NUMERICAL PROBLEMS

1.1 **A normal conversation sound intensity of about 3.0 x 10-6 Wm-2. What is the decibel level for this intensity? What is the intensity of the sound for 100 dB?** *(A.B)*
(SGD-G2)-2015 / (GRW-G2)-2016

Solution:

(a) **Given Data**

Intensity of normal conversation = $I = 3.0\times10^{-6}wm^{-2}$

Intensity of faintest sound = $I_o = 10^{-12}wm^{-2}$

To Find:

Intensity level = $L - L_o$ = ?

Formula:

$$L - L_o = 10\log\frac{I}{I_o}\ dB$$

Calculation:

By using formula, we have

$$= 10\log\frac{3\times10^{-6}\ wm^{-2}}{10^{-12}\ wm^{-2}}\ dB$$

Now intensity for 100 dB

$$L - L_o = 10\log\left(\frac{3\times10^{-6}}{10^{-12}}\right)$$

$$= 10\log\left(3\times10^{-6+12}\right)dB$$

$$= 10\log\left(3\times10^{6}\right)dB$$

$$= 10\times6.47dB$$

= 64.7 dB

(b) **Given Data:**

Intensity level $L - L_o$ = 100 dB

Intensity of faintest sound = $I_o = 10^{-12}wm^{-2}$

To Find:

Intensity of given sound = I = ?

Formula:

$$L - L_o = 10\log\frac{I}{I_o}\ dB$$

Calculation:

By using formula, we have

$$100\ dB = 10\log\frac{I}{10^{-12}\ wm^{-2}}\ dB$$

$$\Rightarrow \frac{100}{10} = \log\frac{I}{10^{-12}\ wm^{-2}}$$

$$10 = \log\frac{I}{10^{-12}}$$

$$10 = \log 10^{12}\times I$$

Taking antilog on both sides

$$\text{Antilog}10 = \text{Antilog}\left[\log\left(10^{12}\times I\right)\right]$$

$$1\times10^{10} = 10^{12}I$$

$$\frac{1\times10^{10}}{10^{12}} = I$$

$$I = 1\times10^{-2}$$

$$I = 0.01Wm^{-2}$$

Result:

Hence, sound intensity level of normal conversation is 64.8 dB and intensity of sound for 100 dB is 0.01 Wm^{-2}

1.2 If at Anarkali bazaar Lahore, the sound level is 80 dB, what will be the intensity level of sound there?

Solution:

Given Data:

Sound level at bazar = $L - L_o = 80$ dB

Intensity of faintest audible sound

$= I_o = 10^{-12}wm^{-2}$

To Find:

Intensity of sound at Anarkali bazar = I = ?

Formula:

$$L - L_o = 10 \log \frac{I}{I_o} \text{ dB}$$

Calculation:

By using formula, we have

$$80 \cancel{dB} = 10 \log \frac{I}{10^{-12} wm^{-2}} \cancel{dB}$$

$$\frac{80}{10} = \log \frac{I}{10^{-12} wm^{-2}}$$

$$8 = \log\left(10^{12} \times I\right)$$

Taking antilog on both sides

$$\text{Antilog } 8 = \text{Antilog}\left[\log\left(10^{12} \times I\right)\right]$$

$$10^8 = 10^{12} \times I$$

$$\frac{10^8}{10^{12}} = I$$

$$I = 10^{8-12}$$

$$I = 10^{-4} Wm^{-2}$$

Result:

Hence, the intensity of sound at Anarkali bazar is 10^{-4} Wm^{-2}

1.3 At a particular temperature, the speed of sound in air is $330ms^{-1}$. If the wavelength of a note is 5cm, calculate the frequency of the sound wave. Is this frequency lies in the audible range of the human ear?

Solution:

Given Data:

Speed of sound = v = 330 ms^{-1}

Wavelength = λ = 5cm

$$\lambda = \frac{5}{100} \text{m} = 0.05\text{m}$$

To Find:

Frequency = f = ?

Formula:

$v = f\lambda$

Calculation:

By wave equation,

$v = f\lambda$

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

$$\Rightarrow \quad = \frac{330\text{ms}^{-1}}{0.05\text{m}}$$

$$= 6600\text{s}^{-1} \qquad \left(\because \text{s}^{-1} = \text{Hz}\right)$$

$$f = 6.6\times10^3 \text{Hz}$$

∵ yes this frequency lies in the range of human ear

Result:

Hence, the frequency of sound wave is 6.6×10^3 Hz, which lies within the audible frequency range of human ear.

1.4 A doctor counts 72 heartbeats in 1 min. Calculate the frequency and period of the heartbeats.

Solution:

Given Data:

No of heartbeats = n = 72
Time = t = 1 min = 60sec

To Find:

Frequency = f = ?
Time period = T = ?

Solution:

We know that

$$f = \frac{n}{t}$$

$$= \frac{72}{60\,\text{sec}} \Rightarrow 1.2\text{s}^{-1} \qquad (\because \text{s}^{-1} = \text{Hz})$$

As $T = \frac{1}{f}$

$$= \frac{1}{1.2\,\text{s}^{-1}}$$

T = 0.833 sec.

Result:

Hence, the frequency and time period of heart beat is 1.2 Hz and 0.833 s respectively.

1.5 A marine survey ship sends a sound wave straight to the sea bed. It receives an echo 1.5s later. The speed of sound in a sea water is 1500 ms^{-1}. Find the depth of the sea at this position. (BWP-G2)-2016

Solution:

Given Data:

Time to hear echo = t = 1.5 s
Speed of sound = v = 1500ms^{-1}

To Find:

Depth of sea = h = ?

Formula:

S = v × t

Calculation:

By using formula, we have

S = vt
= (1500) (1.5)
= 2250m

For hearing echo, the minimum depth from sea bed to ship must be half of this depth (2250m)

Therefore,

$$h = \frac{S}{2}$$

$$= \frac{2250}{2} \qquad \Rightarrow \qquad h = 1125m$$

Result:

Hence, the depth of sea from a marine suwey ship is 1125 m.

11.6 A student clapped his hands near a cliff and heard the echo after 5s. What is the distance of the cliff from the student if the speed of the sound, v is taken as 346 ms^{-1}?

Given data:

Time to clear echo = t = 5s

Speed = v = 346 ms^{-1}

To Find:

Distance = d = ?

Formula:

S = v × t

Calculation:

By using formula, we have

S = vt

= 346 x 5

S = 1730 m

For hearing echo, the minimum distance from obstacle to the source of sound must be half of this distance (1730m).

Therefore,

$$d = \frac{S}{2}$$

$$d = \frac{1730}{2}$$

d = 865 m

Result:

Hence, the distance of different from the student to hear the echo is 865 m.

11.7 A ship sends out ultrasound that returns from the seabed and is detected after 3.42s. If the speed of ultrasound through seawater is 1531 ms^{-1}, what is the distance of the seabed from ship?

Solution:

Given data:

Time taken by sound = t = 3.42S

Speed of sound = v = 1531 ms^{-1}

To Find:

Distance of seabed from ship = d = ?

Calculation:

By using formula, we have

S = vt

= 1531 x 3.42

= 5236.02 m

For hearing echo, the minimum depth of the seabed from the must be half of this distance (5236.02m)

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

$$d = \frac{5236.02}{2}$$

$$d = 2618m$$

Result:

Hence, the distance of seabed from ship is 2618 m.

11.8 The highest frequency sound humans can hear is about 20,000 Hz. What is the wavelength of sound in air at this frequency at temperature of 20°C? What is the wavelength of the lowest sounds we can hear of about 20 Hz? Assume the speed of sound in air at 20°'C is 343 ms^{-1}.

Solution:

Given Data:

Highest frequency = f_1 = 20,000 Hz

Lowest frequency = f_2 = 20 Hz

Speed of sound = v = 343 ms^{-1}

To Find:

Wavelength of highest frequency = λ_1 = ?

Wavelength of lowest frequency = λ_2 = ?

Formula:

$v = f\lambda$

Calculation:

By using wave equation, we have

$v = f\lambda$

$$\Rightarrow \lambda_1 = \frac{v}{f_1}$$

$$= \frac{343 ms^{-1}}{20,000 s^{-1}}$$

λ_1 = 0.01715 m = 1.7×10^{-2} m

As $V = f_2 \lambda_2$

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

$$\Rightarrow = \frac{343 ms^{-1}}{20 s^{-1}}$$

$$= 17.15 m$$

$$\lambda_2 = 17.2 m$$

Result:

Hence, the wavelength of highest and wavelength of lowest frequency is 1.7×10^{-2} m respectively.

11.9 A sound wave has frequency of 2 kHz and wavelength 35cm. How long will it take to travel 1.5 km? (LHR-G2)-2015 / (LHR-G1)-2016

Solution:

Given Data:

Frequency of wave = f = 2×10^3 Hz

Wavelength = λ = 35 cm = 0.35m

Distance travelled = s = 1.5 Km = 1500 m

To Find:

Time taken = t = ?

Formula:

$S = v \times t$

Calculation:

By wave equation

$V = f\lambda$

$= 2 \times 10^3 \text{ Hz} \times 0.35 \text{ m}$

$V = 700 \text{ ms}^{-1}$

As $S = v \times t$

$1500 \text{ m} = 700 \text{ ms}^{-1} \times t$

$$t = \frac{1500 m}{700 ms^{-1}}$$

$t = 2.1$ sec

Result:

Hence, to travel 1.5 km sound wave will take 2.1 s.