Numerical Problems

1. What are the wavelengths of television station which transmits vision on 500 MHz and sound on 505 MH respectively? C = 3x10^8 ms^{-1}.

Data:

Frequency at which television transmits vision f_1 =500 MHz = 500 $\times 10^6$ Hz

Frequency at which television transmits sound f_2=505 MHz = 505 $\times$ 10^6 Hz

i) Wavelength at which television transmit vision λ_1=?

ii) Wavelength at which television transmit sound λ_2=?

Solution

Since

$$C = f\lambda$$

$$\lambda = \frac{C}{f}$$

$$\lambda_1 = \frac{C}{f_1}$$

Putting values

$$\lambda_1 = \frac{3 \times 10^8 \, m/s}{500 \times 10^6 \, Hz}$$

$$\boxed{\lambda_1 = 0.6m}$$

$$\lambda_2 = \frac{C}{f_2}$$

Putting values

$$\lambda_2 = \frac{3 \times 10^8 \, m/s}{505 \times 10^6 \, Hz}$$

$$\boxed{\lambda_2 = 0.594m}$$

2. A person on sea shore observes that 48 waves reach the shore in one minute. If the wave length of the wave is 10m, then find its speed.

Data:

No. of waves $n = 48$

Time taken by wave $t = 60$ sec

Frequency of the wave $f = 48/60 = 0.8$ Hz

Wave length $\lambda = 10$ m

Speed of the wave $v = ?$

Solution

As $v = f\lambda$

$v = 0.8 \text{ Hz} \times 10 \text{ m}$

$\boxed{v = 8 \text{ m/s}}$

3. In a ripple tank 500 waves passes through a certain point in 10 sec. If the speed of the wave is 3.5 m/s, then find the wave length of the wave.

Data:

No. of waves $n = 500$

Time taken by waves $t = 10$ sec

Frequency of waves $f = \frac{500}{10} = 50$ Hz

Speed of the waves $v = 3.5$ m/s

Wave length of the waves $\lambda = ?$

Solution

As $v = f\lambda$

$\Rightarrow \qquad \lambda = \frac{v}{f}$

$\Rightarrow \qquad \lambda = \frac{3.5 \text{ m/s}}{50 \text{Hz}}$

$\Rightarrow \qquad \lambda = 7 \text{cm}$

4. A string of guitar 1.3 m long vibrates with 4 nodes, 2 of them at the two ends. Find the wave length & speed of the wave in the string if it vibrates at 500 Hz.

Data:

The total length of string = 1.3 m

No. of nodes in the string = 4

Frequency of vibration f = 500 Hz

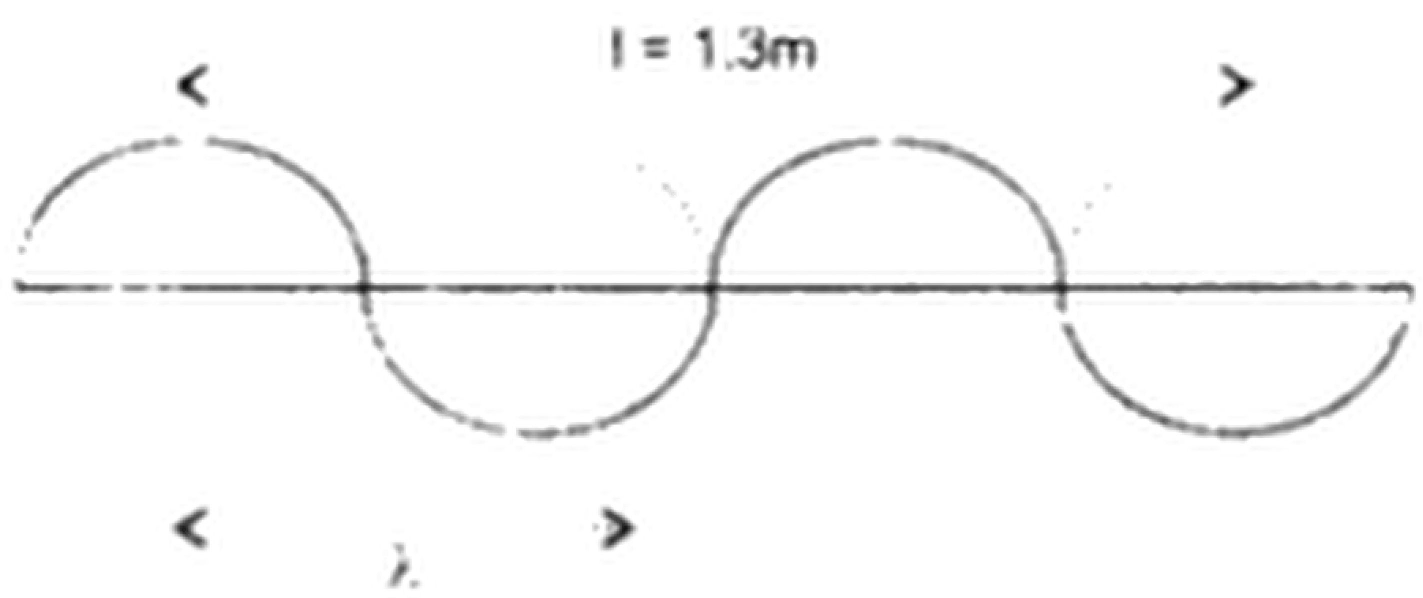
Wave length of vibration λ = ?

Speed of vibration v = ?

Solution

Since the string of a guitar vibrates with 4 nodes as shown in fig.

i) Relation between length & wave length is given as



$$l = \frac{4\lambda}{2}$$
$$\lambda = \frac{l}{2}$$
$$\lambda = \frac{1.3}{2}$$
$$\lambda = 0.65 \text{ m}$$

ii) Since $v = f\lambda$

$v = 500 \text{ Hz} \times 0.65 \text{ m}$

$\boxed{v = 325 \text{ m/s}}$

5. Find the speed of sound in Helium gas at 27°C.

γ = 1.66 and R=8334 J/k mol.

Data:

Speed of sound in Helium gas v = ?

Temperature T = (27°C+273)k = 300 k

γ =1.66

R = 8334 J/k mol.

Atomic mass of Helium M = 4 kg

Solution

As

$$\upsilon = \sqrt{\frac{\gamma RT}{M}}$$
$$\upsilon = \sqrt{\frac{1.6 \times 8334 \times 300}{4}}$$
$$\upsilon = 1018.6 \text{ m/s}$$

6. The speed of sound in air at 0°C is 332 m/s. What will be the speed of sound at 22°C?

Data:

The speed of sound in air at 0°C $\upsilon_0 = 332$ m/s

The speed of sound in air at 33°C υ_T = ?

Since $$\frac{\upsilon_T}{\upsilon_0} = \sqrt{\frac{T}{T_0}}$$

$$\upsilon_T = \upsilon_0\sqrt{\frac{T}{T_0}} \qquad \ldots\ldots\ldots\ldots(1)$$

$$\upsilon_T = 332 \text{ m/s}$$

$$\upsilon_T \boxed{= 345.2 \text{ m/s}}$$

7. Two tuning forks P & Q give 4 beats per second. On leading 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?

Data:

Number of beats per second of tuning forks before loading P & Q$N_1 = 4$

Number of beats per second of tuning forks when Q is loaded with wax $N_2 = 3$

Frequency of 'Q' before and after loading f_1 & f_2 = ?

Frequency of P is $f_2 = 512$ Hz

Solution

i) Frequency of 'Q' before loading

$$N_1 = f_1 - f_2$$

$\Rightarrow$ $$4 = f_1 - 512$$

$$\boxed{f_1 = 516\ Hz}$$

ii) Frequency of 'Q' after loading

$$N_1 = f_1' - f_2$$

$\Rightarrow$ $$4 = f_1' - 512$$

$$\boxed{f_1' = 516\ Hz}$$

8. On a sunny day, the speed of sound in the air is 340 m/s, 2 tuning forks A & B are sounded simultaneously. The wave length of the sound emitted are 1.5 m and 1.68 m respectively. How many beats will produce per second?

Data:

Speed of sound in air V = 340 m/s

The wave length emitted by fork A $\lambda_A = 1.5$ m

The wave length emitted by fork B $\lambda_B = 1.68$ m

Number of beats per second N = ?

Solution

Frequency emitted by fork A 'f_A' = $\frac{V}{\lambda_A}$

$$f_A = 226.6\ Hz$$

Frequency emitted by fork B 'f_B' = $\frac{V}{\lambda_B}$

$$f_B = 202.3\ Hz$$

Since number of beats per second is given as

$$N = f_A - f_B$$

$$N = 226.6 - 202.3$$

$$\boxed{N = 24 \text{ approximately}}$$

9. A sound source vibrates at 200 Hz and is recording from a stationary observer at 18 m/s. If the speed of sound is 331 m/s then what frequency does the observer hear?

Data:

Frequency of source f = 200 Hz

Speed of source moving away from the observer $v_s = 18$ m/s

Speed of sound v = 331 m/s

The frequency observed by observer f' = ?

Solution

Since $$f' = \left(\frac{v}{v_s + v}\right) f$$

$$f' = \left(\frac{331}{18 + 331}\right) \times 2000$$

$$\boxed{f' = 189.68 \text{ Hz}}$$

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

Solution

Since the first overtone of an open organ pipe $f_2 = \frac{v}{L_1}$ .... (1)

& the first overtone of a closed organ pipe $f_2 = \frac{v}{4L_2}$ .... (2)

Length of closed organ pipe L_2 = 3.6 m

Length of open organ pipe L_1 = ?

According to the given condition

$$\frac{v}{L_1} = 3\left(\frac{v}{4L_2}\right)$$

$$L_1 = \frac{4L_2}{3}$$

$$L_1 = \frac{4 \times 3.6}{3}$$

$$\boxed{L_1 = 4.8\text{ m}}$$