PHYSICS

BOOKS - BHARATI BHAWAN PHYSICS (HINGLISH)

VIBRATIONS OF COLUMNS

Examples

1. The lengths of an open and a closed organ pipe are respectively 160 cm and 75 cm. When both are sounded together 70 beats are counted in 10 seconds. Find the velocity of sound in air.

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2. The third overtone of a closed pipe is found to be in unison with the firest overtone of an open pipe. Find the ratio of the lengths of the pipes.

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3. The shortest length of a resonance tube which resonates with a turning fork of frequency $256Hz$ is 32 cm. The corresponding length for a fork of frequency $384Hz$ is 20.8 cm. Calculate the end-correction and velocity of sound in air.

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4. In a Kundt's tube experiment it was found that the distance between nodes was 6.6 cm when the sounding rod used was of total length 80 cm. Calculate the velocity of sound in the rod if velocity of sound in air $330ms^{-1}$.

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5. A copper rod of length $l = 50cm$ is clamped at its midpoint. Find the number of natural longitudinal oscillations of the rod in the frequency

range from 20 to $50kHz$. What are those frequencies equal to ?

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6. Two closed organ pipes A and B have length 50 cm and 75 cm, respectively. The 5th harmonic (= 2nd overtone) of A corresponds to nth overton eof B. Find n.

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Exercise

1. A closed pipe 28 cm long is filled with a gas and is in resonance with a tuning fork. If a 42 cm long open pipe filled with air is in unison with the same fork, find the velocity of sound in the gas. (Velocity of sound in air at the temperature $= 350ms^{-1}$)

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2. A tuning fork is held a little above the open end of a resonance tube. Resonance is heard when the length of air column are respectively. 24 cm and 74.1 cm. Calculate the end-correction and diameter of the tube.

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3. Two open pipes are sounded together, each produces notes consisting of the fundamental and also two upper harmonics. Fundamental note of one is 256 Hz and that of the other is 170 Hz. Would there be any beats produced, if so, how many ?

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4. Two open organ pipes 100 and 101 cm long give 17 beats in 10 seconds when each is sounding its fundamental. Calculate the frequencies of the fundamental and the velocity of sound in air.

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5. The frequency of an organ pipe at $40^\circ C$ is 256 Hz. What will be its frequency at $20^\circ C$?

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6. Two organ pipe give 5 beta per second when sounded together in air at a temperature $20^\circ C$. How many beats would be produced by

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7. Two tuning forks A and B give $18 beats in 2s$. A resonates with one end closed air column of $15cm$ long and B with both ends open column of 30.5 long. Calculate their frequencies.

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8. Calcuate the least mass of air that will resonate with a tuning fork of frequency $340Hz$ in a closed tube of diameter 4 cm at $30^\circ C$. (Velocity of sound in air at $30^\circ = 350ms^{-1}$ and density of air at $30^\circ C = 1.3kg$ per cubie metre). Neglect end -correction .

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9. A tuning fork of frequency 440 Hz is to be mounted on a wooden box with one end open to reinforce its sound. What would be the length of the sounding box ? (Velocity of sound in air $= 332ms^{-1}$)

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10. The first overtone of an open pipe and the fundamental tone of a closed pipe give 5 beats pe second when sounded together. If the length of the closed pipe is 25 cm, what are the possible length of the open pipe ? (Velocity of sound in air is $340ms^{-1}$)

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11. An open organ pipe is emitting a note of 200 Hz. What will be the effect on the frequency of the note emitted when one of its ends is suddenly closed ?

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12. Two organ pipes, open at both ends, are sounded together and six beats per second are produced. The length of the shorter pipe is 60 cm. Find the length of the other. ltVeocity of sound in air $= 330ms^{-1}$)

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13. Calcuate the length of a narrow tube closed at one end, which will resonate with a tuning fork of frequency $510Hz$ if the velocity of sound is $340ms^{-1}$.

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14. A fork of frequency 512 Hz is found to produce resonance in the air column, first when the length of the air column is 16.5 cm and again when it is 50.5 cm. Find the velocity of sound, wavelength of wave emitted by the fork and end-correction. Also calculate radius of the tube.

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15. A pipe of length 1.5 m closed at one end is filled with a gas and it resonates at $30^\circ C$ in its fundamental with a tuning fork. Another pipe of the same length but open at both ends and filled with air and it resonates in its fundamental with the same tuning fork. Calculate the velocity of sound at $0^\circ C$ in the gas, given that the velocity of sound in air is $360ms^{-1}$ at 30°.

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16. A tuning fork of frequency $340Hz$ is excited and held above a cylindrical tube of length $120cm$. It is slowly filled with water. The minimum height of water column required for resonance to be first heard(Velocity of sound $= 340ms^{-1}$) is.

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17. In a Kundt's tube experiment a brass rod 120 cm long was used. If had a fundamental frequency of $1400Hz$. The gas in the tube was CO_2 at $20^\circ C$ and the disatance between nodal heaps of powder was found to be 9 cm. Calculate the velocity of sound in brass and in CO_2 at $0^\circ C$.

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18. In a Kundt's dust tube experiment a brass rod was found to resonate with 10 cm of a sonometre wire stretched by 6 kg. One hundred centimetre of the wire was found to weight 653 mg. This rod produced nodal heaps 12 cm apart in air. Calculate the velocity of sound in air.

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19. The sounding rod of a dust tube apparatus is made of brass and is 160 cm long. The distance between adjacent nodes in the wave tube was 11.35 cm. Calculate the Young's modulus of the rod assuming that velocity of sound in air at room temperature is $350ms^{-1}$ and density o fbrass 900 kg m^(-3)`

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20. A tuning fork of frequency 270 resonates with an air column of length 31.2 cm. When the tube is rasied it resonates again when the length is 96.3 cm. Calcuate the velocity of sound in moist air in the tube. Reduce this velocity to STP if the pressure and temperature at the time of the experiment are 0.7 m of Hg and $30^{\circ}C$, respectively. Saturated vapour pressure at $30^{\circ}C = 32mm$ o fmercury.

$$\left[\text{Hint} \quad C_n = 2n(l_2 - l_1) \quad \text{and} \quad C_m = C_d\sqrt{\left(\frac{P}{P - 0.385f}\right)} \quad \text{and} \quad \frac{C}{C_0} = \right.$$

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21. Find the number of possible natural frequencies of an air column in a pipe whose frequencies lie below 1250 Hz. The length of the pipe is 85 cm. The speed of sound is $340ms^{-1}$. Consider the two cases: (a) the pipe is closed at one end and (b) the pipe is open at both ends.

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22. The pipe of a pop gun of length 15 cm is closed by a cork at one end a piston at the other end. When the pisotr is moved slowly and the pressure increase to 2.5 atm, the cork moves out with a pop sound. Calculate the frequency of the pop sound. The velocity of sound in air $= 384m/s$

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23. When $1m$ long metallic wire is stressed, an extension of $0.02m$ is produced. An organ pipe $0.5m$ long and open at both ends, when sounded with this stressed metallic wire, produced 8 beats in its fundamental mode. By decreasing the stress in the wire, the number of beats are found to decrease. Find the Young's modulus of the wire. The density of metallic wire is $10^4 kg/m^3$ and velocity of sound in air is $292m/s$.

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24. An organ pipe 17 cm long open at one end radiates a tone of frequency 1.5 kHZ at temperature $16^\circ C$. What harmonic is this ? What is the fundamental frequency of these oscillations velocity of sound at $NTP = 330m/s$.

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25. In a pipe closed at both ends the maximum amplitude of vibration is 5mm and the amplitude of vibration at a distance 5 cm form one end is 4.33 mm. The length of the pipe is 120 cm. To what mode of vibration does it correspond ? What is the frequency of the note emitted by the pipe ? Velcoity of sound in the gas enclosed in the pipe 336 m/s

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26. A long horzontal pipe is fitted with a piston of mass 10 kg which is connected to another mass 10.5 kg by a string passing over a frictionless pulley. A source of sound of frequency 512 Hz is placed in front of the piston. Initially the piston is almost in touch with the source and it moves away form the source when the hanging mass is released. Find the time/s when maximum sound is heard. Assume the string horizontal between pulley and piston. There is no friction. Velocity of sound $= 340m/s$

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