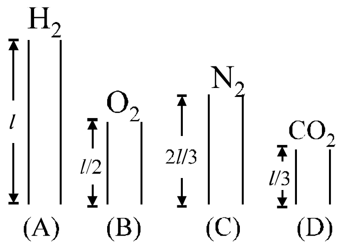
(C)


(D)


33. The second overtone of an open pipe A and a closed pipe B have the same frequencies at a given temperature. Both pipes contain air. The ratio of fundamental frequency of A to the fundamental frequency of B is:

(A) 3: 5 (B) 5: 3 (C) 5: 6 (D) 6: 5

34. 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 γ_{CO_2} = 7/5]



(A) $f_A/f_B = \sqrt{2}$

(B) $f_B/f_C = \sqrt{72/28}$

(C) $f_C/f_D = \sqrt{11/28}$

(D) $f_D/f_A = \sqrt{76/11}$

35. In an organ pipe whose one end is at x = 0, the pressure is expressed by

$p = p_0 \cos \frac{3\pi x}{2} \sin 300\pi t$ where x is in meter and t in sec. The organ pipe can be

(A) closed at one end, open at another with length = 0.5m

(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

36. Two tuning forks of frequency 250 Hz and 256 Hz produce beats. If a maximum of intensity is observed just now, after how much time the minimum is observed at the same place ?

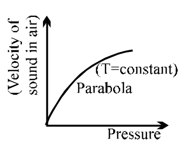
(A) $\frac{1}{18}$ sec

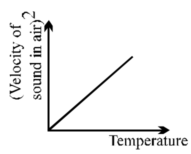
(B) $\frac{1}{4}$ sec.

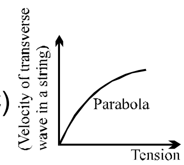
(C) $\frac{1}{3}$ sec.

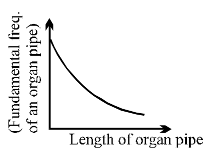
(D) $\frac{1}{12}$ sec.

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

(A)


(B)


(C)


(D)


MULTIPLE CORRECT ANSWER(S) TYPE QUESTIONS

38. Two narrow organ pipes, one open (length ℓ_1) and the other closed (length ℓ_2) are sounded in their respective fundamental modes. The beat frequency heard is 5 Hz. If now the pipes are sounded in their first overtones, then also the beat frequency heard is 5 Hz. Then:

(A) $\frac{\ell_1}{\ell_2} = \frac{1}{2}$

(B) $\frac{\ell_1}{\ell_2} = \frac{1}{1}$

(C) $\frac{\ell_1}{\ell_2} = \frac{3}{2}$

(D) $\frac{\ell_1}{\ell_2} = \frac{2}{3}$

39. In a resonance tube experiment, a closed organ pipe of length 120 cm resonates when tuned with a tuning fork of frequency 340 Hz. If water is poured in the pipe then (given v_{air} = 340 m/sec.) :

(A) minimum length of water column to have the resonance is 45 cm.

(B) the distance between two successive nodes is 50 cm.

(C) the maximum length of water column to create the resonance is 95 cm.

(D) none of these.

40. Which one of the following statements is incorrect for stable interference to occur between two waves?

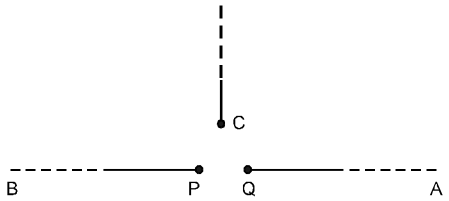
(A) The waves must have the same wave length

(B) The waves must have a constant phase difference

(C) The waves must be transverse only

(D) The waves must have equal amplitudes.

41. Two monochromatic sources of electromagnetic wave, P and Q emit waves of wavelength λ = 20 m and separated by 5m as shown. A,B and C are three points where interference of these waves is observed. If phase of a wave generated by P is ahead of wave generated by Q by $\pi/2$ then (given intensity of both waves is I) :



(A) phase difference of these waves at B is 180^0

(B) intensities at A,B and C are in the ratio 2 : 0 : 1 respectively.

(C) intensities at A,B and C are in the ratio 1 : 2 : 0 respectively.

(D) phase difference at A is 0^0.

42. A cylindrical tube, open at one end and closed at the other, is in acoustic unison (resonance) with an external source of sound of single 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 π 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) the wave reflected from the closed end does not suffer reflection at the open end

43. A car moves towards a hill with speed v_c. It blows a horn of frequency f which is heared by an observer following the car with speed v_0. 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 $\frac{v-v_c}{f}$

(C) the beat frequency observed by the observer is $\left(\frac{v+v_o}{v-v_c}\right)f$

(D) the beat frequency observed by the observer is $\frac{2v_c(v+v_o)f}{v^2-v_c^2}$

44. A sound wave of frequency ν travels horizontally to the right. It is reflected from a large vertical plane surface moving to left with a speed u. The speed of sound in medium is c.

(A) The number of waves striking the surface per second is $\frac{(c+u)}{c}\nu$

(B) The wavelength of reflected wave is $\frac{c(c-u)}{\nu(c+u)}$

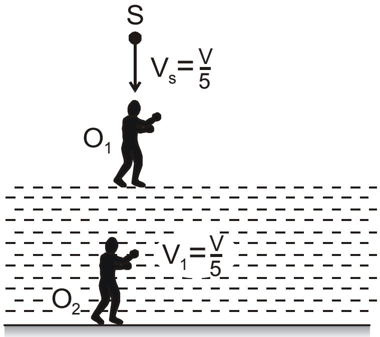
(C) The frequency of the reflected wave as observed by the stationary observer is $\nu\frac{(c+u)}{(c-u)}$

(D) The number of beats heard by a stationary listener to the left of the reflecting surface is $\frac{u\nu}{c-u}$

45. Two identical straight wires are stretched so as to produce 6 beats/sec. when vibrating simultaneously. n changing the tension slightly in one of them, the beat frequency remains unchanged. Denoting by T_1, T_2, the higher & the lower initial tensions in the strings, then it could be said that while making the above changes in tension:

(A) T_2 was decreased (B) T_2 was increased (C) T_1 was increased (D) T_1 was decreased

46. In the figure shown an observer O_1 floats (static) on water surface with ears in air while another observer O_2 is moving upwards with constant velocity $V_1 = V/5$ in water. The source moves down with constant velocity $V_s = V/5$ and emits sound of frequency 'f'. The velocity of sound in air is V and that in water is 4V. For the situation shown in figure :



(A) The wavelength of the sound received by O_1 is $\frac{4V}{5f}$

(B) The wavelength of the sound received by O_1 is V/f

(C) The frequency of the sound received by O_2 is $\frac{21f}{16}$

(D) The wavelength of the sound received by O_2 is $\frac{16V}{5f}$

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

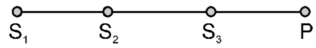
(A) If gas is changed from H_2 to O_2, the resonant frequency will increase
(B) If gas is changed from O_2 to N_2, the resonant frequency will increase
(C) If gas is changed from N_2 to He, the resonant frequency will decrease
(D) If gas is changed from He to CH_4, the resonant frequency will decrease

PART - II : SUBJECTIVE QUESTIONS

1. The intensity of sound wave whose frequency is 250 Hz is $\frac{\pi^2 \times 10^{-9}}{n} W/m^2$ then find the value of n. [The displacement amplitude of particles of the medium at this position is 1×10^{-8} m. The density of the medium is 1 kg/m^3, bulk modulus of elasticity of the medium is 400 N/m^2.]

2. A source of sound operates at 2.0 kHz, 20 W emitting sound uniformly in all directions. The speed of sound in air is 340 m/s and the density of air is 1.2 kg/m^3. (a) The intensity at a distance of 6.0 m from the source is 11nW/m^2 and Pressure amplitude at this point is m Pa then find the value of m and n.

3. Three sources of sound S_1, S_2 and S_3 of equal intensity are placed in a straight line with $S_1S_2 = S_2S_3$ (figure). At a point P, far away from the sources, the wave coming from S_2 is 120° ahead in phase of that from S_1. Also, the wave coming from S_3 is 120° ahead of that from S_2. What would be the resultant intensity of sound at P?

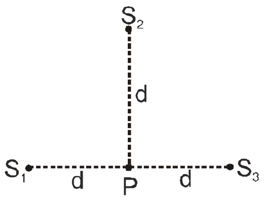


4. A source of sound with natural frequency v_0 = 1.8 k Hz moves uniformly along a straight line separated from a stationary observer by a distance ℓ = 250 m . The velocity of the source is equal to η = 0.80 times the velocity of the sound . If the frequency of the sound received by the observer at the moment when the source gets closest to him is yKHz then find the value of y.

5. The temperature of air in a 900 m long tunnel varies linearly from 100 K at one end to 900 K at other end. If the time taken by sound to cross the tunnel (given that the speed of sound in air at 400 K is 360 m/s) is $\frac{n}{2}$ sec, then find the value of n.

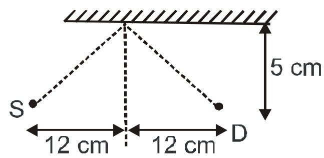
6. A point sound source is located on the axis of a ring centred at O. The distance between the point O and the source is ℓ = 1.00 m and the radius of the ring is R = 0.50 m. The mean energy flow rate across the area enclosed by the ring is (10x) μW. If at the point O, the intensity of sound is equal to I_0 = 30 μW/m^2, find the value of x . (Neglect the damping of the waves).

7.



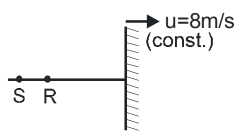
Three point sources S_1, S_2 and S_3 of same power P_0 are arranged as shown. S_1 lags S_2 by 120º and S_3 leads S_2 by 120º. The resultant intensity at point P due to three sources is y then find the value of y.

8. A sound source, detector and a cardboard are arranged as shown in figure. The wave is reflected from the cardboard at the line of symmetry of source and detector. Initially the reflected wave is out of phase with direct wave. The distance by which the cardboard should be moved so that both waves are in phase is x cm , then find the value of x.



9. A closed organ pipe has length 'ℓ'. The air in it is vibrating in 3rd overtone with maximum amplitude 6 mm. If the amplitude at a distance of ℓ/7 from closed end of the pipe is x mm then find the value of x.

10. S is source and R is receiver such that R and S are at rest. Frequency of sound from S is 169 Hz. The beat frequency registered by R is z Hz, then find the value of z. (Velocity of sound is 330 m/s)



11. A tuning fork P of unknown frequency gives 7 beats in 2 sec with another tuning fork Q. When Q runs towards the wall with a speed of 5 m/s it gives 5 beats per sec with its echo. On loading wax on P it gives 5 beats per second with Q . The original frequency of P is 20 y Hz, then find the value of n. (Assume speed of sound = 332 m/s)

12. 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 repsectively below the open end. If the diameter of the tube is y (cm) then find the value of y.

13. A car is moving towards a huge wall with a speed = $\frac{c}{10}$ (where c = speed of sound in still air). A wind is also blowing parallel to the velocity of the car in the same direction and with the same speed. If the car sounds a horn of frequency 45 Hz then the frequency of the reflected sound of the horn heard by driver of the car is 11n (Hz). Find the value of n.

14. A metal rod of length l = 100 cm is clamped at two points. Distance of each clamp from nearer end is a=30cm. If density and Young's modulus of elasticity of rod material are ρ = 9000 kg m^{-3} and Y = 144 GPa respectively. Minimum and next higher frequency of natural longitudinal oscillations of the rod are 5m KHz and 5n KHz then find the values of m and n.

EXERCISE # 3

PART-I IIT-JEE (PREVIOUS YEARS PROBLEMS)

* ***Marked Questions are having more than one correct option.***

1. A police car moving at 22 m/s, chases a motorcyclist. The police man sounds his horn at 176 Hz, while both of them move towards a stationary siren of frequency 165 Hz. Calculate the speed of the motorcycle, if it is given that he does not observe any beats. **[JEE-2003 (screening)3/84]**
(A) 33 m/s (B) 22 m/s (C) zero (D) 11 m/s

2. In the experiment for the determination of the speed of sound in air using the resonance column method, the length of the air column that resonates in the fundamental mode, with a tuning fork is 0.1 m. When this length is changed to 0.35 m, the same tuning fork resonates with first overtone. Calculate the end correction. **[JEE- 2003 (Screening), 3/84]**
(A) 0.012 m (B) 0.025 m (C) 0.05 m (D) 0.024 m

3. In a resonance tube experiment to determine the speed of sound in air, a pipe of diameter 5 cm is used. The air column in pipe resonates with a tuning fork of frequency 480 Hz when the minimum length of the air column is 16 cm. Find the speed of sound in air at room temperature. **[JEE - 2003, 2/60]**

4. A source S having frequency 600 Hz is kept at rest in the bed of a flowing river. Find out the frequency detected by a stationary detector present above the river in air.
[Velocity of sound in water = 1500 m/s ; velocity of sound in air = 300 m/s] **[JEE Sc. 2004]**
(A) 200 Hz (B) 3000 Hz (C) 120 Hz (D) 600 Hz

5. A closed organ pipe of length L and an open organ pipe contain gases of densities ρ_1 and ρ_2 respectively. The compressibility of gases are equal in both the pipe. Both the pipes are vibrating in their first overtone with same frequency. The length of the open organ pipe is : **[JEE- 2004 (screening)3/84]**
(A) $\frac{L}{3}$ (B) $\frac{4L}{3}$ (C) $\frac{4L}{3}\sqrt{\frac{\rho_1}{\rho_2}}$ (D) $\frac{4L}{3}\sqrt{\frac{\rho_2}{\rho_1}}$

6. An open pipe is in resonance in 2nd harmonic with frequency f_1. Now one end of the tube is closed and frequency is increased to f_2 such that the resonance again occurs in nth harmonic. Choose the correct option : **[JEE- 2005 (Screening), 3/84]**

(A) n = 3, $f_2 = \frac{3}{4}f_1$ (B) n = 3, $f_2 = \frac{5}{4}f_1$ (C) n = 5, $f_2 = \frac{3}{4}f_1$ (D) n = 5, $f_2 = \frac{5}{4}f_1$

7. A train is passing a stationary observer at station with constant velocity. If the frequency observed by the person during its approach and recession are 2.2 kHz and 1.8 kHz respectively. Then find the velocity of train if the velocity of sound in air is 300 m/s. **[JEE 2005 (Main), 2/60]**

Paragraph for question Nos. 8 to 10 :

Two plane harmonic sound waves are expressed by the equations. **[JEE' 2006, 5 × 3 = 15 /184]**

$y_1(x, t) = A \cos (0.5 \pi x - 100 \pi t)$

$y_2(x, t) = A \cos (0.46 \pi x - 92 \pi t)$

(All parameters are in MKS) :

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

(A) 4 (B) 10 (C) 6 (D) 8

9. What is the speed of the sound ?

(A) 200 m/s (B) 180 m/s (C) 192 m/s (D) 96 m/s

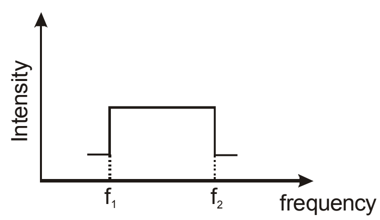
10. At x = 0 how many times $y_1 + y_2$ is zero in one second ?

(A) 192 (B) 48 (C) 100 (D) 96

Paragraph for Question Nos. 11 to 13

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 engines of train A blows a long whistle. **[JEE' 2007, 4 × 3 = 12 /81]**

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 still air is 340 m/s.



11. The speed of sound of the whistle is

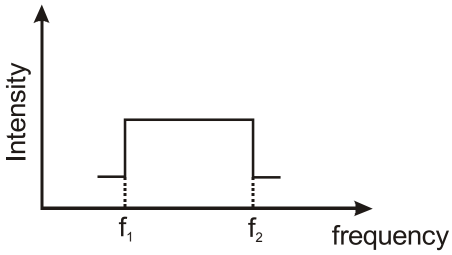
(A) 340 m/s for passengers in A and 310 m/s for passengers in B

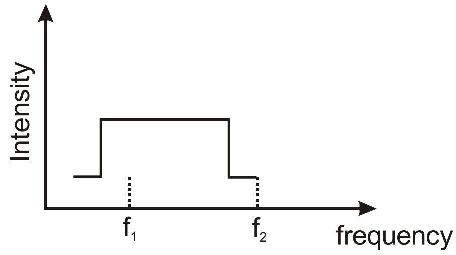
(B) 360 m/s for passengers in A and 310 m/s for passengers in B

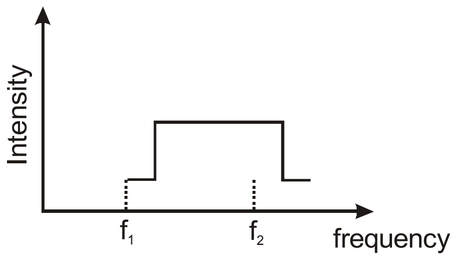
(C) 310 m/s for passengers in A and 360 m/s for passengers in B

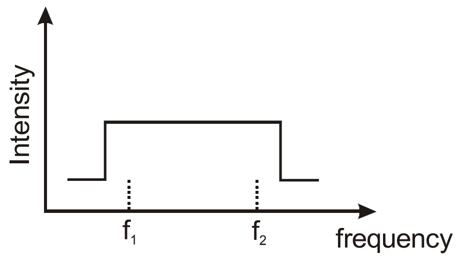
(D) 340 m/s for passengers in both the trains

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

(A) 

(B) 

(C) 

(D) 

13. 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

14. 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 per second 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 **[JEE' 2008, 3/163]**

(A) 344 (B) 336 (C) 117.3 (D) 109.3

15. 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,

[JEE' 2009, 4/160, –1]

(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 1/4th of the wavelength of the sound in air.

16. A stationary source is emitting sound at a fixed frequency f_0, 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_0. 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, 3/163]**

17. 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, 5/163, –2]**

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

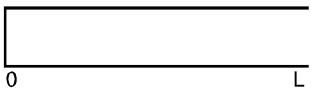
18. A police car with a siren of frequency 8 kHz is moving with uniform velocity 36 km/hr towards a tall building which reflects the sound waves. The speed of sound in air is 320 m/s. The frequency of the siren heard by the car driver is **[2011conducted by IIT Kanpur]**

(A) 8.50 kHz (B) 8.25 kHz (C) 7.75 kHz (D) 7.50 kHz

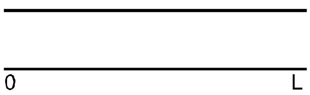
19. **Column** I shows four systems, each of the same length L, for producing standing waves. The lowest possible natural frequency of a system is called its fundamental frequency, whose wavelength is denoted as λ_f. Match each system with statements given in **Column** II describing the nature and wavelength of the standing waves. **[2011conducted by IIT Kanpur]**

Column I

(A) Pipe closed at one end

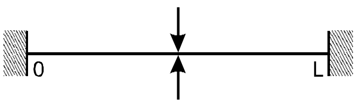


(B) Pipe open at both ends



(C) Stretched wire clamped at both ends

(D) Stretched wire clamped at both ends and at mid-point



Column II

(p) Longitudinal waves

(q) Transvers waves

(r) $\lambda_F = L$

(s) $\lambda_f = 2L$

20. 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, **[JEE 2012, 4/136]**

(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 traveling up the pipe, if the other end of the pipe is closed.

(D) a high-pressure pulse starts traveling up the pipe, if the other end of the pipe is closed.

21. A student is performing the experiment of Resonance Column. The diameter of the column tube is 4cm. The frequency of the tuning fork is 512 Hz. The air temperature is 38° C in which the speed of sound is 336 m/s. The zero of the meter scale coincides with the top end of the Resonance Column tube. When the first resonance occurs, the reading of the water level in the column is : **[JEE 2012, 3 –1/136]**

(A) 14.0 cm (B) 15.2 cm (C) 16.4 cm (D) 17.6 cm

PART-II AIEEE (PREVIOUS YEARS PROBLEMS)

* ***Marked Questions are having more than one correct option.***

1. 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]**

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

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

(1) 286 cps (2) 292 cps (3) 294 cps (4) 288 cps

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

(1) increases (2) decreases

(3) remain same (4) increases or decreases depending on the material

4. A tuning fork of known frequency 256 Hz. makes 5 betas 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]**

(1) (256 + 2) Hz. (2) (256 – 2) Hz (3) (256 – 5) Hz (4) (256 + 5) Hz

5. When two tuning forks (fork 1 and fork 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 1 is 200 Hz, then what was the original frequency of fork 2? **[AIEEE 2005]**

(1) 200 Hz (2) 202 Hz (3) 196 Hz (4) 204 Hz

6. 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]**

(1) Zero (2) 0.5% (3) 5% (4) 20%

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 upto a maximum of 10,000 Hz, the maximum value of v upto which he can hear the whistle is: **[AIEEE 2006]**

(1) 30 ms^{-1} (2) $15\sqrt{2}$ ms^{-1} (3) $15\sqrt{2}$ ms^{-1} (4) 15 ms^{-1}

8. A sound absorber attenuates the sound level by 20 dB. The intensity decreases by a factor of :

(1) 1000 (2) 10000 (3) 10 (4) 100 **[AIEEE 2007]**

9. The speed of sound in oxygen (O_2) 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]**

(1) 500 ms^{-1} (2) 650 ms^{-1} (3) 1419 ms^{-1} (4) 1419 m/s

10. 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]**

(1) x > 54 (2) 54 > x > 36 (3) 36 > x > 18 (4) 18 > x

11. A motor cycle starts from rest and accelerates along a straight path at 2 m/s^2. 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 ms^{-1})

(1) 98 m (2) 147 m (3) 196 m (4) 49 m **[AIEEE 2009]**

12. A cylindrical tube, open at both ends, has a fundamental frequncy, 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]**

(1) f (2) f/2 (3) 3f/4 (4) 2f

EXERCISE # 4

NCERT QUESTIONS

1. A stone dropped from the top of a tower of height 300 m high splashes into the water of a pond near the base of the tower. When is the splash heard at the top given that the speed of sound in air is 340 m s^{-1} ? (g = 9.8 m s^{-2}). (g = 9.8 m s^{-2}).

2. Use the formula υ = to explain why the speed of sound in air
(a) is independent of pressure,
(b) increases with temperature,
(c) increases with humidity.

3. A bat emits ultrasonic sound of frequency 1000 kHz in air. If the sound meets a water surface, what is the wavelength of (a) the reflected sound, (b) the transmitted sound? Speed of sound in air is 340 m s^{-1} and in water 1486 m s^{-1}.

4. A hospital uses an ultrasonic scanner to locate tumours in a tissue. What is the wavelength os found in the tissue in which the speed of sound is 1.7 km s^{-1} ? The operating frequency of the scanner is 4.2 MHz.

5. A meter- long tube open at one end, with a movable piston at the other end, shows resonance with a fixed frequency source (a tuning fork of frequency 340 Hz) when the tube length is 25.5 cm or 79.3 cm. Estimate the speed of sound in air at the temperature of the experiment. The edge effects may be neglected.

6. Two sitar string A and B playing the note 'Ga' are slightly out of tune and produce beats of frequency 6 Hz. The tension in the string A is slightly reduced and the beat frequency is found to reduce to 3 Hz. If the original frequency of A is 324 Hz, what is the frequency of B ?

7. A train, standing at the outer signal of a railway station blows a whistle of frequency 400 Hz in still air.
(i) What is the frequency of the whistle for a platform observer from the platform with a speed of 10 m s^{-1}?
(ii) What is the speed of sound in each case ? The speed of sound in still air can be taken as 340 M s^{-1}.

8. A train , standing in a station-yard, blows a whistle of frequency 400 Hz in still air. The wind starts blowing in the direction from the yard to the station with at a speed of 10 m s^{-1}. What are the frequency, wavelength, and speed of sound for an observer standing on the station's platform? Is the situation exactly identical to the case when the air is still and the observer runs towards the yard at a speed of 10 m s^{-1}? The speed of sound in still air can be taken as 340 m s^{-1}.t

9. A narrow sound pulse (for example, a short pip by a whistle) is sent across a medium. (a) Does the pulse have a definite (i) frequency, (ii) wavelength, (iii) speed of propagation? (b) If the pulse rate is 1 after every 20 s, (that is the whistle is blown for a split of second after every 20 s), is the frequency os the note produced by the whistle equal to 1.20 or 0.05 Hz ?

10. A bat is flitting about in a cave, navigating via ultrasonic bleeps. Assume that the sound emission frequency of the bat is 40 kHz. During one fast swoop directly toward a flat wall surface, the bat is moving at 0.03 times the speed of sound in air. What frequency does the bat hear reflected off the wall?

ANSWERS

Exercise # 1

PART-I

A-1.	(D)	**A-2.**	(D)	**A-3.**	(A)	**A-4.**	(B)	**A-5.**	(D)	**B-1.**	(C)	**B-2.***	(AC)
B-3.*	(AD)	**C-1.**	(C)	**C-2.***	(AD)	**C-3.**	(B)	**C-4.***	(CD)	**C-5.**	(D)	**C-6.**	(B)
C-7.	(B)	**C-8.**	(A)	**D-1.**	(D)	**D-2.**	(A)	**D-3.***	(ABD)	**D-4.**	(B)	**D-5.**	(A)
D-6.	(B)	**D-7.**	(A)	**D-8.**	(B)	**E-1.**	(B)	**E-2.***	(ABC)	**E-3.**	(C)	**F-1.***	(AD)
F-2.	(C)	**F-3.**	(B)	**F-4.**	(B)	**F-5.**	(C)	**F-6.**	(C)	**F-7.**	(B)	**F-8.**	(C)
F-9.	(C)	**F-10.**	(B)	**F-11.**	(D)	**F-12.**	(D)	**F-13.**	(C)	**F-14.**	(C)	**F-15.**	(B)
G-1.	(A)	**G-2.***	(D)	**G-3.**	(B)	**G-4.**	(B)	**G-5.**	(A)	**G-6.**	(D)	**G-7.**	(B)
H-1.	(A)	**H-2.**	(D)	**H-3.**	(C)	**H-4.**	(C)	**H-5.**	(C)	**H-6.**	(B)	**H-7.**	(B)
H-8.	(D)												

PART-II

1.	(A)	**2.**	(B)	**3.**	(A)	**4.**	(A)	**5.**	(B)	**6.**	(A)	**7.**	(D)
8.	(A)	**9.**	(A)	**10.**	(B)	**11.**	(A)	**12.**	(A)				

13. (A) p, q ; (B) q, s ; (C) r ; (D) s,q

14. (A) $\rightarrow$ (r); (B) $\rightarrow$ (s); (C) $\rightarrow$ (p); (D) $\rightarrow$ (q)

15.	**False**	**16.**	**False**	**17.**	**False**	**18.**	**True**	**19.**	**False**	**20.**	**0.1**

21. $P_m = 3 \times 10^{-5}\ P_a$, $A = 1/3\pi \times 10^{-10}$ m

22. $a\,[\sin(kx + \omega t) + 2\sin(kx - \omega t)]$

23. **4**

Exercise # 2

PART-I

1.	(B)	**2.**	(C)	**3.**	(D)	**4.**	(A)	**5.**	(D)	**6.**	(D)	**7.**	(C)
8.	(D)	**9.**	(B)	**10.**	(A)	**11.**	(D)	**12.**	(A)	**13.**	(A)	**14.**	(C)
15.	(A)	**16.**	(D)	**17.**	(D)	**18.**	(C)	**19.**	(B)	**20.**	(A)	**21.**	(C)
22.	(B)	**23.**	(B)	**24.**	(D)	**25.**	(C)	**26.**	(A)	**27.**	(C)	**28.**	(C)
29.	(A)	**30.**	(A)	**31.**	(D)	**32.**	(A)	**33.**	(B)	**34.**	(C)	**35.**	(C)
36.	(B)	**37.**	(C)	**38.**	(B)	**39.**	(ABC)	**40.**	(CD)	**41.**	(ABD)	**42.**	(ABC)
43.	(BD)	**44.**	(ABC)	**45.**	(BD)	**46.**	(ACD)	**47.**	(BD)				

PART-II

1.	**4**	**2.**	**m = 6, n = 4**			**3.**	**0**	**4.**	**5**	**5.**	**5**	**6.**	**2**
7.	**0**	**8.**	**4**	**9.**	**6**	**10.**	**8**	**11.**	**8**	**12.**	**3**	**13.**	**5**
14.	**m = 2, n = 6**												

Exercise # 3

PART-I

1.	(B)	**2.**	(B)	**3.**	336 m/s	**4.**	(D)	**5.**	(C)	**6.**	(D)	**7.** V_s = 30 m/s	
8.	(A)	**9.**	(A)	**10.**	(C)	**11.**	(B)	**12.**	(A)	**13.**	(A)	**14.**	(A)
15.	(AD)	**16.**	7	**17.**	(B)	**18.**	(A)	**19.** (A) $\rightarrow$ p, t (B) $\rightarrow$ p, s (C) $\rightarrow$ q, s (D) $\rightarrow$ q, r					
20.	(BD)	**21.**	(B)										

PART-II

1.	(3)	**2.**	(2)	**3.**	(2)	**4.**	(3)	**5.**	(3)	**6.**	(4)	**7.**	(4)
8.	(4)	**9.**	(4)	**10.**	(1)	**11.**	(1)	**12.**	(1)				

Exercise # 4

1. 8.7s

2. Assume ideal gas law : $P = \frac{\rho RT}{M}$, where ρ is the density, M is the molecular mass, and T is the temperature of the gas. This gives $u = \sqrt{\frac{\gamma RT}{M}}$. This shows that u is :

(a) Independent of pressure.
(b) Increases as $\sqrt{T}$.
(c) The molecular mass of water (18) is less than that of N_2 (28) and O_2 (32).
Therefore as humidity increases, the effective molecular mass of air decreases and hence u increases.

3. (a) 3.4×10^{-4} (b) 1.49×10^{-3} m **4.** 4.1×10^{-4} m

5. 347 m s^{-1}

Hints : $v_n = \frac{(2n-1)v}{4\ell}$; n = 1, 2, 3, ...for a pipe with one end closed

6. 318 Hz

7. (i) (a) 412 Hz, (b) 389 Hz, (ii) 340 m s^{-1} in each case.

8. 400 Hz, 0.875 m, 350 m s^{-1} ; No, because in this case, with respect to the medium, both the observer and the source are in motion.

9. (a) The pulse does not have a definite wavelength or frequency, but has a definite speed of propagation (in a non-dispersive medium).
(b) No.

10. 42.47 kHz