EXERCISE-1

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

A 1. A person can hear sound waves in the frequency range 20 Hz to 20 kHz. Find the minimum and the maximum wavelengths of sound that is audible to the person. The speed of sound is 340 m/s.

A 2. Find the minimum and maximum wavelengths of sound in water that is in the audible range (20 - 20000 Hz) for an average human ear. Speed of sound in water = 1500 m/s.

A 3. 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 ?

A 4. The equation of a travelling sound wave is $y = 6.0 \sin (600\, t - 1.8\, x)$ where y is measured in 10^{-5} 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.

SECTION (B) : SPEED OF SOUND

B 1. 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.

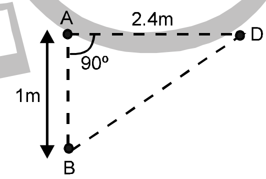
B 2. Calculate the speed of sound in oxygen from the following data. The mass of 22.4 litre of oxygen at STP (T = 273 K and p= 1.0×10^5 N/m^2) is 32 g, the molar heat capacity of oxygen at constant volume is $C_v = 2.5$ R and that at constant pressure is $C_p = 3.5$ R.

SECTION (C) : INTENSITY OF SOUND, DECIBEL SCALE

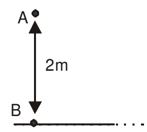
C 1. Two sound waves one in air and the other in fresh water are equal in intensity .
(a) Find the ratio of pressure amplitudes of the wave in water to that of the wave in air .
(b) If the pressure amplitudes of the waves are equal then what will be the ratio of the intensities of the waves .
[V_{sound} = 340 m/s in air & density of air = 1.22 kg/m^3 , V_{water} = 1488 m/s]

SECTION (D) : INTERFERENCE

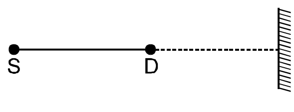
D 1. Two point sound sources A and B each of power 25π W and frequency 850 Hz are 1 m apart.
(a) Determine the phase difference between the waves emitting from A and B received by detector D as in figure.
(b) Also determine the intensity of the resultant sound wave as recorded by detector D . Velocity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



D 2. 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.



D 3. 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.



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

E 1. The stationary wave $y = 2a \sin kx \cos \omega t$ in a closed organ pipe is the result of the superposition of $y = a \sin (\omega t - kx)$ & ________ . **[REE - 94, 2]**

E 2. A metallic rod of length 1 m is rigidly clamped at its end points. Longitudinal stationary waves are setup in the rod in such a way that there are six antinodes of displacement wave observed along the rod. The amplitude of the antinode is 2×10^{-6} m. Write the equations of the stationary wave and the component waves at the point 0.1 m from the one end of the rod. [Young's modulus = 7.5×10^{10} N/m^2 , density = 2500 kg/m^3]

SECTION (F) : ORGAN PIPES AND RESONANCE

F 1. In a standing wave pattern in a vibrating air column, nodes are formed at a distance of 4.0 cm. If the speed of sound in air is 328 m/s, what is the frequency of the source?

F 2. The first overtone frequency of a closed organ pipe P_1 is equal to the fundamental frequency of an open organ pipe P_2. If the length of the pipe P_1 is 30 cm, what will be the length of P_2?

F 3. Two successive resonance frequencies in an open organ pipe are 1944 and 2592 Hz. Find the length of the tube. The speed of sound in air is 324 m/s.

F 4. A tube 1.0 m long is closed at one end. A wire of length 0.3 m and mass 1×10^{-2} 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_{sound} = 330 m/s]

F 5. A closed organ pipe of length ℓ = 100 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.

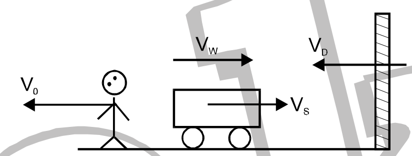
SECTION (G) : BEATS

G 1. A source of sound with adjustable frequency produces 4 beats per second with a tuning fork when its frequency is either 474 Hz. or 482 Hz. What is the frequency of the tuning fork?

G 2. 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.

SECTION (H) : DOPPLER EFFECT

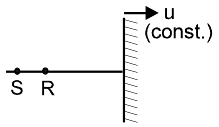
H 1. S, O & W represent source of sound (of frequency f), observer & wall respectively. V_O , V_S, V_D, V are velocity of observer, source, wall & sound (in still air) respectively. V_W is the velocity of wind. They are moving as shown. Find :



(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.

H 2. An observer rides with a sound source of frequency f and moving with velocity v towards a large vertical wall. Considering the velocity of sound waves as c, find :
(i) the number of waves striking the surface of wall per second
(ii) the wavelength of the reflected wave
(iii) the frequency of reflected wave
(iv) beat frequency heard by the observer.

H 3. 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.



SECTION (I) : MISCELLANEOUS

I 1. 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.

EXERCISE-2

SECTION (A) : EQUATION OF SOUND WAVE, WAVELENGTH, FREQUENCY, PRESSURE AND 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) $p = \Sigma\, p_{on} \sin (k_n x - \omega_n t)$

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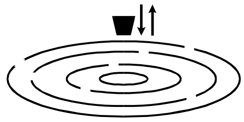
Successful People Replace the words like; "wish", "try" & "should" with "I Will". Ineffective People don't.

Here p denotes the change in pressure from the equilibrium value.

A 3. 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 :
(A) 65 Hz (B) 56 Hz (C) 46 Hz (D) 64 Hz

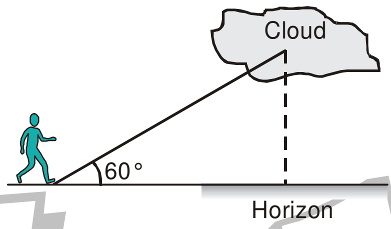
A 4. A piece of cork is floating on water in a small tank. The cork oscillates up and down vertically when small ripples pass over the surface of water. The velocity of the ripples being 0.21 ms^{-1}, wave length 15 mm and amplitude 5 mm, the maximum velocity of the piece of cork is -



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

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 sends sound waves in air. If the temperature of the air increases, which of the following parameters will change?
(A) displacement amplitude (B) Frequency
(C) Wavelength (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

B 4. The ratio of speed of sound in neon to that in water vapours at any temperature (when molecular weight of neon is 2.02×10^{-2} kg mol^{-1} and for water vapours is 1.8×10^{-2} kg mol^{-1})
(A) 1.06 (B) 1.60 (C) 6.10 (D) 15.2

SECTION (C) : INTENSITY OF SOUND, DECIBEL SCALE

C 1*. 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 2. Two sound waves move in the same direction in the same medium. The pressure amplitudes of the waves are equal but the wavelength of the first wave is double the second. Let the average power transmitted across a cross-section by the first wave be P_1 and that by the second wave be P_2. Then
(A) $P_1 = P_2$ (B) $P_1 = 4P_2$ (C) $P_2 = 2P_1$ (D) $P_2 = 4P_1$

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. 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

SECTION (D) : INTERFERENCE

D 1. When two waves with same frequency and constant phase difference interfere,
(A) there is a gain of energy

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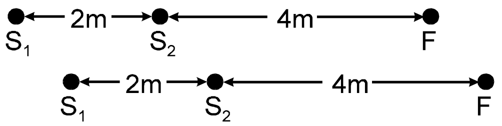
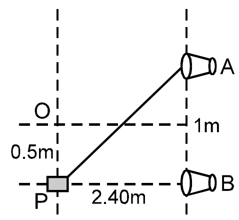
(B) there is a loss of energy
(C) the energy is redistributed and the distribution changes with time
(D) the energy is redistributed and the distribution remains constant in time

D2*. S_1 and S_2 are two sources of sound emitting sine waves. The two sources are in phase. The sound emmited by the two sources interfere at point F. The waves of wavelength :



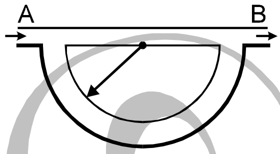
(A) 1 m will result in constructive interference
(B) $\frac{2}{3}$ m will result in constructive interference
(C) 2m will result in destructive interference
(D) 4m will result in destructive interference

D3. Two speakers S_1 and S_2, placed 1 m apart, each produce sound waves of frequency 1800 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}

D4. 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*. 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

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. 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

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.

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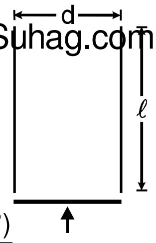


One end of tube is now closed. The lowest frequency of resonance of tube is ν_2.

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) $\frac{1}{2}\frac{(d+0.3\ell)}{(d+0.6\ell)}$

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 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) 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

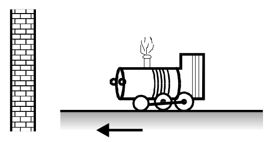
G 5. A closed organ pipe and an open pipe of same length produce 4 beats when they are set into vibrations simultaneously. If the length of each of them were twice their initial lengths, the number of beats produced will be [Assume same mode of vibration in both cases]
(A) 2 (B) 4 (C) 1 (D) 8

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

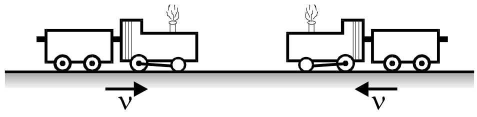
H 2. The change in frequency due to Doppler effect does not depend on
(A) the speed of the source (B) the speed of the observer
(C) the frequency of the source (D) separation between the source and the observer

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. 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 5. 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)

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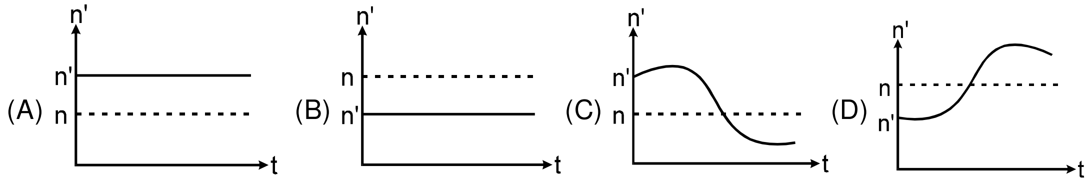
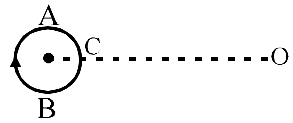


H 6. A small source of sound moves on a circle as shown in fig. and an observer is sitting at O. Let at $\upsilon_1, \upsilon_2, \upsilon_3$ be the frequencies heard when the source is at A, B, and C respectively.



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

SECTION (I) : MISCELLANEOUS

I 1. 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

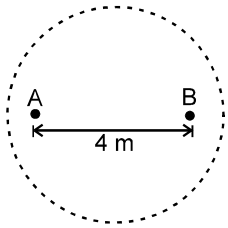
(A) $\frac{2u}{\lambda}$ (B) $\frac{u}{\lambda}$ (C) $\frac{u}{3\lambda}$ (D) $\frac{2\lambda}{u}$

EXERCISE-3

1. A closed pipe resonates at its fundamental frequency of 300 Hz. Which one of the following statements is wrong ?
300 Hz
(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. **[REE - 93]**

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. **[REE - 93]**

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

6*. 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.) :

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(A) minimum length of water column to have the resonance is 45 cm.
(B) the distance between two succesive nodes is 50 cm.
(C) the maximum length of water column to create the resonance is 95 cm.
(D) none of these.

7. Two second 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

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 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

10.* A girl stops singing a pure note. She is surprised to hear an echo of higher frequency, i.e., a higher musical pitch. Then :
(A) there could be some warm air between the girl and the reflecting surface
(B) there could be two identical fixed reflecting surfaces, one half a wavelength of the sound wave away from the other
(C) the girl could be moving towards a fixed reflector
(D) the reflector could be moving towards the girl

11. 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 : **[REE' 97, 5]**
(A) $n = \frac{n' + n''}{2}$ (B) $\sqrt{n' n''}$ (C) $n = \frac{2n' n''}{n' + n''}$ (D) $n = \frac{2n' n''}{n' - n''}$

EXERCISE-4

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

A 1. Calculate the bulk modulus of air from the following data about a sound wave of wavelength 35 cm travelling in air. The pressure at a point varies between $(1.0 \times 10^5 \pm 14)$ Pa and the particles of the air vibrate in simple harmonic motion of amplitude 5.5×10^{-6} m.

SECTION (B) : SPEED OF SOUND

B 1. The absolute temperature of air in a region linearly increases from T_1 to T_2 in a space of width d. Find the time taken by a sound wave to go through the region in terms of T_1, T_2 and the speed v_0 of sound at T_0 K.

SECTION (C) : INTENSITY OF SOUND, DECIBEL SCALE

C 1. 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/m³. (a) What is the intensity at a distance of 6.0 m from the source? (b) What will be the pressure amplitude at this point? (c) What will be the displacement amplitude at this point?
(b) What will be the pressure amplitude at this point?
(c) What will be the displacement amplitude at this point?

SECTION (D) : INTERFERENCE

D 1. Two sources of sound, S_1 and S_2, emitting waves of equal wavelength 20.0 cm, are placed with a separation of 20.0 cm between them. A detector can be moved on a line parallel to S_1S_2 and at a distance of 20.0 cm from it. Initially, the detector is equidistant from the two sources. Assuming that the waves emitted by the sources are in phase, find the minimum distance through which the detector should be shifted to detect a minimum of sound.

D 2. 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

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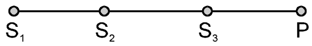
intensity of sound at P?



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

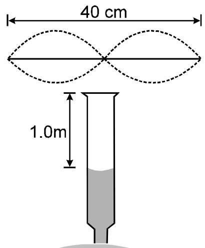
E 1. The equation of a longitudinal stationary wave in a metal rod is given by, $y = 0.002 \sin \frac{\pi x}{3} \sin 1000\, \pi t$, where x & y are in cm and t is in seconds . Find the maximum tensile stress at the point x = 2 cm, if young's modulus of the material is $\frac{3}{8\pi}$ dynes/cm^2.

E 2. A closed organ pipe has length 'ℓ'. The air in it is vibrating in 3rd overtone with maximum amplitude 'a'. Find the amplitude at a distance of ℓ/7 from closed end of the pipe.

SECTION (F) : ORGAN PIPES AND RESONANCE

F 1. An electronically driven loudspeaker is placed near the open end of a resonance column apparatus. The length of air column in the tube is 80 cm. The frequency of the loudspeaker can be varied between 20 Hz-2kHz. Find the frequencies at which the column will resonate. Speed of sound in air = 320 m/s.

F 2. Consider the situation shown in figure. The wire which has a mass of 4.00 g oscillates in its second harmonic and sets the air column in the tube into vibrations in its fundamental mode. Assuming that the speed of sound in air is 340 m/s, find the tension in the wire.



SECTION (G) : BEATS

G 1. A string 25 cm long fixed at both endsand having a mass of 2.5 g is under tension . A pipe closed from one end is 40 cm long. When the string is set vibrating in its first overtone and the air in the pipe in its fundamental frequency, 8 beats per second are heard. It is observed that decreasing the tension in the string decreases the beat frequency. If the speed of sound in air is 320 m/s. Find tension in the string.

G 2. Two radio stations broadcast their programs at the same amplitude A & at slightly different frequencies f_1 & f_2 respectively, where $f_2 - f_1 = 10^3$ Hz. A detector receives the signals from the two stations simultaneously. It can only detect signals of intensity $\geq 2A^2$. [Note : assume that $I = A^2$]
(i) Find the time interval between successive maxima of the intensity of the signal received by the detector .
(ii) Find the time for which the detector remains idle in each cycle of intensity of the signal.

[JEE - 93, 4]

SECTION (H) : DOPPLER EFFECT

H 1. 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 fraction of the velocity of the sound . Find :
(a) the frequency of the sound received by the observer at the moment when the source gets closest to him.
(b) the distance between the source and the observer at the moment when observer receives a frequency $v = v_0$.

H 2. Two vehicles A and B are moving towards each other with same speed u. They blow horns of the same frequency f. Wind is blowing at speed W in the direction of motion of A. The driver of vehicle A hears the sound of horn blown by vehicle B and the sound of horn of his own vehicle after reflection from the vehicle B. Find the frequency and wavelength of both sounds received by A. Velocity of sound is V.

H 3. A small source of sound oscillates in simple harmonic motion with an amplitude of 17 cm. A detector is placed along the line of motion of the source. The source emits a sound of frequency 800 Hz which travels at a speed of 340 m/s. If the width of the frequency band detected by the detector is 8 Hz, find the time period of the source.

SECTION (I) : MISCELLANEOUS

I 1. 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 . What is the original frequency of P ? Assume speed of sound = 332 m/s.

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EXERCISE-2

1. 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 **[JEE - 96, 2]**

2. An open pipe is suddenly closed at one end with the result that the frequency of third harmonic of the closed pipe is found to be higher by 100 Hz than the fundamental frequency of the open pipe. The fundamental frequency of the open pipe is - **[JEE - 96, 2]**
(A) 200 Hz (B) 300 Hz (C) 240 Hz (D) 480 Hz

3. A whistle emitting a sound of frequency 440 Hz is tied to a string of 1.5 m length and rotated with an angular velocity of 20 rad s^{-1} in the horizontal plane. Calculate the range of frequencies heard by an observer stationed at a large distance from the whistle. (v_{sound} = 330 m/s) **[JEE - 96, 3]**

4. When 0.98 m long metallic wire is stretched, an extension of 0.02 m is produced . An organ pipe 0.5 m long & open at both ends, when sounded with this stressed metallic wire, produces 8 beats in its fundamental mode. By decreasing the strain in the wire, the number of beats are found to decrease. Find Young's modulus of the wire . The density of metallic wire is 10^4 kgm^{-3} & sound velocity in air is 292 ms^{-1} . **[REE - 96, 5]**

5. A pipe of length 1m is closed at one end. The velocity of sound in air is 300 ms^{-1}. The air column in the pipe will resonate for sound of frequencies **[REE - 96]**
(A) 75 Hz (B) 225 Hz (C) 275 Hz (D) 375 Hz

6. A whistle giving out 450 Hz approaches a stationary observer at a speed of 33m/s.The frequency heard by the observer in Hz is
(A) 409 (B) 429 (C) 517 (D) 500 **[JEE - 97, 1]**

7. 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. (v_{sound} = 330 m/s) **[JEE - 97, 5]**

8. A band playing music at a frequency *f* is moving towards a wall at a speed v_b . A motorist is following the band with a speed v_m . If v is the speed of sound, obtain an expression for the beat frequency heard by the motorist . **[JEE - 97, 5]**

9. Two sound waves reaching a point at time t are represented by $P = P_{01} \sin (kx - \omega t)$ and $P = P_{02} \sin [k (x + \Delta x) - \omega t + \delta_0]$ respectively. The phase difference between these waves is _____. **[REE - 97,1]**

10. The air column in a pipe closed at one end is made to vibrate in its second overtone by a tuning fork of frequency 440 Hz. The speed of sound in air is 330 ms^{-1}. End corrections may be neglected. Let P_0 denote the mean pressure at any point in the pipe & ΔP_0 the maximum amplitude of pressure variation. **[JEE - 98,8]**
(i) Find the length L of the air column.
(ii) What is the amplitude of pressure variation at the middle of the column ?
(iii) What are the maximum & minimum pressures at the open end of the pipe.
(iv) What are the maximum & minimum pressures at the closed end of the pipe ?

11. When a tuning fork vibrates with 1.0 m or 1.05 m long wire of a sonometer, 5 beats per second are produced in each case. What will be the frequency of the tuning fork ? **[REE - 98]**
(A) 195 (B) 200 (C) 205 (D) 210

12. The ratio of speed of sound in nitrogen gas to that in helium gas at 300 K is **[JEE - 99]**
(A) $\sqrt{2/7}$ (B) $\sqrt{1/7}$ (C) $\sqrt{3}/5$ (D) $\sqrt{6/5}$

13. A closed pipe and an open pipe have their first overtones identical in frequency. Their lengths are in the ratio- **[REE - 99]**
(A) 1 : 2 (B) 2 : 3 (C) 3 : 4 (D) 4 : 5

14. Two monoatomic ideal gases 1 and 2 of molecular masses m_1 and m_2 respectively are enclosed in separate containers kept at the same temperature. The ratio of the speed of sound in gas 1 to that in gas 2 is given by
(A) $\sqrt{\frac{m_1}{m_2}}$ (B) $\sqrt{\frac{m_2}{m_1}}$ (C) $\frac{m_1}{m_2}$ (D) $\frac{m_2}{m_1}$ **[JEE - 2000]**

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15. A train moves towards a stationary observer with speed 34m/s. The train sounds a whistle and its frequency registered by the observer is f_1. If the train's speed is reduced to 17m/s, the frequency registered is f_2. If the speed of sound is 340m/s then the ratio f_1/f_2 is
(A) 18/19 (B) 1/2 (C) 2 (D) 19/18
[JEE - 2000 Screening, 1]

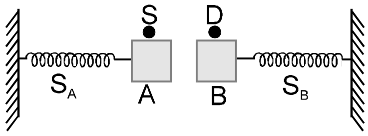
16. A 3.6 m long vertical pipe resonates with a source of frequency 212.5 Hz when water level is at certain heights in the pipe. Find the heights of water level (from the bottom of the pipe) at which resonances occur. Neglect end correction. Now, the pipe is filled to a height H (~ 3.6 m). A small hole is drilled very close to its bottom and water is allowed to leak. Obtain an expression for the rate of fall of water level in the pipe as a function of H . If the radii of the pipe and the hole are 2×10^{-2} m and 1×10^{-3} m respectively, calculate the time interval between the occurrence of first two resonances. Speed f sound in air is 340 m/s and g = 10 m/s^2 .[Note : This can be done after studying Fluid mechanics.]
[JEE - 2000 Mains, 10]
[Note for foundation students of Resonance : This can be done after studying Fluid mechanics.]

17. A source of sound revolving in a circle of radius 15 m is emitting a signal of frequency 200 Hz. It completes one revolution in 3 seconds . Calculate the maximum and minimum frequencies of the signal heard at a point 30 m from the centre of the circle . **[REE - 2000 Mains, 3]**
(speed of sound = 330 ms^{-1}) (= 330 ms^{-1})

18. It is desired to increase the fundamental resonance frequency in a tube which is closed at one end. This can be achieved by **[REE - 2000]**
(A) replacing the air in the tube by hydrogen gas (B) increasing the length of the tube
(C) decreasing the length of the tube (D) opening the closed end of the tube

19. A boat is travelling in a river with a speed 10 m/sec along the stream flowing with a speed 2 m/sec . From this boat, a sound transmitter is lowered into the river through a rigid support. The wavelength of the sound emitted from the transmitter inside the water is 14.45 mm. Assume that attenuation of sound in water and air is negligible ,
(a) What will be the frequency detected by a receiver kept inside the river downstream ?
(b) The transmitter and the receiver are now pulled up into air . The air is blowing with a speed 5 m/sec in the direction opposite the river stream. Determine the frequency of the sound detected by the receiver .
[Temperature of the air and water = 20º C ; Density of river water = 10^3 kg/m^3
Bulk modulus of the water = 2.088×10^9 Pa ; Gas constant R = 8.31 J/mol-K
Mean molecular mass of air = 28.8×10^{-3} Kg/mol ; C_P/C_V for air = 1.4]
[velocity of boat was assumed to be w.r.t. ground] **[JEE - 2001 (Mains)]**

20. A source S emitting sound of 300 Hz is fixed on block A which is attached to the free end of a spring S_A as shown in figure. The detector D fixed on block B attached to free end of spring S_B detects this sound. The blocks A and B are simultaneously displaced towards each other through a distance of 1.0m and then left to vibrate. Find the maximum and minimum frequencies of sound detected by D if the vibrational frequencies of each block is 2 Hz. **[REE - 2001]**



21. 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 **[JEE - 2002 Screening, 3]**

(A) $\frac{242}{252}$ (B) 2 (C) $\frac{5}{6}$ (D) $\frac{11}{6}$

22. 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_A. Pipe B is open at one end and closed at the other end , and is filled with a diatomic gas of molar mass M_B. 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 $\frac{M_A}{M_B}$.
(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. **[JEE - 2002 (Mains)]**

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23. A police van moving with velocity 22 m/s and emitting sound of frequency 176 Hz, follows a motorcycle which 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 **[JEE - 2003]**
(A) 33 m/s (B) 22 m/s (C) 11 m/s (D) 0

24. A resonance cylindrical tube when sounded with a tuning fork gives resonance when length of air column is 0.1 m it again gives resonance when the length of air column is 0.35 m. Then end correction is :
(A) 0.025 m (B) 0.020 m (C) 0.015 m (D) 0.010 m **[JEE - 2003]**

25. In a speed of sound experiment, air column in a pipe is made to resonate with a given tuning fork of frequency 480 Hz. The diameter of the pipe is 5 cm and it is open at one end. The smallest resonating length is observed to be 16 cm. Calculate the speed of sound in ms^{-1} from the given experimental data.
[JEE - 2003, 2]

26. 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) 1500 Hz (B) 600 Hz (C) 1200 Hz (D) 300 Hz

27. A closed pipe of length L contains gas of density ρ_1, another open pipe contains gas at density ρ_2. Both the gases have same compressibility factor and both pipes resonates with same frequency in their first overtone then the length of second pipe is : **[JEE Sc. 2004]**

(A) $\frac{4L}{3}\sqrt{\frac{\rho_2}{\rho_1}}$ (B) $\frac{4L}{3}\sqrt{\frac{\rho_1}{\rho_2}}$ (C) $\frac{4L}{3}$ (D) $\frac{L}{2}$

28. 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 : **[2005 S]**

(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) $n = 5,\ f_2 = \frac{5}{4}f_1$

29. 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 respectively. Find the speed of the train (speed of sound = 300 m/s) **[2005 2 marks]**
Ans **.** $v_T = 30$ m/s

Paragraph

Two plane harmonic sound waves are expressed by the equations. **[2006 5×3 marks]**

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

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

(All parameters are in MKS) : MKS

30. How many times does an observer hear maximum intensity in one second ?
(A) 4 (B) 10 (C) 6 (D) 8

31. What is the speed of the sound ?
(A) 200 m/s (B) 180 m/s (C) 192 m/s (D) 96 m/s

32. At x = 0 how many times the amplitude of $y_1 + y_2$ is zero in one second at x = 0 ?
(A) 192 (B) 48 (C) 100 (D) 96

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ANSWER

EXERCISE - 1

SECTION (A) :

A 1. **17 mm, 17 m**

A 2. **7.5 cm, 75 m**

A 3. **(a) $\pi/2$ (b) $2\pi/35$**

A 4. **(a) 1.7×10^{-5} m, (b) 1.08×10^{-4}**

SECTION (B) :

B 1. **333 m/s** **B 2.** **310 m/s**

SECTION (C) :

C 1. (a) $\frac{P_{0_w}}{P_{0_a}} = 60$ (b) $\frac{P_w}{P_a} = 2.8 \times 10^{-4}$

SECTION (D) :

D 1. (a) π (b) $I = \left(\sqrt{I_A} - \sqrt{I_B}\right)^2 = (25/312)^2$

D 2. 83 Hz

D 3. **420 Hz**

SECTION (E) :

E 1. $a\,[\sin(kx + \omega t) + 2\sin(kx - \omega t)]$

E 2. $Y = 2 \times 10^{-6} \sin \frac{6\pi}{10} \cos(6\sqrt{30}\pi \times 10^3\, t) + \theta$

at x = 0.1 ,

$Y = 1.9 \times 10^{-6} \cos(6\sqrt{30}\pi \times 10^3\, t) + \theta$

SECTION (F) :

F 1. **4.1 kHz** **F 2.** **20 cm**

F 3. **25 cm** **F 4.** 735 N

F 5. 20, 80 cm, 200 Hz

SECTION (G) :

G 1. **478 Hz** **G 2.** 2 %

SECTION (H) :

H 1. (i) $(V - V_W + V_S)/f$

(ii) $(V + V_W - V_S)/f$

(iii) $(V - V_W - V_D)/f_r$

where $f_r = (V + V_W + V_D/V + V_W - V_S)\, f$

(iv) $(V - V_W - V_O/V - V_W - V_D)\, f_r$

H 2. (i) $n = \frac{fc}{c - v}$

(ii) $\lambda' = \lambda - \left(\frac{v}{f}\right) = \left(\frac{c}{f}\right) - \left(\frac{v}{f}\right) = \left(\frac{c - v}{f}\right)$

(iii) $n'' = n'$

(iv) $f_{beat} = \left[\frac{(c + v)n'}{c}\right] - f$

H 3. $f_b = \frac{2uf}{v + u}$

SECTION (I) :

I 1. $L_c = 0.75$ m , $L_o = \frac{150}{151}$ m , 1.006 m

EXERCISE - 2

SECTION (A) :

A 1. D **A 2.** D **A 3.** B

A 4. A

SECTION (B) :

B 1. C **B 2.** C **B 3.** A

B 4. A

SECTION (C) :

C 1*. CD **C 2.** A **C 3.** B

C 4. B

SECTION (D) :

D 1. D **D2*.** ABD **D3.** B

D4. B

SECTION (E) :

E 1*. ABC

SECTION (F) :

F 1*. AD **F 2.** C **F 3.** B

F 4. B **F 5.** C **F 6.** C

SECTION (G) :

G 1. A **G 2.** BD **G 3.** B

G 4. B **G 5.** A

SECTION (H) :

H 1. AD **H 2.** D **H 3.** C

H 4. C **H 5.** B **H 6.** D

SECTION (I) : MISCELLANEOUS

I 1. A

EXERCISE - 3

1. B **2.** C **3.** D

4. A **5*.** BC **6*.** ABC

7. D **8.** D **9.** A

10.* CD **11.** C

EXERCISE - 4

SECTION (A) :

A 1. **1.4×10^5 N/m²**

SECTION (B) :

B 1. $\frac{2d}{v_0} \cdot \frac{\sqrt{T_0}}{\sqrt{T_1} + \sqrt{T_2}}$

SECTION (C) :

C 1. **(a) 44 mW/m²**

(b) 6.0 Pa

(c) 1.2×10^{-6} m

SECTION (D) :

D 1. **12.6 cm** **D 2.** **zero**

SECTION (E) :

E 1. $\frac{1}{8} \times 10^{-3}$ dynes/cm² **E 2.** a

SECTION (F) :

F 1. **100 (2n + 1) Hz where n = 0, 1, 2, 3, ..., 9**

F 2. **11.6 N**

SECTION (G) :

G 1. 27.0400 N

G 2. (i) 10^{-3} sec (ii) 5×10^{-4} s

SECTION (H) :

H 1. (a) $v = \dfrac{v_0}{(1-\eta^2)} = 5$ k Hz

(b) $r = \sqrt{1+\eta^2} = 0.32$ km

H 2. Direct from B : $f' = \dfrac{(v-w)+u}{(v-w)-u}$

From reflection : $f'' = \left[\dfrac{(v-w)+u}{(v-w)-u}\right]\left[\dfrac{v+w+u}{v+w-u}\right]$

H 3. **0.63 s**

SECTION (I) :

I 1. 160 Hz

EXERCISE - 5

1. A **2.** A

3. $f_{max} = 484$ Hz , $f_{min} = 403.3$ Hz

4. $Y = 1.76 \times 10^{11}$ N/m²

5. ABD **6.** D

7. $L_c = 0.75$ m ; $L_o = 0.99$ m or 1.006 m

8. $\dfrac{2v_b(v+v_m)f}{v^2 - v_b^2}$ **9.** $k\,\Delta x + \delta_0$

10. (i) $L = \dfrac{15}{16}$ m (ii) $\dfrac{\Delta P_0}{\sqrt{2}}$

(iii) $P_{max} = P_{min} = P_0$

(iv) $P_{max} = P_0 + \Delta P_0$, $P_{min} = P_0 - \Delta P_0$

11. C **12.** C **13.** C

14. B **15.** D

16. h = 3.2, 2.4, 1.6, 0.8, 0

; $= 5 \times 10^{-3}\sqrt{5H}$; $\Delta t = 80\,(4 - 2\sqrt{3})$

17. $200 \pm \dfrac{200\pi}{33}$ i.e. 221.0 Hz, 182.6 Hz.

18. A C D

19. (a) $f' = 98.20$ K Hz

(b) $f'' = 100.47$ K Hz

20. $v_{min} = \left(\dfrac{340 - 12.56}{340 + 12.56}\right) \times 300 = 278.6$ Hz

21. B

22. (a) $\dfrac{M_A}{M_B} = \dfrac{400}{189}$ (b) $\dfrac{f_A}{f_B} = \dfrac{3}{4}$

23. B **24.** A **25.** 336 m/s

26. B **27.** B **28.** D

29. $v_T = 30$ m/s **30.** A

31. A **32.** C

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