1. Calculate the wavelength of a sound wave whose frequency is 220 Hz and speed is 440 m/ s in a given medium.

   Solution:

   Frequency, v = 220 Hz

   Speed of sound, v = 440 m/ s

   The wavelength can be described by the relationship,

   Wave velocity = Wavelength of the wave x Frequency of the wave

   440 m s^{-1} = l × 220 Hz = l × 220 s^{-1}

   So l $= \frac{440\ ms^{-1}}{220 s^{-1}} =$ 2 m

   Therefore, wavelength of the sound wave is 2 m.

2. A boat at anchor is rocked by waves whose consecutive crests are 100 m apart. The wave velocity of the moving crests is 20 m/ s. What is the frequency of rocking of the boat?

   Solution:

   Distance between two consecutive crests = 100 m

   Wave velocity v = 20 m/ s

   The distance between two consecutive crests is equal to the wavelength of the wave. So,

   Frequency $= \frac{\text{Wave velocity}}{\text{Wave length}} = \frac{20\ m/s}{100\ m} =$ 0.2 s^{-1}

   So, the frequency of rocking of the boat is 0.2 s^{-1}.

3. A longitudinal wave is produced on a toy slinky. The wave travels at a speed of 30 cm/ s and the frequency of the wave is 20 Hz. What is the minimum separation between the consecutive compressions of the slinky?

   Solution:

   Wave speed, v = 30 cm/ s

   Frequency of the wave, v = 20 Hz = 20 s^{-1}

   The minimum separation between the consecutive compressions is equal to the wavelength. Therefore,

Wavelength $= \frac{30\ \text{cm/s}}{20\ \text{s}^{-1}} = 1.5\ \text{cm}$

Thus, the minimum separation between the consecutive compression of the slinky is 1.5 cm.

4. A gun is fired in the air at a distance of 660 m, from a person. He hears the sound of the gun after 2 s. What is the speed of sound?

Solution:

Distance travelled by sound = 660 m, Time taken by the sound = 2 s,

Speed of sound in air = ?

So, Speed of sound $= \frac{\text{Distance travelled by sound}}{\text{Time taken by the sound}}$

Speed of sound $= \frac{660\text{m}}{2\ \text{s}} = 330\ \text{m/s}$

Thus, the speed of sound in the air is 330 m/s.

5. A ship sends on a high frequency sound wave and receives an echo after 1 second. What is the depth of the sea? Speed of sound in water is 1500 m/s.

Solution:

Let,

Depth of the sea = d

So, Total distance travelled by the sound wave = 2d

Time taken by sound to travel both ways = 1 s

As per definition

Speed of the sound =

Then, $1500\ \text{m s}^{-1} = \frac{2\text{d}}{1\text{s}}$

or $\text{d} = \frac{1500\ \text{ms}^{-1} \times 1\text{s}}{2} = 750\ \text{m}$

Thus the depth of the sea is 750 metres.

6. A sonar echo takes 2.2 s to return from a whale. How far away is the whale?

Solution:

Total time taken by the signal = 2.2 s

So, Time taken the signal to reach the whale = = 1.1 s

Distance of the whale = d ?

From the literature, speed of sound in sea water at 25°C = 1533 ms^{-1}

So, Distance of the whale, d = Speed of the signal x Time taken

or d = 1533 m s^{-1} × 1.1 s = 1686.3 m

7. A human heart, on an average, is found to beat 75 times a minute. Calculate its frequency.

Solution:

$$\text{No. of beats of human heart} = 75\ \text{min}^{-1} = \frac{75}{1\ \text{min}} = \frac{75}{60\text{s}} = 1.25\ \text{s}$$

So, Average frequency of human heart beating = 1.25 s^{-1}

8. A bat can hear sound at frequencies up to 120 kHz. Determine the wavelength of sound in the air at this frequency. Take the speed of sound in the air as 344 m/s.

Solution:

Sol. Frequency, v = 120 kHz = 120 × 10^3 Hz = 120 × 10^3 s^{-1}

Velocity of sound in the air, v = 344 m/s

Wavelength of the sound wave, l = ?

We know,

$$\text{Wavelength, l} = \frac{\text{Wave velocity}}{\text{Frequency}} = \frac{344\ \text{m/s}}{120 \times 10^3 \text{s}^{-1}}$$

= 2.87 × 10^{-3} m = 0.29 cm

9. A person is listening to sound of 50 Hz sitting at a distance of 450 m from the source of sound. What is the time interval between successive compressions from the source reaches him?

Solution:

Frequency of the sound = 50 Hz

Distance from the source = 450 m

Time between the successive compressions is equal to time taken by the sound to travel a distance equal to its wavelength. Thus, we have to find out the time period we know,

$$\text{Time period, T} = \frac{1}{\text{Frequency (v)}}$$

$$\text{So T} = \frac{1}{50\ \text{Hz}} = \frac{1}{50\ \text{s}^{-1}} = 0.02\ \text{s}$$

The successive compressions will reach the person after every 0.02 s.

10. Two waves of the same pitch have amplitudes in the ratio 1: 3 What will be the ratio of their (i) loudness, (ii) pitch ?

Solution:

Loudness α $(\text{amplitude})^2$

(i) Ratio of loudness $= \frac{L_1}{L_2} = \frac{(a_1)^2}{(a_2)^2} = \frac{(1)^2}{(3)^2} = \frac{1}{9} = 1:9$

(ii) Two waves of same pitch

$\therefore \frac{\text{Pitch of first wave}}{\text{Pitch of second wave}} = \frac{1}{1} = 1:1$