PROBLEMS

1. What are wavelengths of television station which transmits vision on 500 MHz and sound on 505 MHz respectively. Take the speed of electromagnetic waves as 3×10^8 m/s.

SOLUTION

Frequency of vision $f_1 = 500\text{MHz} = 500 \times 10^6$ Hz

Frequency of sound $f_2 = 505\text{MHz} = 505 \times 10^6$ Hz

Speed of electromagnetic waves $C = 3.0 \times 10^8$ m/s

Wave length of vision $\lambda_1 = ?$

Wavelength of sound $\lambda_2 = ?$

$$\text{Wavelength of vision } \lambda_1 = \frac{C}{f_1} = \frac{3 \times 10^8}{500 \times 10^6} = 0.6 \text{ m} = 60 \text{ cm}$$

$$\text{Wavelength of vision } \lambda_2 = \frac{C}{f_2} = \frac{3 \times 10^8}{505 \times 10^6} = 0.59 \text{ m} = 59 \text{ cm}$$

2. A person on sea shore observes that 48 waves reach the shore in one minute. If the wavelength of the waves is 10 meter, then find the velocity of the waves.

SOLUTION

Number of waves N = 48 waves Time taken t = 1 min = 60 sec

Frequency $f = N/t = 48/60 = 0.8$ Hz

Wavelength $\lambda = 10$ m

Velocity V =?

Since, $V = f\lambda = 0.8 \times 10 = 8$ m/s

3. In a ripple tank 500 waves passes through a certain point in 10 seconds, if the speed of the wave is 3.5 ms^{-1}, then find the wavelength of the waves.

Solution

Number of waves = 500 wave Time taken t = 10 Sec

$$\text{Time period } T = \frac{t}{N} = \frac{10}{500} = 0.02 \text{ s}$$

$$\text{Frequency } f = \frac{1}{T} = \frac{1}{0.02} = 50 \text{ hz}$$

Speed of wave V = 3.5 m/sec

Wavelength $\lambda = ?$

Since $V = f\lambda$

$$\Rightarrow \quad \lambda = \frac{V}{f} = \frac{3.5}{50} = 0.07 \text{ m} = 7 \text{ cm}$$

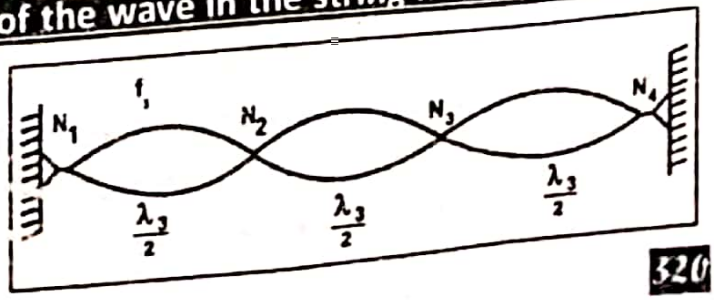
4. A string of a guitar 1.3 m long vibrates with 4 notes, 2 of them at the two ends. Find the wavelength and speed of the wave in the string if it vibrates at 500 Hz.

SOLUTION

Length of string L = 1.3 m

Frequency $f_3 = 500$ Hz

Wavelength $\lambda_3 = ?$



Speed V =?

Since, $\lambda_3 = \frac{2L}{3} = \frac{2\times1.3}{3} = 0.87$ m

$V = f_3 \lambda_3 = 0.87 \times 500 = 435$ m/s

5. Find the speed of sound in Helium gas at 27°C. (γ = 1.66 & R = 8334 J/K mol.)

SOLUTION Temperature T = 27° C + 273 = 300 γ = 1.66 R = 8334 J/K mol.

Mass of 1 kilo mole of Helium m = 4 kg/kmol Speed = V =?

As, $V = \sqrt{\frac{\gamma RT}{m}} = \sqrt{\frac{1.66 \times 8334 \times 300}{4}} = 1018.6$ m/s

6. The speed of sound in the air at 0°C is 332 ms^{-1}. What will be the speed of sound at 22°c?

SOLUTION

Initial temperature T_0 = 0°C+273= 273 K

Final temperature T = 22 + 273 = 295 K

Initial speed V_0 = 332 m/sec

Final Speed V =?

$$\frac{V}{V_0} = \sqrt{\frac{T}{T_0}}$$

$$V = V_0 \sqrt{\frac{T}{T_0}} = 332 \sqrt{\frac{295}{273}} = 345.2 \text{ m/s}$$

7. Two tuning forks P and Q give 4 beats per second. On loading Q slightly with wax, we get 3 beats per second. What is the frequency of Q before and after loading if the frequency of P is 512 Hz?

SOLUTION

Number of beats before loading N = 4

Number of beats after loading N$'$ = 3

Frequency of tuning fork P f_P = 512 cycle/s

Frequency of tuning fork Q before loading f_Q =?

Frequency of tuning fork Q after loading f_Q' =?

The number of beats per second is equal to the difference in frequencies of the two sources. So the frequency of tuning fork Q before loading, we have:

$$f_P - f_Q = \pm 4$$

$$f_Q = f_P \pm 4$$

Thus the frequency of tuning fork Q is either,

$f_Q = f_P + 4 = 512 + 4 = 516$ cycle/s

Or $f_Q = f_P - 4 = 512 - 4 = 508$ cycle/s

Similarly, after loading the frequency of Q is

$$f_P - f_Q' = \pm 3$$

$f_P \pm 3 = f_Q'$

Thus either the frequency of Q is either,

$$f'_Q = f_P + 3 = 512 + 3 = 515 \text{ Hz}$$

Or the frequency of Q is;

$$f'_Q = f_P - 3 = 512 - 3 = 509 \text{ Hz}$$

Since after loading the number of beats decreases, so the frequency of Q before loading is given by;

$$f_Q = 516 \text{ Hz} \quad \&$$

After frequency of Q after loading

$$f'_Q = 515 \text{ Hz}$$

8. On a sunny day, the speed of sound in the air is 340 ms^{-1}, two tuning forks A and B are sounded simultaneously. The wavelength of the sound emitted are 1.5 m and 1.68 m respectively. How many beats will produce per second?

SOLUTION

Speed of sound V = 340 m/s

Wavelength of fork A = λ_1 = 1.5 m

Frequency of fork A = $f_1 = V/\lambda_1 = 340/1.5 = 226.7$ Hz

Wavelength of fork B = λ_2 = 1.68 m

Frequency of fork B = $f_2 = V/\lambda_1 = 340/1.68 = 202.4$ Hz

Number of beats N =?

$N = f_1 - f_2 = 226.67 - 202.38 = 24$ beats

9. As sound source vibrates at 200Hz and is receding from a stationary observer at 18 ms^{-1}. If the speed of sound is 331ms^{-1} then what frequency does the observer hear?

SOLUTION

Source frequency f = 200 Hz Speed of source a = 18 m/s

Speed of sound V = 331 m/s The observed frequency f′ =?

Since $f' = \frac{V}{V+a} f = \frac{331}{331+18} \times 200 = 189.7$ Hz

10. The fundamental frequency of an open organ pipe has the same frequency as the fundamental frequency of a closed pipe 3.6 m in length. What is the length of the open organ pipe?

SOLUTION

Length of a closed pipe L_1 = 3.6 m

Length of an open pipe L_2 =?

$(f_1)_{open} = (f_1)_{closed}$

$V/2L_2 = V/4L_1$

$2L_2 = 4L_1$

$L_2 = 2L_1 = 2 \times 3.6 = 7.2$ m