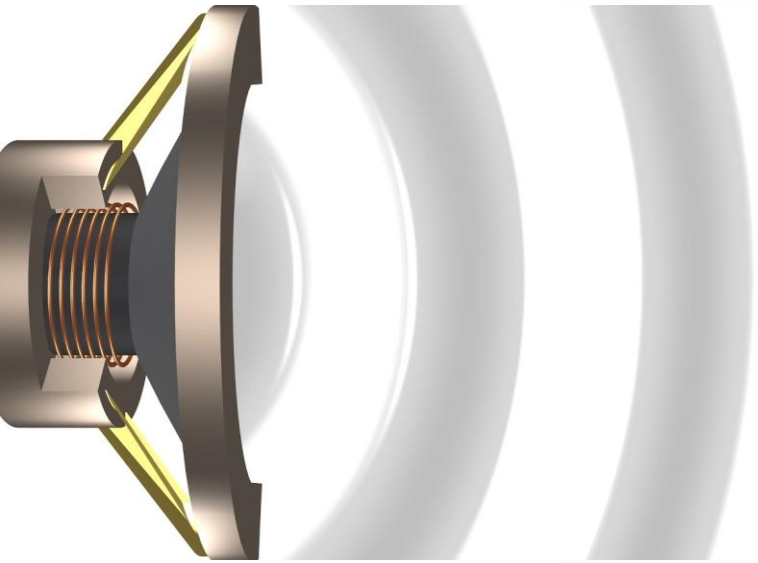
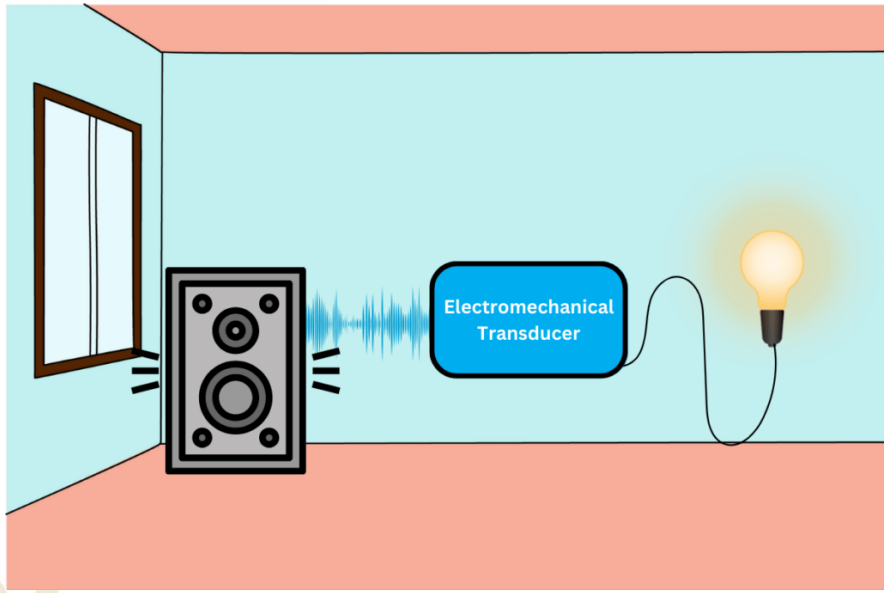
Unit One



Chapter 5



Sound Energy

Prepared and presented by: Mr. Mohamad Seif

Sound energy quiz duration: 20min

Part A: Intensity and Sound Intensity level.

A low-frequency generator feeds a loudspeaker, placed on the ground and emitting an audible sound wave of frequency f = 100 Hz in all directions of the space above it.

A sound level meter, placed at a distance r above the loudspeaker and directed towards it, measures a sound level L.

The sound power emitted by the loudspeaker is distributed homogeneously over the half-sphere of radius r and surface $4\pi r^2$.

The threshold of hearing of a human for a frequency 100 Hz is L $= 38\text{dB}$. $I_0 = 10^{-12} W/m^2$.

Sound energy quiz duration: 20min

1)For r = 0.25 m, the measured level is L = 56dB.

a)Find the acoustic intensity (I) and the corresponding sound power received at this distance.

b)Determine, for r = 0.50m, the acoustic intensity and the corresponding intensity level.

2)Show that if the distance between the loudspeaker and the sound level meter is doubled, the measured intensity level is decreased by 6 dB.

3)Calculate how far a human ear should be found in order not to hear the sound

Sound energy quiz duration: 20min

f = 100 Hz; area of sphere $4\pi r^2$; threshold of hearing of a human for a frequency 100 Hz is L = 38dB

1)For r = 0.25 m, the measured level is L = 56dB.

a)Find the acoustic intensity (I) and the corresponding sound power received at this distance.

$$L = 10log\left[\frac{I}{I_0}\right] \Rightarrow 56 = 10log\left[\frac{I}{10^{-12}}\right] \Rightarrow I = 3.98 \times 10^{-7} W/m^2$$

$$I = \frac{P}{S} \Rightarrow P = I \times S \Rightarrow P = 3.98 \times 10^{-7} \times 4\pi(0.25)^2$$

$$\Rightarrow P = 3.1243 \times 10^{-7} W$$

Sound energy quiz duration: 20min

f = 100 Hz; area of sphere $4\pi r^2$; threshold of hearing of a human for a frequency 100 Hz is L = 38dB

b) Determine, for $r = 0.50m$, the acoustic intensity and the corresponding intensity level.

$$I = \frac{P}{S} \Rightarrow I = \frac{P}{4\pi r^2} \Rightarrow I = \frac{P}{4\pi r^2} = \frac{3.1243 \times 10^{-7}}{4\pi(0.5)^2}$$

$$I = 9.95 \times 10^{-8} W/m^2$$

$$L = 10log\left[\frac{I}{I_0}\right] \Rightarrow L = 10log\left[\frac{9.95 \times 10^{-8}}{10^{-12}}\right] \Rightarrow L \approx 50dB$$

2)Show that if the distance between the loudspeaker and the sound level meter is doubled, the measured intensity level is decreased by 6 dB.

At a distance r:

$$L = 10log\left[\frac{I}{I_0}\right]$$

At a distance $r' = 2r$:

$$L' = 10log\left[\frac{I'}{I_0}\right]$$

$$I' = \frac{P}{S'} = \frac{P}{4\pi(2r)^2} \Rightarrow I' = \frac{P}{4 \times 4\pi r^2} \Rightarrow I' = \frac{I}{4}$$

Sound energy quiz duration: 20min

$$L' = 10log\left[\frac{I'}{I_0}\right]$$

$$L' = 10log\left[\frac{\frac{I}{4}}{I_0}\right]$$

$$L' = 10log\left[\frac{I}{4I_0}\right]$$

$$L' = 10log\left[\frac{9.95 \times 10^{-8}}{4 \times 10^{-8}}\right]$$

$$L' = 10log\left[\frac{9.95 \times 10^{-8}}{4 \times 10^{-8}}\right]$$

$$L' \approx 44bB$$

$$L' = L - 6$$

Sound energy quiz duration: 20min

f = 100 Hz; area of sphere $4\pi r^2$; threshold of hearing of a human for a frequency 100 Hz is L = 38dB

3)Calculate how far a human ear should be found in order not to hear the sound.

$$L = 10log\left[\frac{I}{I_0}\right] \Rightarrow 38 = 10log\left[\frac{I}{10^{-12}}\right] \Rightarrow I = 6.3 \times 10^{-9} W/m^2$$

$$I = \frac{P}{S} \Rightarrow I = \frac{P}{4\pi r^2} \Rightarrow 6.3 \times 10^{-9} = \frac{3.1243 \times 10^{-7}}{4\pi r^2} \Rightarrow r = 1.98m$$

Then the human ear should be found at a distance greater than 1.98m in order not to hear the sound

Sound energy quiz duration: 20min

Part B: Doppler effect

In a siren, a sound of frequency 14222 Hz is emitted continuously.
On the pavement, a person records the sound he perceives.

After analysis, the person measures on a spectrum that the sound which it recorded at a frequency 17263 Hz. The sound propagates at a speed of 351 m/s.

1)After reading these measures, it can be said that the siren is moving away or approaching? Explain.
2)Calculate the speed of the siren.

Sound energy quiz duration: 20min

$f = 14222\ Hz; v_{sound} = 351 m/s; f_{spectrum} = 17263\ Hz$

1)After reading these measures, it can be said that the siren is moving away or approaching? Explain.

The siren approaches the person because the frequency recorded by him is greater than that emitted by the siren.

$f = 14222\ Hz; v_{sound} = 351 m/s; f_{spectrum} = 17263\ Hz$

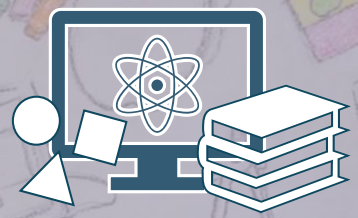
2) Calculate the speed of the siren.

The siren approaches the observer: $f' = f.\frac{V_{sound}}{V_{sound} - V_{siren}}$

$$17263 = \frac{351 \times 14222}{V_{sound} - V_{siren}} \Rightarrow (V_{sound} - V_{siren}) = \frac{4991922}{17263}$$

$$\Rightarrow (351 - V_{siren}) = 289.16 \Rightarrow V_{siren} = 61.83 m/s$$

The End



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