PHYSICS

BOOKS - HC VERMA PHYSICS (HINGLISH)

SOUND WAVES

Examples

1. A wave of wavelength 0.60 cm is produced in air and it travels at a speed of 300 ms^-1. Will it be audible?

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2. A sound wave of wavelength 40 cm travels in air. If the difference between the maximum and minimum pressures at a

given point is $1.0 \times 10^{-3} Nm^{-2}$, find the amplitude of vibration of the particle o the medium. The bulk modulus of air is $1.4 \times 10^{5} Nm^{-2}$.

A. $4.4 \times 10^{-10} m$

B. $2.2 \times 10^{-12} m$

C. $4.4 \times 10^{-12} m$

D. $2.2 \times 10^{-10} m$

Answer: D

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3. The pressure amplitude in a sound wave from a radio receiver is $2.0 \times 10^{-2} Nm^{-2}$ an the intensity at a point is $5.0 \times 10^{-7} Wm^{-2}$. If by turning the volume knob the pressure amplitude in increased to $2.5 \times 10^{-2} Nm^{-2}$ evaluate intensity.

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4. If the intensity increased by a factor of 20, byhow may decibels is the sound level increased?

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5. Two sound waves, originating from the same source, travel along different paths in air and then meet at a point. If the source vibrates at a frequency of 1.0 kHz and one path is 83 cm longer than the other, what will be the nature of interference? The speed of sound in air is $332ms^{-1}$.

A. Constructive

B. Destructive

C. Either constructive or destructive

D. Cannot be determined

Answer: B

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6. An air columnis constructed by fitting a movable piston in along cylindrical tube. Longitudinal waves are sent in the tube by as tunning fork of frequency 416 Hz. How far from the open end should the piston, be so that the air column in the tube may vibrate in its fitst overtone? Speed of soud in air is $333ms^{-1}$.

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7. A tuning fork A frequency 384Hz gives 6 beats in 2 seconds when sounded with another tuning fork B. What could be the frequency of B?

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8. A sound detector is placed on a railway platform. A train, approaching the platform at a speed of $36kmh^{-1}$, sounds irts whistle. The detector detects 12.0 kHz s the most dominant frequency in the whistle. If the trasin stops at the platform and sounds the whistle, what would be the most dominant frequency detected? The speed of sound in air is $340ms^{1}$.

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Worked Out Examples

1. An ultrasound signal of frequency 50 kHz is sent vertically into sea water. The signal gets reflected from the ocean bed and returns to the surface 0.80 s after it was emitted. The speed of

sound in sea water is $1500ms^{-1}$. a. Find the depth of the sea. b. What is the wavelength of this signal in water.

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2. An aeroplane is going towrds east at a speed of $510kmh^{-1}$ at a height of2000 m. At a certain instant, the sound o theh plane heard by a ground obserger appears to come from a point vertically above him. Where is the plane at this instant? Speed of sound in air $= 340ms^{-1}$

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3. A sound wave of frequency 10 kHz is travelling in air with a speed of $340ms^{-1}$. Find the minimum separation between two points where the phase difference is 60°.

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4. On a winter day sound travels 336 meters in one second. Find the atmosphere temperature. Speed of sound at $0^\circ C = 332ms^{-1}$.

A. $7^\circ C$

B. $10^\circ C$

C. $17^\circ C$

D. $15^\circ C$

Answer: A

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5. The constant γ of oxygen as well as for hydrogen is 1.40. If the speed of sound in oxygen is $470ms^{-1}$, What will be the speed in

hydrogen at the same temperature and pressure?

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6. A microphone of cross sectional area $0.80cm^2$is placed in front of a small speaker emitting 3.0 W of sound output. If the distance between the microphone and the speaker is 2.0 m how much energy falls on the microphone in 5.0 s?

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7. Find the amplitude of the vibration of the particles of air through which a sound wave of intensity $2.0 \times 10^{-6} Wm^{-2}$ and frequency 1.0kHz is passing. Density of air =1.2 kgm^-3 and speed of sound in air $= 330ms^{-1}$.

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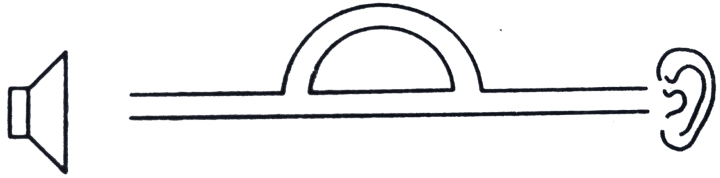
8. Figure shows a tube structure in which a sund signal is sent from one end and is received at the other end.The semicircular part has a radius of 20.0 cm. The frequency ohet sound source can be varied elertronically between 1000 and 4000 Hz. Find the frequencies at which maxima of intensity are detected. The speed of sound in air =`3400ms^-1.



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9. A source emitting sound of frequency 180 Hz is alced in front of a wall at a distance of 2 m from it. A detector is also placed in front of the weal at the same distance from it. Find the minimum distance between the source and the detector for which the

detector detects a maximum of sound. Speed of sound in air $= 360ms^{-1}$.

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10. A tuning fork vibrates at 264 Hz. Find the length of the shortest closed organ pipe that will resonarte wilth the tuning fork. Speed of sound in air is `350ms^-1.

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11. The funadamental frequency of a closed organ pipe is equal to the first overtone frequency of an open organ pipe. If the length of the open pipe is 60 cm, what is the length closed pipe?

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12. A tuning fork vibrating at frequency 800 Hz produces resonance in a resonance column tube. The upper end is open and the lower end is closed by the water surface which can be varied. Successive resonances are observed at lengths 9.75 cm, 31.25 cm and 52.75 cm. Calculate the speed of sound in air from these data.

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13. A certain organ pipe resonates in its fundamental mode at a frequency of 500 Hz in air. What will be the fundamental frequency if the air is replaced by hydrogen at the same temperature? The density of air is $1.20 kgm^{-3}$ and that of hydrogen is $0.089 kgm^{-3}$.

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14. An aluminium rod having a length of 90.0 cm is clamped at its middle point and is set into longitudinal vibrations by stroking it with a rosined cloth. Assume that the rod vibrates in it sfundmental mode of vibration. The density of aluminiumis $2600 kgm^{-3}$ and it s Young's modulus is $7.80 \times 10^{10} Nm^{-2}$. Find a. the speed of sound in aluminium, b. the wavelength of sound waves produced in the rod. c. THefrequency of the sound produced and d.the wavelength of the sound produced in air. Take the speed of sound in air t be $340 ms^{-1}$.

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15. The string of violin emits a note of 440 Hz at its correct tension. The string is bit taut and produces 4 bets er second with a tunning fork of frequency 440 Hz. Find the frequency of the note emitted by this taut string.

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16. A siren is fitted on as car going towards a vertical wall at a speed of 36 km/h. A person standing on the ground, behind the car, listens to the siren sound coming directly from the source as well as that coming after refelction from the siren to the person and b. coming after reflection. Take the speed of sound to be $340ms^{-1}$

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17. Two trains are moving towards each other at speeds of $72kmh^{-1}$ and $54kmh^{-1}$ relative to the ground. The first train sounds a whistle of frequency 600 Hz. Find the frequency of the whistle as heard by a passenger in the second train a. before the

trains meet and b. after teh trains have crossed each other. The speed of sound in air is $340ms^{-1}$

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18. A person going away from a factory on his scooter at a speedof $36kmh^{-1}$ listens to the siren of the factory. If the main frequency of the siren is 600 hz and a wind is blowing alongthe direction of the scooter at $36kmh^{-1}$, find the main frequency as heard by the person.

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19. A source and a detector moveaway fro each other, each with a speed of $10ms^{-1}$ with respect to the grond with no wind. If the detector detects a frequency 1950 Hz of the sound coming from

thesorce, what is the original frequency of the source? Speed of sound in air $= 340 ms^{-1}$.

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20. The driver of as car approaching a vertical wall notices that the frequency of his car's horn charges from 440 Hz to 480 Hz when it gets reflected from the wal. Find the speed of the car if that of the sound is $330 ms^{-1}$.

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21. A train approachign a railway crossing at a speed of $120 kmh^{-1}$ sounds a short whistle at frequency 640 Hz when it is 300 m away from the crossing. The speed of sound in air is $340 ms^{-1}$. What will be the frequency heard by a person standing

on a road perpendicular to the track through the crossing at a distance of 400 m from the crossing ?

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Short Answer

1. If you are walking on the moon, can you hear the sound of stones cracking behind you ? Can you hear the sound of your own footsteps ?

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2. Can you hear your own words if you are standing in a perfect vacuum ? Can you hear your, friend in the same conditions ?

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3. A vertical rod is hit at one end. What kind of wave propagates in the rod if (a) the hit is made vertically (b) the hit is made horizontally ?

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4. Two loudspeakers are arranged facing each other at some distance. Will a person standing behind one of the loudspeakers clearly hear the sound of the other loudspeaker or the clarity will be seriously damaged because of the 'collision' of the two sounds in between ?

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5. The voice of a person, who has inhaled helium, has a remarkably high pitch. Explain on the basis of resonant vibration of vocal cord filled with air and with helium.

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6. Draw a diagram to show The standing pressure wave and standing displacement wave for the 3rd overtone mode of vibration of an open organ pipe.

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7. Two tuning forks vibrate with the same amplitude but the frequency of the first is double the frequency of the second. Which fork produces more intense sound in air ?

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8. In discussing Doppler effect, we use the word "apparent frequency". Does it mean that the frequency of the sound is still that of the source and it is some physiological phenomenon in the listener's ear that gives rise to Doppler effect ? Think for the observer approaching the source and for the source approaching the observer.

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Objective 1

1. Consider the following statements about and pasing through a gas.

A. the pressure of the gas ast a point oscillages in time.

B. The position of a small layer of the gas oscillates in time.

A. both A and B are correct

B. A is correct but B is wrong

C. B is correct but A is wrong

D. Both A and B are wrong

Answer: A

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2. When we clap our hands, the sound produced is best described by Here p denotes the change in pressure from the equilibrium value

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. $p = \sum p_{0n} \sin(k_n x - \omega_n t)$

Answer: D

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3. The bulk modulus and the density of water are greater than those of air. With this much of information, we can say that velocity of sound in air

A. is larger than its value in water

B. is smaler than its value in water

C. is equal to its value in water

D. cannot be compared with its value inn water.

Answer: D

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4. A tuning fork sends sound waves in air. If the temperature of the air increases, which of the following parameters will changes?

A. displacement amplitude

B. frequency

C. wavelength

D. time period

Answer: C

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5. 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

Answer: D

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6. The speed of sound in a medium depends on

A. the elastic property but not on the inertia property

B. the inertia property but not on the elastic property

C. the elastic property as well as the inertia property

D. neither the elastic property nor the inertia property

Answer: C

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7. When two waves with same frequency and constant phase differenc 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.

Answer: D

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8. 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 distances L/4 inside the ends

D. at distance L/8 inside the ends

Answer: B

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9. An organ pipe, open at both ends, contains

A. longitudinal stationary waves

B. longitudinal travelling waves

C. transverse stationary waves

D. transverse travelling waves

Answer: A

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10. A cylinderical tube open at both ends, has a fundamental frequency f in air. The tube is dipped vertically in water so that half of it is in water. The fundamental frequency of air column is now

A. $\frac{v}{4}$

B. $\frac{v}{2}$

C. v

D. $2v$

Answer: C

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11. The phenomenon of beats can take place

A. for longitudinal waves only

B. for transverse waves only

C. for both longitudinal and transverse waves

D. for sound waves only

Answer: C

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12. A tuning fork of frequency 512 Hz is vibrated with sonometer wire and 6 beats per seconds are heard. The beat frequency reduces if the tension in the string is slightly increased. The original freqency of vibration of the string is

A. 506 Hz

B. 512 Hz

C. 518 Hz

D. 524 Hz

Answer: A

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13. The engine of a train sound a whistle at frequency v, the frequency heard by a passenger is

A. $> v$

B. $< v$

C. $= \frac{1}{v}$

D. $= v$

Answer: D

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14. The change in frequency due to Doppler effect does not depend on

A. the speed of the source

B. the speed of the observor

C. the frequency of the source

D. separation between the source and the observer

Answer: D

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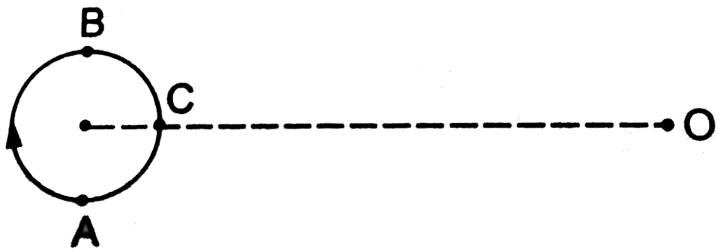
15. A small source of sound moves on a circle as shown in figure and an observer is sitting at O. Let v_1, v_2, v_3 be the frequencies heard when the source is at A,B and C respectively.



A. $v_1 > v_2 < v_3$

B. $v_1 = v_2 > v_3$

C. $v_2 > v_3 > v_1$

D. $v_1 > v_3 > v_2$

Answer: C

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Objective 1

1. Two sound waves moves 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. $P_2 = 4P_1$

Answer: A

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Objective 2

1. When you speak of your friend which of the following parameters have a unique value in the sound produced?

A. Frequency

B. wavelength

C. Amplitude

D. Wave velocity

Answer: D

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2. An electrically maintained tuning fork vibrtes with constant frequency and constant amplitude. If the temperature of the surronding air increases but pressure remains constnt, the sound produced will have

A. larger wavelength

B. larger frequency

C. larger velocity

D. larger time period

Answer: A::C

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3. The fundamental frequency of a vibrating organ pipe is 200 Hz.

A. the first overtone is 400 Hz.

B. The first overtone may be 400 Hz

C. The first overtone may be 600 Hz

D. 600 Hz is an overtone

Answer: B::C::D

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4. A source of sound moves towards an observer

A. The frequency of the source is increased

B. The velocity of sound in the medium is increased

C. The wavelength of sound in the medium towards the observer is decreased

D. The amplitude of vibration of the particle is increased.

Answer: C

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5. A listener is at rest with respect to the souce 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

Answer: A::D

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Exercises

1. A steel tube of length 1.00 m is struck at one end. A person with his er close to the othr end hears the sound of the blow twice one travelign through the body of the tube and the other through the air in the tube. Find the time gap between the two hearings. Use the table in the next for speeds of sound in various substances.

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2. At a prayer meeting, the disciples sing JAI-RAM JAI-RAM. The sound amplified by a loudspeaker comes back after reflection from a building at a distance of 80 m from the meeting. What maximum time interval can be kept between one JAI-RAM and the next JAI-RAM so that the echo S eed of does not disturb a listener sitting in the meeting. p sound in air is $320ms^{-1}$.

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3. A man stands before a large wall at a distance of 50.0 m and claps his hands at regular intervals. Initially, the interval is large. He gradually reduces the interval and fixes it at a value when the echo of a clap merges with the next clap. If he has to clap 10 times during every 3 seconds, find the velocity of sound in air.

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4. 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 $360 ms^{-1}$.

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5. 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 $= 1450ms^{-1}$.

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6. Sound waves from a loudspeaker spread nearly uniformly in all directions if the wavelength of the sound is much larger than the diameter of the loudspeaker. (a) Calculate the frequency for which the wavelength of sound in air is ten times the diameter of the speaker if the diameter is 20 cm. (b) Sound is essentially transmitted in the forward direction if the wavelength is much shorter than the diameter of the speaker. Calculate the frequency at which the wavelength of the sound is one tenth of the diameter of the speaker d- iescribed above. Take the speed of sound to be $340ms^{-1}$.

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7. Ultrasonic waves of frequency 4.5 MHz are used to detect tumour in soft tissues. The speed of sound in tissue is $1.5 kms^{-1}$ and that in air is $340 ms^{-1}$. Find the wavelength of this ultrasonic wave in air and in tissue.

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

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9. A sound wave of frequency 100 Hz is travelling in air. The speed of sound in air is $350ms^{-1}$ (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 ?

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10. Two point sources of sound are kept at a separation of 10 cm. They vibrate in phase to produce waves of wavelength 5.0 cm. What would be the phase difference between the two waves arriving at a point 20 cm from one source (a) on the line joining the sources and (b) on the perpendicular bisector of the line joining the sources ?

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11. Calculate the speed of sound in oxygen from the following data. The mass of 22.4 litre of oxygen at STP $\left(T = 273K \text{ and } p = 1.0 \times 10^5 Nm^{-2}\right)$ is 32 g, the molar heat capacity of oxygen at constant volume is $C_V = 2.5R$ and that at constant pressure is $C_p = 3.5R$.

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12. The speed of sound as measured by a student in the laboratory on a winter day is 340 m s when the rdoobmy temperature is $17^\circ C$. What speed will be measure another student repeating the experiment on a day when the room temperature is $32 \circ C$?

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13. At what temperature will the speed of sound be double of its value at $0 \circ C$?

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14. The absoulte temperature of air in a region linearly increases from $T_1 \rightarrow T_2$ 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_2d and the speed v of sound at 273 K. Evalute this time for $T_1 = 280K, T_2 = 310K, d33m$ and $v = 330ms^{-1}$

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15. Find the change in the volume of 1.0 litre kerosene when it is subjected to an extra pressure of $2.0 \times 10^5 Nm^{-2}$ from the

following data. Density of kerosene $= 800 kgm^{-3}$ and speed of sound in kerosene $= 1330 ms^{-1}$

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16. 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 $\left(1.0x10^{5} \pm 14\right)$ Pa and the particles of the air vibrate in simple harmonic motion of amplitude$5.5x10^{-6}m$.

A. $2.4 \times 10^{-5} N/m^2$

B. $1.4 \times 10^{-4} N/m^2$

C. $1.4 \times 10^{-5} N/m^2$

D. $1.4 \times 10^{-4} N/m^2$

Answer: C

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17. A source of sound operates at 2.0 kHz, 20 W emitting sound uniformly in all direction. The speed of sound in air is $340ms^{-1}$ at a distance of air is $1.2kgm^{-3}$ (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 ?

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18. The intensity of sound from a point source is $1.0 \times 10^{-8}Wm^{-2}$, at a distance of 5.0 m from the source. What will be the intensity at a distance of 25 m from the source ?

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19. The sound level at a point 5-0 m away from a point source is 40 dB. What will be the level at a point 50 m away from the source ?

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20. If the intensity of sound is doubled, by how many decibels does the sound level increase ?

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21. Sound with intensity larger than 120 dB appears painful to a person. A small speaker delivers 2.0 W of audio output. How close can the person get to the speaker without hurting his ears ?

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22. If the sound level in a room is increased from 50 dB to 60 dB, by what factor is the pressure amplitude increased ?

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23. The noise level in a classroom in absence of the teacher is 50 dB when 50 students are present. Assuming that on the average each student outputs same sound energy per second, what will be the noise level if the number of students is increased to 100 ?

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24. In Quincke's experiment the sound detected is changed from a maximum to a minimum when the sliding tube is moved through a distance of 2.50 cm. Find the frequency of sound if the speed of sound in air is $340 ms^{-1}$.

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25. In Quincke's experiment, the sound intensity has a minimum value I at a particular position. As the sliding tube is pulled out by a distance of 16.5 mm, the intensity increases to a maximum of 9 I. Take the speed of sound in air to be `330 m s^-1. (a) Find the frequency of the sound source. (b) Find the ratio of the amplitudes of the two waves arriving at the detector assuming that it does not change much between the positions of minimum intensity and maximum intensity.

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26. Two audio speakers are kept some distance apart and are driven by the same amplifier system. A person is sitting at a place 6.0 m from one of the speakers and 6.4 m from the other. If the sound signal is continuously varied from 500 Hz to 5000 Hz, what

are the frequencies for which there is a destructive interference at the place of the listener? Speed of sound in air $= 320ms^{-1}$

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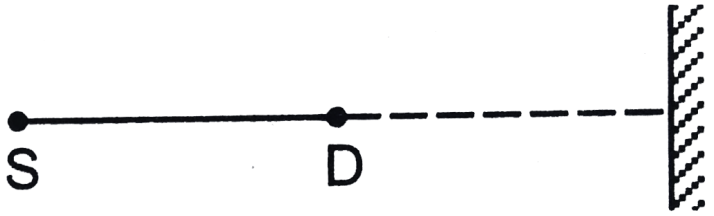
27. A source of sound S and a detector D are placed at some distance from one another. A big cardboard is placed near the detector and perpendicular to the line SD as shown in figure. It is gradually moved away and it is found that the intensity changes from a maximum to a minimum as the board is moved through a distance of 20 cm. Find the frequency of the sound emitted. Velocity of sound in air is $336ms^{-1}$.



A. 420 Hz

B. 440 Hz

C. 336 Hz

D. 340 Hz

Answer: A

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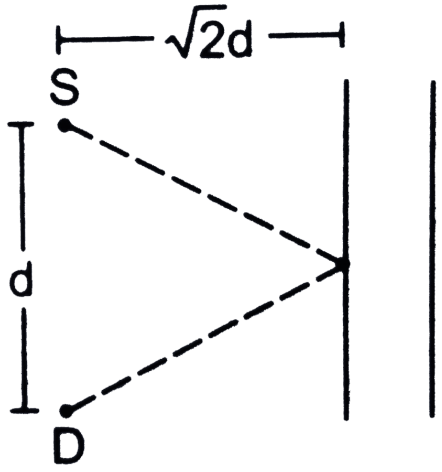
28. A source S and a detector D are placed at a distance d apart. A big cardboard is placed at a distance $\sqrt{2}d$ from the source and the detector as shown in figure. The source emits a wave of wavelength $= \frac{d}{2}$ which is received by the detector after reflection from the cardboard. It is found to be in phase with the direct wave received from the source. By what minimum distance should the cardboard be shifted away so that the reflected wave

becomes out of phase with the direct wave ?



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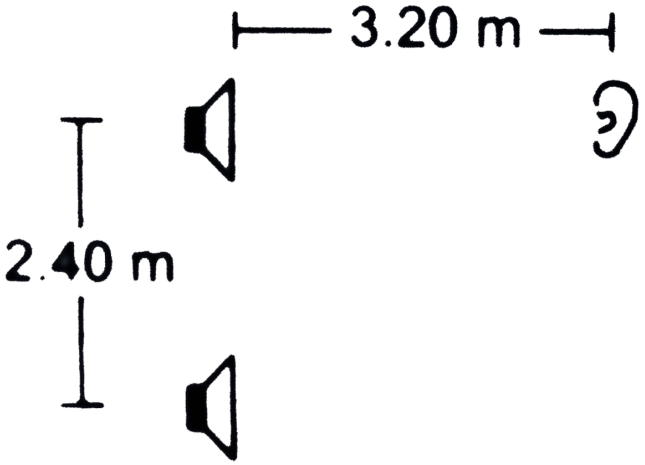
29. Two stereo speakers are separated by a distance of 2.40 m. A person stands at a distance of 3.20 m directly in front of one of the speakers as shown in figure. Find the frequencies in the audible range (20-2000 Hz) for which the listener will hear a

minimum sound intensity. Speed of sound in air $= 320 ms^{-1}$



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30. 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 P 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 wffich the detector should be shifted to detect a minimum of sound.

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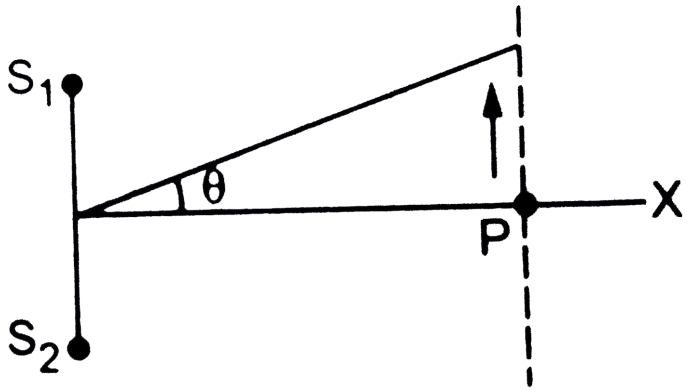
31. Two speakers S_1 and S_2 , driven by the same amplifier, areplaced at $y = 1.0m$ and $y = -1.0m$. The speakers vibrate in phase at 600 Hz. A man stands at a point on the X-axis at a very large distance from the origin and starts moving parallel to the Y-axis. The speed of sound in air is$330ms^{-1}$ (a) At what angle θ will the intensity of sound drop to a minimum for the first time ? (b) At what angle will he hear a maximum of sound intensity for the first time ? (c) If he continues to walk along the line, how many

more maxima can he hear ?



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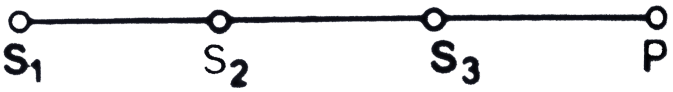
32. Three sources of sound S_1, S_2 and $S_3 ofequal \int ensityareplaced \in astraightl \in ewith$ S_1S_2=S_2=S_3 . $Atap \oint P.\ farawayomthesources, thewaveco$ min $gomS\_2$ si 120^@$ahead \in phaseoft\hat{o}mS\_1.\ Also, thewaveco$ min $gomS\_3$ is 120^@$aheadoft\hat{o}mS\_2$`. What would be the resultant intensity of

sound at P?



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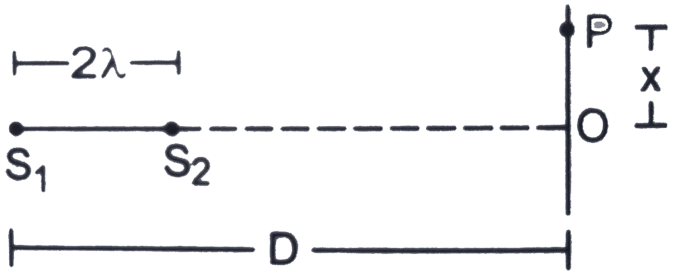
33. Two coherent narrow slits emitting sound of wavelength lamda in the same phase are placed parallel to each other at a small separation of 2λ. The sound is detected by moving a detector on the screen $\sum$ at a distance D(gtgtlamda) from the slit S_1 as shown in figure. Find the distance x such that the intensity at P is equal to the intensity at O.



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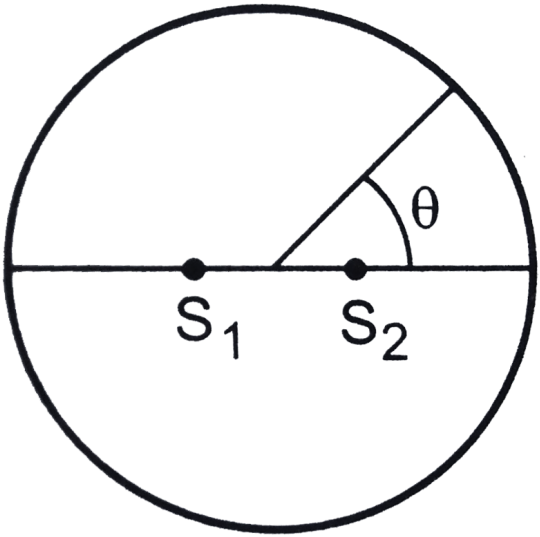
34. Figure shows two coherent sources S_1 and S_2 which emit sound of wavelength λ in phase. The separation between the sources is 3λ. A circular wire at large radius is placed in such a way that S_1S_2 lies in its plane and the middle point of S_1S_2, is at the centre of the wire. Find the angular positions 0 on the wire for which constructive interference takes place.



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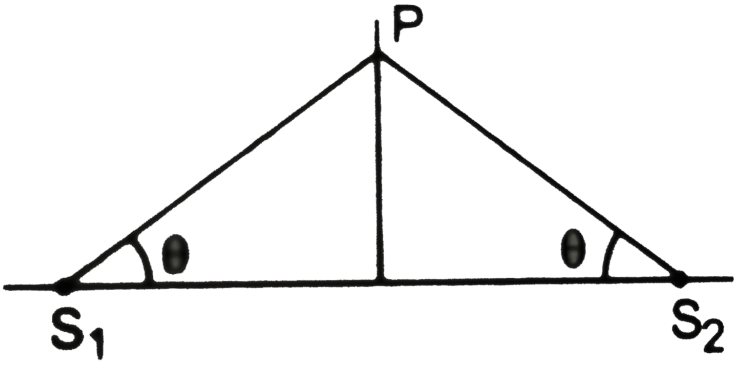
35. Two sources of sound S_1 and S_2 vibrate at same frequency and are in phase. The intensity of sound detected at a point P as shown in the figure is I_0 . (a) If theta equals 45°, what will be the intensity of sound detected at this point if one of the sources is switched off ? (b) What will be the answer of the previous part if $\theta = 60^\circ$?



A. $\frac{I_0}{4}, \frac{I_0}{2}$

B. $\frac{I_0}{2}, 3\frac{I_0}{4}$

C. $\frac{I_0}{4}, \frac{I_0}{4}$

D. $\frac{I_0}{2}, \frac{I_0}{4}$

Answer: C

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36. Find the fundamental, first overtone and second overtone frequencies of an open organ pipe of length 20 cm. Speed of sound in air is $340 ms^{-1}$.

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37. A closed organ pipe can vibrate at a minimum frequency of 500 Hz. Find the length of the tube. Speed of sound in air $= 340 ms^{-1}$.

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38. 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 $328ms^{-1}$ what is the frequency of the source ?

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39. The separation between a node and the next antinode in a vibrating air column is 25 cm. If the speed of sound in air is $340ms^{-1}$, find the frequency of vibration of the air column.

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40. A cylindrical metal tube has a length of 50 cm and is open at both ends. Find the frequencies between 1000 Hz and 2000 Hz at

which the air column in the tube can resonate. Speed of sound in air is $340 ms^{-1}$.

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41. In a resonance column experiment, a tuning fork of frequency 400 Hz is used. The first resonance is observed when the air column has a length of 20.0 cm and the second resonance is observed when the air column has a length of 62.0 cm. (a) Find the speed of sound in air.(b) How much distance above the open end does the pressure node form ?

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42. 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 ofP_2?

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43. A copper rod of length 1.0 m is clamped at its middle point. Find the frequencies between 20 Hz and 20,000 Hz at which standing longitudinal waves can be set up in the rod. The speed of sound in copper is $3.8 kms^{-1}$.

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44. Find the greatest length of an organ pipe open at both ends that will have its fundamental frequency in the normal hearing range (20-20,000 Hz). Speed of sound in air $= 340 ms^{-1}$.

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45. An open organ pipe has a length of 5 cm. (a) Find the fundamental frequency of vibration of this pipe. (b) What is the highest harmonic of such a tube that is in the audible range ? Speed of sound in air is $340ms^{-1}$ and the audible range is 20-20,000 Hz.

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46. 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 and 2 kHz. Find the frequencies at which the column will resonate. Speed of sound in air $= 320ms^{-1}$

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47. Two successive resonance frequencies in an open organ pipe are 1944 Hz and 2592 Hz. Find the length of the tube. The speed of sound in air is $324ms^{-1}$.

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48. A piston is fitted in a cylindrical tube of small cross section with the other end of the tube open. The tube resonates with a tuning fork of frequency 512 Hz. The piston is gradually pulled out of the tube and it is found that a second resonance occurs when the piston is pulled out through a distance of 32.0 cm. Calculate the speed of sound in the air of the tube.

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49. A U-tube having unequal arm-lengths has water in it. A tuning fork of frequency 440 Hz can set up the air in the shorter arm in its fundamental mode of vibration and the same tuning fork can set up the air in the longer arm in its first overtone vibration. Find the length of the air columns Neglect any end effect and assume that the speed of sound in air $= 330ms^{-1}$

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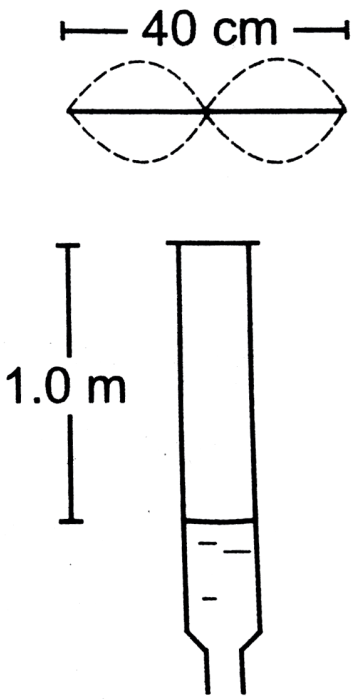
50. Consider the situation shown in figure. The wire which has a mass of 4.00 g oscillates in its second harmonic and sets the air column in the tube into vibrations in its fundamental mode. Assuming that the speed of sound in air is $40ms^{-1}$, find the

tension in the wire.



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51. A 30.0-cm-long wire having a mass of 10.0 g is fixed at the two ends and is vibrated in its fundamental mode.A 50.0-cm-long closed organ pipe, placed with its open end near the wire, is set

up into resonance in its fundamental mode by the vibrating wire. Find the tension in the wire. Speed of sound in air $= 340 ms^{-1}$.

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52. Show that if the room temperature changes by a small amount from $T \to T + \triangle T$, the fundamental frequency of an organ pipe changes from $v \to v + \triangle v, where$(/_\v)/v=1/2(/_\T)/T`.

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53. The fundamental frequency of a closed pipe is 293 Hz when the air in it is at a temperature of $20^\circ C$. What will be its fundamental frequency when the temperature changes to $22^\circ C$?

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54. A Kundt's tube apparatus has a copper rod of length 1.0 m clamped at 25 cm from one of the ends. The tube contains air in which the speed of sound is $340ms^{-1}$ The powder collects in. heaps separated by a distance of 5.0 cm. Find the speed of sound waves in copper.

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55. A Kundt's tube apparatus has a steel rod of length 1.0 m 66. clamped at the centre. It is vibrated in its fundamental mode at a frequency of 2600 Hz. The lycopodium powder dispersed in the tube collects into heaps separated by 6.5 cm. Calculate the speed of sound in steel and in air.

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56. A source of sound with adjustable frequency produces 2. beats per second with a tuning fork when its frequency is either 476 Hz or 480 Hz. What is the frequency of the tuning fork ?

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57. A tuning fork produces 4 beats per second with another 68. tuning fork of frequency 256 Hz. The first one is now loaded with a little wax and the beat frequency is found to increase to 6 per second. What was the original frequency of the tuning fork ?

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58. Calculate the frequency of beats produced in air when two sources of sound are activated, one emitting a wavelength of 32

cm and the other of 32.2 cm. The speed of sound in air is $350ms^{-1}$.

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59. A tuning fork of unknown frequency makes 5 beats per second with another tuning fork which can cause a closed organ pipe of length 40 cm to vibrate in its fundamental mode. The beat frequency decreases when the first tuning fork is slightly loaded with wax. Find its original frequency. The speed of sound in air is $320ms^{-1}$

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60. A piano wire A vibrates at a fundamental frequency of 600 Hz. A second identical wire B produces 6 beats per second with it

when the tension in A is slightly increased. Find the ratio of the tension in A to the tension in B.

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61. A tunnig fork of frequency 256 Hz produces 4 beats per second with a wire of length 25 cm vibrating in its fundamental mode. The beat frequency decreases when the length is slightly shortened. What could be the minimum length by which the wire be shortened so that it produces no beats with the tuning fork ?

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62. A traffic policeman standing on a road sounds a whistle emitting the main frequency of 2.00 kHz. What could be the apparent frequency heard by a scooter driver approaching the

policeman at a speed of $36.0 kmh^{-1}$? Speed of sound in air $= 340 ms^{-1}$.

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63. The horn of a car emits sound with a dominant frequency of 2400 Hz. What will be the apparent dominant frequency heard by a person standing on the road in front of the car if the car is approaching at $18.0 kmh^{-1}$? Speed of sound in air $= 340 ms^{-1}$

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64. A person riding a car moving at $72 kmh^{-1}$ sounds a whistle emitting a wave of frequency 1250 Hz. What frequency will be heard by another person standing on the road (a) in front of the car (b) behind the car ? Speed of sound in air $= 340 ms^{-1}$.

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65. A train approaching a platform at a speed of $54kmh^{-1}$ sounds a whistle. An observer on the platform finds its frequency to be 1620 Hz. The train passes the platform keeping the whistle on and without slowing down. What frequency will the observer hear after the train has crossed the platfrom ? The speed of sound in air $= 332ms^{-1}$

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66. A bat emitting an ultrasonic wave of frequecy 4.5×10^4 Hz flies at a speed of $6ms^{-1}$ between two parallel walls. Find the two frequecies heard by the bat and the beat frequecy between the two. The speed of sound is $330ms^{-1}$

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67. A bullet passes past a person at a speed of $220ms^{-1}$. Find the fractional change in the frequency of the whistling sound heard by the person as the bullet crosses the person. Speed of sound in air $= 330ms^{-1}$.

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68. Two electric trains run at the same speed of $72kmh^{-1}$ along the same track and in the same direction with a separation of 2.4 kin between them. The two trains simultaneously sound brief whistles. A person is situated at a perpendicular distance of 500 m from the track and is equidistant from the two trains at the instant of the whistling. If both the whistles were at 500 Hz and the speed of sound in air is $340ms^{-1}$, find the frequencies heard by the person.

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69. A violin player riding on a slow train plays a 440 Hz note. Another violin player standing near the track plays the same note. When the two are close by and the train approaches the person on the ground, he hears 4'0 beats per second. The speed of sound in air $= 340ms^{-1}$ (a) Calculate the speed of the train. (b) What beat frequency is heard by the player in the train ?

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70. Two identical tuning forks vibrating at the same frequency 256 Hz are kept fixed at some distance apart. A listener runs between the forks at a speed of $3.0ms^{-1}$ so that he approaches one tuning-fork and recedes from the other. find the beat frequency

bserved by the listener. Speed of sound in air $= 332ms^{-1}$.

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71. Figure shows a person standing somewhere in between two identical tunning forks, each vibrating at $512Hz. If \perp hthetun \in gf$ or $ksmove \to wardsrightataspeedof$ 5.5 ms^-1 , $f \in dthe\nu mberofbeatsheardbytheliste \neq r. Speedofsound \in air$ =330 ms^-1`.

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72. A small source of sound vibrating at frequency 500 Hz is rotated in a circle of radius $\frac{100}{2}\pi$ cm at a constant angular speed of 5-0 revolutions per second. A listener situates himself in the plane of the circle. Find the minimum and the maximum frequency of the sound observed. Speed of sound in air $= 332ms^{-1}$.

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73. Two trains are travelling towards each other both at a speed of $90kmh^{-1}$. If one of the trains sounds a whistle at 500 Hz, what will be the apparent frequency heard in the other train ? Speed of sound in air `= 350 m s^-1.

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74. A traffic policeman sounds a whistle to stop a car-driver approaching towards him. The car-driver does not stop and takes the plea in court that because of the Doppler shift, the frequency of the whistle reaching him might have gone beyond the audible limit of 20 kHz and he did not hear it. Experiments showed that the whistle emits a sound with frequency close to 16 kHz. Assuming that the claim of the driver is true, how fast was he driving the car ? Take the speed of sound in air to be $330ms^{-1}$. Is this speed practical with today's technology ?

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75. A car moving at $108kmh^{-1}$ finds another car in front of it going in the same direction at $72kmh^{-1}$. The first car sounds a horn that has a dominant frequency of 800 Hz. What will be the

apparent frequency heard by the driver in the front car ? Speed of sound in air $= 330ms^{-1}$

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76. Two submarines are approaching each other in a calm sea. The first submarine travels at a speed of $36kmh^{-1}$ and the other at $54kmh^{-1}$ relative to the water. The first submarine sends a sound signal (sound waves in water are also called sonar) at a frequency of 2000 Hz. (a) At what frequency is this signal received by the second submarine ? (b) The signal is reflected from the second submarine. At what frequency is this signal received by the first submarine. Take the speed of the sound wave in water to be $1500ms^{-1}$.

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77. 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 $340ms^{-1}$ If the width of the frequency band detected by the detector is 8 Hz, find the time period of the source.

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78. A boy riding on his bike is going towards east at a speed of $4\sqrt{2}ms^{-1}$. At a certain point he produces a sound pulse of frequency 1650 Hz that travels in air at a speed of $334ms^{-1}$. A second boy stands on the ground 45° south of east from him. Find the frequency of the pulse as received by the second boy.

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79. A sound source, fixed at the origin, is continuously emitting sound at a frequency of 660 Hz. The sound travels in air at a speed of $330ms^{-1}$. A listener is moving along the line x = 336 m at a constant speed of 26 m Find the frequency of the sound as observed by the listener when he is a. at $y = -140m, b.\ aty = 0$ and $c.\ aty = 140m.$

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80. A train running at `108 km h^-1 towards east whistles at a dominant frequency of 500 Hz. Speed of sound in air is 340 m/s. What frequency will a passenger sitting near the open window hear ? (b) What frequency will a person standing near the track hear whom the train has just passed ? (c) A wind starts blowing towards east at a speed of 36 km h-1. Calculate the frequencies

heard by the passenger in the train and by the person standing near the track.

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81. A boy riding on a bicycle going at $12kmh^{-1}$ towards a vertical wall whistles at his dog on the ground. If the frequency of the whistle is 1600 Hz and the speed of sound in air is `330 m s^-1, find (a) the frequency of the whistle as received by the wall (b) the frequency of the reflected whistle as received by the boy.

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82. A person standing on a road sends a sound signal to the driver of a car going away from him at a speed of $72kmh^{-1}. Thesignaltravell \in gat$330 m s^-1 in air and having a frequency of 1600 Hz gets reflected from the body of the car and

returns. Find the frequency of the reflected signal as heard by the person.

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83. A car moves with a speed of $54 kmh^{-1}$ towards a cliff. The horn of the car emits sound of frequency 400 Hz at a speed of $335 ms^{-1}$. (a) Find the wavelength of the sound emitted by the horn in front of the car. (b) Find the wavelength of the wave reflected from the cliff (c) What frequency does a person sitting in the car hear for the reflected sound wave ? (d) How many beats does he hear in 10 seconds between the sound coming directly from the horn and that coming after the reflection ?

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84. An operator sitting in his base camp sends a sound signal of frequency 400 Hz. The signal is reflected back from a car moving towards him The frequency of the reflected sound is found to be 410 Hz. Find the speed of the car. Speed of sound in air $= 324ms^{-1}$.

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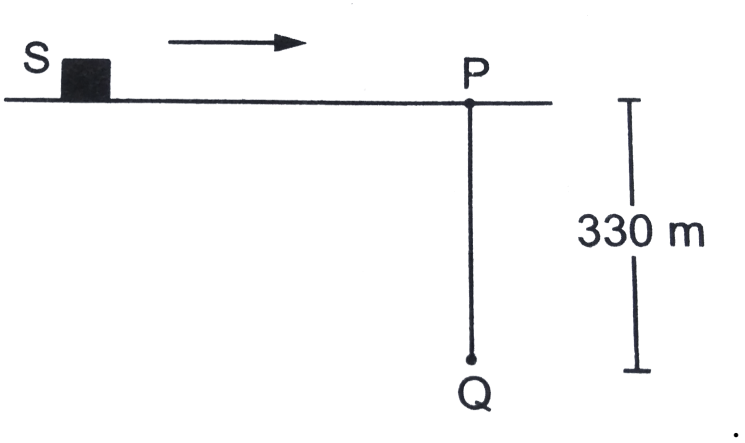
85. Figure shows a source of sound moving along the X-axis at a speed of $22ms^{-1}$ continuously emitting a sound of frequency 2.0 kHz which travels in air at a speed of $330 \in s^{-1}$. A listener Q stands on the Y-axis at a distance of 330 m from the origin. At t = 0, the source crosses the origin P. (a) When does the sound emitted from the source at P reach the listener Q 9 (b) What will be the frequency heard by the listener at. this instant 9 (c) Where

will the source be at this instant ?



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86. A source emitting sound at frequency 4000 Hz, is moving along the Y-axis with a speed of $22ms^{-1}$. A listener is situated on the ground at the position (660 m, 0). Find the frequency of the sound received by the listener at the instant the source crosses the origin. Speed of sound in air $= 330ms^{-1}$.

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87. A source of sound emitting a 1200 Hz note travels along a straight line at a speed of $170ms^{-1}$. A detector is placed at a distance of 200 m from the line of motion of the source. (a) Find the frequency of sound received by the detector at the instant when the source gets closest to it. (b) Find the distance between the source and the detector at the instant it detects the frequency 1200 Hz. Velocity of sound in air $= 340ms^{-1}$.

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88. A small source of sound S of frequency 500 Hz is attached to the end of a light string and is whirled in a vertical circle of radius 1.6 in. The string just remains tight when the source is at the highest point. (a) An observer is located in the same vertical plane at a large distance and at the same height as the centre of the circle. The speed of sound in air $= 330ms^{-1}$ and g = 10ms^-2`. Find the maximum frequency heard by the observer. (b) An

observer is situated at a large distance vertically above the centre of the circle. Find the frequencies heard by the observer corresponding to the sound emitted by the source When it is at the same height as the centre. ltbr.

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89. A source emitting a sound of frequency v is placed at a large distance from an observer. The source starts moving towards the observer with a uniform acceleration a. Find the frequency heard by the observer corresponding to the wave emitted just after the source starts. The speed of sound in the medium is v.

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