**(1) A person observes smoke from a cannon when it was fired. 1.5 seconds later, he hears the bang. If the cannon is 510 m away from the observer, calculate velocity of the sound in air.**

**Solution:**

**Data:** Distance = d = 510 m, time = t = 1.5 seconds.

**To find:** Velocity of sound

$$\text{Velocity} = \frac{\text{Distance}}{\text{Time}} \qquad \text{(Relationship for velocity)}$$

$$\therefore \quad v = \frac{510}{1.5} = 340 \text{ m/s}$$

**Ans. The velocity of the sound in air was 340 m/s.**

**(2) Using the SONAR, sound pulses are emitted at the surface of the water. The echo is heard after 3 seconds. Find the depth of the sea at that place if velocity of sound in seawater = 1550 m/s.**

**Solution:**

**Data:** Velocity of sound in seawater = 1550 m/s. Total time taken by the pulse to leave the transmitter and get reflected from the seabed = 3 seconds (for two way journey)

$\therefore$ Time taken by the pulse for 1 way journey = $\frac{3}{2}$

= 1.5 s.

**To find:** Depth of the sea i.e. distance.

$$\text{Velocity} = \frac{\text{Distance}}{\text{Time}} \qquad \text{(Relationship for velocity)}$$

$\therefore$ Distance = Velocity x Time

$\therefore$ Distance = 1550 x 1.5 = 2,325 m

**Ans. The depth of the sea at that place = 2,325 m.**

*** (3) A person standing before a cliff shouts and hears the echo after 1.6 seconds. If the speed of sound in air is 340 m/s, state the distance between the person and the cliff.**

**Solution:**

**Data:** Speed of the sound = 340 m/s. Time for the echo to be heard = 1.6 second. Time for 1 way journey of the sound = $\frac{1.6}{2}$ = 0.8 s.

**To find:** Distance between the person and the cliff.

$$\text{Velocity} = \frac{\text{Distance}}{\text{Time}} \qquad \text{(Relationship for velocity)}$$

$\therefore$ Distance = Velocity x Time

$\therefore$ Distance = Speed x Time

$\therefore$ Distance = 340 x 0.8

$\therefore$ Distance = 272 m

**Ans. The distance between the person and the cliff = 272 m.**

**(4) A person hears the thunder 3 seconds after a flash of lightning is seen. At what distance has the lightning struck? (Velocity of sound in air = 340 m/s).**

**Solution:**

**Data:** Time = 3 s, velocity of sound = 340 m/s.

**To find :** Distance.

$$\text{Velocity} = \frac{\text{Distance}}{\text{Time}} \qquad \text{(Relationship for velocity)}$$

$\therefore$ Distance = Velocity x Time

$\therefore$ Distance = 340 x 3

$\therefore$ Distance = 1020 m

**Ans. The lightning struck at a distance of 1020 m.**

*** (5) Velocity of sound in air at 0 °C is 332 m/s. It increases by 0.6 m/s for each degree Celsius rise in temperature. At what temperature of air will the velocity be 350 m/s.?**

**Solution:**

**Data:** Let the temperature of air be t °C

Velocity of sound in air at t °C = 350 m/s

Velocity of sound in air at 0 °C = 332 m/s

$\therefore$ The difference between the two velocities = 350 m/s - 332 m/s = 18 m/s.

$\therefore$ For an increase of velocity of 0.6 m/s temperature increases by 1 °C.

$\therefore$ For an increase of velocity of 18 m/s, temperature increases by $\frac{18}{0.6}$ = 30 °C.

$\therefore$ The final temperature = Initial temperature + increase in temperature

$\therefore$ The final temperature = (0 + 30) °C

$\therefore$ The final temperature = 30 °C

**Ans. The temperature of air, when the velocity of sound is 350 m/s is 30 °C.**

**(6) A person observes the smoke from a gun 0.7 second before he hears its bang. If the person is 238 m away from the gun, find the speed of sound in air.**

**Solution:**

**Data:** Distance = 238 m, time = 0.7 s.

**To find:** Speed of the sound in air.

$$\text{Speed} = \frac{\text{Distance}}{\text{time}} = \frac{238}{0.7} = 340 \text{ m/s}$$

**Ans. Speed of sound in air = 340 m/s.**

**(7) A person, standing 204 m away from a mountain, fires a gun. Find after how many seconds he hears an echo of the gunfire if the speed of sound in air is 340 m/s.**

**Solution:**

**Data:** Speed = 340 m/s, Distance between the person and the mountain is 204 m. There is an echo, hence the sound travels from the gun to mountain and back to the person.

$\therefore$ Total distance covered by the sound = (204 x 2) m = 408 m.

**To find:** Time taken for the echo to be heard.

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

$$\text{Time} = \frac{\text{Distance}}{\text{Speed}} = \frac{408}{340} = 1.2 \text{ seconds}$$

**Ans. The person hears the first echo 1.2 seconds after the gun was fired.**

**(8) Velocity of sound in air at 0 °C is 332 m/s. at 'ordinary temperature' is 340 m/s. Calculate the 'ordinary temperature' in terms of °C.**

**Solution:**

**Data:** Velocity of sound in air at 0 °C = 332 m/s.

Velocity at 'ordinary temperature' = 340 m/s.

$\therefore$ Rise in velocity of sound in air = 340 m/s – 332 m/s = 8 m/s.

The velocity increases by about 0.6 m/s for each degree Celsius rise in temperature of air.

$\therefore$ Rise in temperature of air $= \frac{8}{0.6} = 13.\overline{3}$ °C

$\therefore$ Temperature of air when the velocity of sound is 340 m/s = 0 + $13.\overline{3}$ °C = $13.\overline{3}$ °C

**Ans. The word ordinary temperature in this context means a temperature of $13.\overline{3}$ °C.**

**(9) Velocity of sound in air at 0 °C is 332 m/s and at room temperature it is 344 m/s. Find the room temperature in terms of degree Celsius.**

**Solution:**

**Data:** Velocity of sound in air at 0 °C = 332 m/s.

Velocity at 'room temperature' = 344 m/s

$\therefore$ Rise in velocity of the sound in air = 344 m/s – 332 m/s = 12 m/s.

The velocity of sound increases by about 0.6 m/s for each degree Celsius rise in temperature of air.

$\therefore$ Rise in Temperature of air $= \frac{12}{0.6} = 20$ °C.

$\therefore$ The temperature when velocity of sound in air = 344 m/s

= 0 + 20 °C = 20 °C

**Ans. Room temperature = 20 °C.**

**(10) Two soldiers A and B are standing on two hill tops C and D respectively which are 760 m apart. Wind is blowing from C to D at a velocity of 144 km/hr. The soldiers fire their guns one after the other. Soldier B fires his gun 5 minutes after soldier A fires his gun. How much time will it take for sound of the gun fire to reach from A to B and from B to A. (Take velocity of sound in still air to be 340 m/s.)**

**Solution:**

Wind velocity = 144 km/hr

$$= 144 \times \frac{1000}{60 \times 60} \text{ m/s}$$

$$= 40 \text{ m/s} \quad \ldots(\text{I})$$

Wind blows from C to D, soldier A is at C and soldier B is at D.

Velocity of sound when it travels from A to B is 340 m + 40 m = 380 m/s

$$\text{Velocity} = \frac{\text{Distance}}{\text{Time}} \qquad \text{(Relationship for velocity)}$$

$$\text{Time} = \frac{\text{Distance}}{\text{Speed}} = \frac{760}{380} = 2 \text{ seconds.}$$

Velocity of sound when it travels from B to A is 340 m – 40 m = 300 m/s

$$\text{Time} = \frac{\text{Distance}}{\text{Velocity}} = \frac{760}{300} = 2.53 \text{ seconds.}$$

**Ans. (i) It takes 2 seconds for the sound to reach from A to B.**

**(ii) It takes about 2.53 seconds for the sound to reach from B to A.**

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**(11) A person stands between two cliffs and fires a gun. He hears two successive echoes in 2 seconds and 5 seconds after the gun was fired. Find the distance between the two cliffs.**

**Solution:**

Let the distance between the person and the nearest cliff = (x) m and let the distance between the person and distant cliff = (y) m.

$\therefore$ The distance between two cliffs = (x + y) m ...(I)

First echo was heard 2 s after the gun was fired.

Total distance covered by the sound to produce the first echo = (x + x) = (2x) m

Time required to cover (2x) m (i.e. two way journey) = 2 s

$\therefore$ Time required to cover (x) m (i.e. one way journey)

$= \frac{2}{2} = 1$ s

$$\text{Velocity} = \frac{\text{Distance}}{\text{Time}} \qquad \text{(Relationship for velocity)}$$

∴ Distance = Velocity x Time

∴ Distance (x) = 340 x 1 = 340 m.

The second echo, produced by the distant cliff was heard after 5 s.

The total distance covered by the sound to produce this echo = (2y) m.

∴ Time taken by the sound to complete one-way journey

$= \frac{5}{2} = 2.5$ s.

∴ Distance covered by the sound during 1 way journey

= Velocity x Time

= 340 x 2.5 = 850 m.

∴ Distance (y) = 850 m

∴ Distance x + y = (340 + 850) m = 1190 m

= 1.19 km

**Ans. The distance between the two cliffs is 1190 m or 1.19 km.**

**(12) A boat equipped with SONAR is sailing in a fresh water lake. It emits a sharp pulse of sound, which is reflected from the bottom of the lake after 0.5 s. Determine the depth of the lake at that spot.**

**Solution:**

Velocity of sound in fresh water is 1410 m/s. The time taken for sound to be reflected from the lake bottom (i.e. after two way journey) = 0.5 s

∴ Time required for 1 way journey $= \frac{0.5}{2} = 0.25$ s

$\text{Velocity} = \frac{\text{Distance}}{\text{Time}}$ (Relationship for velocity)

∴ Distance = Velocity x Time

∴ Distance = 1410 x .25

∴ Distance = 352.5 m

**Ans. The distance between the boat and the bottom of the lake i.e. depth of the lake is 352.5 m.**

13. Calculate the wavelength of a sound wave whose frequency is 220 Hz and speed is 440 m/s in a given medium. **(Textbook question)**

**SOLUTION** Velocity of the sound wave ($v$) = 440 m/s

Frequency ($\nu$) of the sound wave = 220 Hz

Wavelength of the sound wave ($\lambda$) = ? (to be calculated)

We know, $v = \nu \times \lambda$

$440 \text{ m/s} = 220 \text{ Hz} \times \lambda$

or $\lambda = \frac{440 \text{ m/s}}{220 \text{ Hz}}$

$\lambda = 2$ m

So, the wavelength of the sound wave is 2 m.

14. A source produces 15 waves in 3 seconds. The distance between a crest and a trough is 15 cm. Find the (a) frequency (b) wavelength, and (c) velocity of the wave.

**SOLUTION** (a) Number of waves produced in 3 seconds = 15

∴ Number of waves produced in 1 second

$= \frac{15}{3} = 5$

So, the frequency ($\nu$) of this wave is 5 Hz.

(b) Distance between crest and trough = 15 cm = half the wavelength

So, $\lambda = 15 \times 2$ cm

$= 30 \text{ cm} = \frac{30}{100} \text{ m} = 0.3$ m

Thus, the wavelength of the wave is 30 cm or 0.3 m.

(c) We know,

$v = \nu \times \lambda$

$v = 5 \text{ Hz} \times 0.3 \text{ m}$

$v = 1.5$ m/s

Thus, the velocity of the wave is 1.5 m/s.

15. A body vibrating with a time period of 2 milliseconds produces a wave travelling in a medium with a velocity of 1250 m/s. What is the wavelength?

**SOLUTION** Time period ($T$) = 2 milliseconds

$= \frac{2}{1000}$ seconds

Velocity ($v$) = 1250 m/s

Wavelength ($\lambda$) = ?

We know, $v = \nu \times \lambda$

$v = \frac{1}{T} \times \lambda$ [since $\nu = \frac{1}{T}$]

$1250 \text{ m/s} = \frac{1}{\frac{2}{1000} \text{ s}} \times \lambda$

$1250 \text{ m/s} = \frac{1000}{2} \text{ s} \times \lambda$

$\lambda = 1250 \text{ m/s} \times \frac{2}{1000} \text{ s}$

$= 2.5$ m

Thus, the wavelength of wave is 2.5 m.