



## PHYSICS

### BOOKS - BHARATI BHAWAN PHYSICS (HINGLISH)

#### VELOCITY OF SOUND

##### Examples

1. Calculate the increase velocity of sound for  $1^{\circ}C$  rise of temperature if the velocity of sound at  $0^{\circ}C$  is  $332\frac{m}{s}$ .



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2. If the velocity of sound in hydrogen at  $0^{\circ}C$  is  $1248\text{ms}^{-1}$ , what will be the velocity of sound in a mixture of two parts by volume of hydrogen to one part of oxygen? (Oxygen is 16 times heavier than hydrogen.)

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3. One cubic metre of water is taken in a strong cylinder and the pressure on it is increased from one atmosphere ( $10^5$  newtons per square metre) to two atmospheres. It is found that it has been compressed by only  $50\text{cc}$ . Is this much sufficient for calculating velocity of sound in water?

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4. Calculate the velocity of sound in moist air at  $27^{\circ}C$  and  $0.7m$  pressure. The dew point is  $15^{\circ}C$ . The saturated vapour pressure at  $15^{\circ}C$  is  $17mm$  of mercury and velocity of sound at  $0^{\circ}C$  in dry air is  $330ms^{-1}$ .

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5. Calculate the velocity of sound on a day when relative humidity is  $80\%$  and temperature and pressure are respectively  $25^{\circ}C$  and  $0.68m$  of mercury. (velocity of sound at  $STP = 332ms^{-1}$ . Saturated vapour pressure at  $25^{\circ}$  is  $0.026m$  of mercury.)

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## Exercise

1. Find the temperature at which the velocity of sound in air is double the velocity of sound in air at  $0^{\circ}C$ .

[Hint : Use  $\frac{C}{C_0} = \sqrt{\frac{T}{T_0}}$ ]



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2. If the velocity of sound in air is 332 meters per second at NTP, find the velocity at  $30^{\circ}C$  and 0.7m of mercury.



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3. A man sets his watch by the noon-whistle of a factory at a distance of 1.5 kilometers. By how many seconds is his watch slower than the clock of the factory? (Velocity of sound in air is  $332\text{ms}^{-1}$ )

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4. Calculate the velocity of sound in steel given Young's modulus of steel  $= 2 \times 10^{11}\text{Nm}^{-2}$  and density of steel  $= 7800\text{kgm}^{-3}$ .

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5. The velocity of sound in hydrogen is  $1270\text{ms}^{-1}$  at  $0^\circ\text{C}$  and the frequency of a fork is  $335\text{Hz}$ . Find the distance travelled by sound in hydrogen at  $0^\circ\text{C}$  and  $30^\circ\text{C}$  in the time in which the fork completes 71 vibrations.

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6. A ship steams towards a hill in the sea and sounds its siren and the echo is heard after 6 s. The siren is sounded again 3 minutes later after the first sounding and the echo is heard after 4 s. If the velocity of the ship is 6.87 kmph, calculate the velocity of sound in air.

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7. A man claps his hands in front of a wall and he hears the echo after  $1.6s$ . He walks  $33m$  nearer the wall and hears the echo  $1.4s$  after clapping. Find the velocity of sound in air.

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8. A man walks towards a cliff while beating a drum at the rate of 5 beats per second till the echo of beating disappears completely. He walks at the rate of 8 kilometres per hour. Calculate the distance of the man from the cliff in the beginning if he walked for 5 minutes. (Velocity of sound in air =  $350m.s^{-1}$  )

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9. A man standing in front of a mountain at a certain distance beats a drum at regular intervals. He increases the beating rate and finds that the echo is not heard distinctly when the rate becomes 40 per minute. He then moves nearer to the mountain by 90 m and finds that the echo is again not heard when the beating rate is 60 per minute. Calculate the velocity of sound and the distance between the mountain and the initial position of the man.

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10. Velocity of sound through an unknown gas at STP is  $258.4\text{ms}^{-1}$  and its density  $1.977\text{kgm}^{-3}$ . What is the atomicity of the molecules of the gas?

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11. Calculate the velocity of sound in air saturated with moisture at  $25^{\circ}C$  and 745 mm pressure. The saturation pressure at  $25^{\circ}C$  is 23.76mm of mercury and the velocity of sound at  $0^{\circ}C$  in dry is  $332ms^{-1}$ .

[Hint: See example 4.]

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12. Show that the velocity of sound in a gas of  $\gamma = 1.41$  is  $0.68C$  where  $C$  is the root mean square velocity of its molecules.

[Hint:  $C = \sqrt{\frac{\gamma P}{D}}$  and  $P = \frac{1}{3}DC^2$  where  $C$  is root mean square velocity]



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13. If the velocity of sound in dry air at  $0^{\circ}C$  is  $332m.s^{-1}$ . Find the temperature at which it will be  $345m.s^{-1}$ , coefficient of volume expansion of air being  $0.00368/^{\circ}C$ .

[Hint: Use  $\frac{C}{C_0} = \sqrt{\frac{T}{T_0}}$ . Now,  $T_0 = \frac{1}{\alpha}$  where  $\alpha =$  coefficient of expansion]



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14. Calculate the velocity of sound in air on a day when temperature is  $30^{\circ}C$ , pressure  $0.74m$  of mercury and relative humidity  $60\%$ . Velocity of sound at NTP =  $330m.s^{-1}$ . Saturated vapour pressure at

$30^\circ C = 0.032m$  of mercury.

$$\left[ \begin{array}{l} \text{Hint: Relative Humidity} = \frac{\text{Vapour pressure at } 30^\circ C}{\text{Saturated vapour pressure at } 30^\circ C} \\ C_m = C_d \sqrt{\frac{P}{P - 0.385f}} \end{array} \right]$$

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15. How long will it take for sound waves to travel the distance  $l$  between points A and B if the air temperature between them varies linearly from  $T_1$  to  $T_2$ ? The velocity of sound at  $T_0$  is  $C_0$ .

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16. Show that if the rate of change of temperature with height  $dT/dh$  called lapse rate is a constant, a sound wave

travelling horizontally is refracted along an arc of radius of

$$\text{curvature } \rho = 2T / \frac{dT}{dh}$$

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**17.** In what gas at the same temperature is the speed  $v$  of sound greater - in nitrogen ( $N_2$ ) or in carbon dioxide ( $CO_2$ )? The vibrational modes of gas molecules are not excited. Compare the velocities when vibrational modes are also excited.

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**18.** The splash of a stone in a well is heard  $\tau = 2.053s$  after the stone is let fall. Calculate the depth of the well

assuming the velocity of sound in the well  $v = 400\text{m/s}$ .

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**19.** Calculate the velocity of sound in a mixture of two gases obtained by mixing  $V_1$  and  $V_2$  volumes of them if the velocity of sound in them be  $C_1$  and  $C_2$ . The atomicity of the gases is the same.

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**20.** A bullet travels horizontally overhead a man at a height  $h = 5\text{m}$  at speed  $v = 0.660\text{ms}^{-1}$ . How far is the bullet from the man when he hears its whistle?  $v$ , velocity of sound  $= 340\text{ms}^{-1}$ .



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21. If  $C = 332 \text{ms}^{-1}$ , say the velocity of sound in dry air at STP, find the velocity of sound in moist air at STP. Molecular weight of air = 28.8, that of water vapour = 18,  $\gamma$  of dry air = 1.4 and  $\gamma$  of water vapour = 1.33. The standard pressure is 750 mm of mercury and standard temperature is  $0^\circ \text{C}$ . the vapour pressure at  $0^\circ \text{C}$  is 4.8 mm of mercury.



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22. Calculate the velocity of sound in a mixture of oxygen, nitrogen and argon at  $0^\circ \text{C}$  when their masses are in the

ratio 2: 7: 1. The molecular weights of gases are 32, 28 and 40 respectively

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**23.** Calculate the velocity of sound in a mixture of two gases obtained by mixing  $m_1$  and  $m_2$  of them if the velocity of sound in them be  $C_1$  and  $C_2$ . The atomicity of the two gases is the same.

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**24.** Calculate the velocity of sound in a medium where change in pressure and volume takes place according to

the law  $p = \frac{\alpha}{V^2}$  where  $\alpha$  is a constant. Treat the medium as an ideal gas and assume  $\rho$  as its normal density.

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**25.** How many degrees of freedom have the gas molecules, if under standard conditions the gas density is  $1.3 \text{kgm}^{-3}$  and the velocity of sound propagation in it is  $C = 330 \text{m.s}^{-1}$ .

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**26.** The temperature of air varies with height linearly from  $T_1$  at the earth's surface to  $T_2$  at a height  $h$ . Calculate the time  $t$  needed for a sound wave produced at a height  $x$  to



reach the earth's surface. The velocity of sound near the earth's surface is  $C$ .



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