Numerical Problems

11.1 A normal conversation involves sound intensities of about $3.0 \times 10^{-6}\ Wm^{-2}$. What is the decibel level for this intensity? What is the intensity of the sound for 100dB?

Answer

$I = 3.0 \times 10^{-6}\ Wm^{-2}$

Sound level =?

Then (Sound level) = 100dB.

$I' =?$

For the 1sl part, we have,

$$\text{Sound level} = 10 \log \left(\frac{I}{I_0}\right) \text{dB}$$

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

because, the faintest intensity of sound is; $I_0 = 10^{-12}\ Wm^{-2}$

$\Rightarrow$ Sound level = $10 \log (3 \times 10^{6})$ dB

or $\boxed{\text{Sound level} = 64.8 \text{ dB}}$

For the second part, we have,

(Sound level) = 10 log

$$= 10 \log \left(\frac{I'}{I_0}\right) \text{dB.}$$

$$100 = 10 \log \left(\frac{I'}{10^{-12}}\right) \text{dB}$$

or $$10 = \log \left(\frac{I'}{10^{-12}}\right)$$

As given in mathematics; $\log\left(\frac{a}{b}\right) = \log a - \log b$

So, $10 = \log I' - \log (10^{-12})$

Also, according to logarithm rules, $\log (10)^a = a \log (10)$

So, $10 = \log I' - (-12) \log (10)$

As, $\log 10 = 1$

So, $10 = \log I' + 12$

$\log I' = -2$

Taking antilog;

$I' = \text{Antilog} (-2)$

$\boxed{I' = 0.01 \text{ Wm}^{-2}}$

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

Answer

Sound level = 80 dB

Intensity level I =?

Intensity of faintest sound, I_0 We have, $= 10^{-2}$ Wm^{-2}

Sound level $= 10 \log \left(\frac{I}{I_0}\right)$ dB

or $80 = 10 \log \left(\frac{I}{10^{\;\;2}}\right)$ dB

$8 = \log I - \log (10^{-12})$

$8 = \log I - (-12) \log (10)$

$8 = \log I + 12$

$\log I = -4$

Taking antilog we have,

$$I = \text{Antilog}(-4)$$

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

11.3 At a particular temperature, the speed of sound in air is 330 ms^*. If the wavelength of a note is 5 cm, calculate the frequency of the sound wave. Does its frequency lie in the audible range of the human ear?

Answer

$v = 330\ ms^{-1}$

$\lambda = 5\ cm$

$= 0.05\ m$

$f = ?$

$v = f\lambda$

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

Putting the values,

$f = \frac{330}{0.05}$

$$\boxed{f = 6.6 \times 10^{1}\ Hz}$$

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

Answer

Number of heart beats, n = 72

Time, t = 1 min

= 60 Seconds

Time period, T =?

frequency, f =?

We have that, the time period is equal to number of vibrations per total time, and frequency is its inverse.

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

Putting the values:

$$f = \frac{72}{60}$$

$$\boxed{f = 1.2 \text{ Hz}}$$

$$f = \frac{1}{T}, \text{ or } T = \frac{1}{f}$$

(As, frequency and time period are reciprocal to each other.)

$$\boxed{T = 0.83 \text{ Seconds}}$$

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

Answer

$$\left\{\begin{array}{l}\text{Time taken by sec and wave from} \\ \text{Ship to the sea bed and then back, } t = 1.5\text{sec.} \\ \text{to ship}\end{array}\right.$$

Time for one side (from ship to sea bed), $t' = \frac{1.5}{2}$

$= 0.75$ Sec

Speed of sound, $V = 1500\ ms^{-1}$

Depth of Sea, $d = ?$

We know that,

$$V = \frac{d}{t'}$$

or $d = v \times t'$

Putting the values, $d = 1500 \times 0.75$

$$\boxed{d = 1125\ m}$$

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

Answer

$$\left\{\begin{array}{l}\text{Time taken Time taken by sound from} \\ \text{the student to cliff and then, } t = 5\text{sec.} \\ \text{back to student}\end{array}\right.$$

Time for one side (from cliff to student $t' = \frac{5}{2}$

$t' = 2.5$ Sec

Velocity, $V = 346\ ms^{-1}$

Distance from cliff to student, d =?

We know that,

$$V = \frac{d}{t'}$$

or $d = v \times t'$

Putting the values, $d = 346 \times 2.5$

$$\boxed{d = 865\ m}$$

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

Answer

$$\left\{\begin{array}{l}\text{Time taken by ultrasound from} \\ \text{Ship to the sea bed and then back, } t = 3.42\text{sec.} \\ \text{to ship}\end{array}\right.$$

Time for one side (from ship to sea bed), $t' = \frac{3.42}{2}$

$= 1.71$ Sec

Speed of ultrasound, $V = 1531\ ms^{-1}$

Distance of sea bed from the ship, d =?

We know that,

$$V = \frac{d}{t'}$$

or $$d = v \times t'$$

Putting the values, $d = 1531 \times 1.71$

$$\boxed{d = 2618\ m}$$

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 a temperature of 20°C? What is the wavelength of the lowest sounds we can hear of about 20Hz? Assume the speed of sound in air at 20°C is 343 ms-1.

Answer

Highest sound frequency, f = 20,000 Hz

Wave length sound, λ =?

Lowest sound frequency, f'= 20 Hz

Wave length of sound, λ' =?

For the first part:

$$v = f\lambda$$

⇒ while V in both the cases will be same;

i.e. $v = 343\ ms^{-1}$

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

= 34320000

$$\boxed{\lambda = 1.7 \times 10^{-2}\ m}$$

For the second part;

$v = f'\lambda'$

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

$= \frac{343}{20}$

$$\boxed{\lambda' = 17.2\ m}$$

11.9 A sound wave has a frequency of 2 kHz and wavelength 35 cm. How long will it take to travel 1.5 km?

Answer

frequency of sound waves, f = 2 kHz

or = 20000 Hz

Wave length, $\lambda = 35$ cm

= 0.35 m

Time taken, t =?

Distance covered, d = 1.5 km

= 1500 m

We know that $= v = \frac{d}{t}$

$t = \frac{d}{v}$ (i)

but velocity is wave is not known,

So, $v = f\lambda$

$= 20000 \times 0.35$

$v = 700\ ms^{-1}$

putting the values of velocity and distance in equation. (1), we get,

$t = \frac{d}{v}$

$= \frac{1500}{700} \Rightarrow \boxed{t = 2.1 \text{ seconds}}$