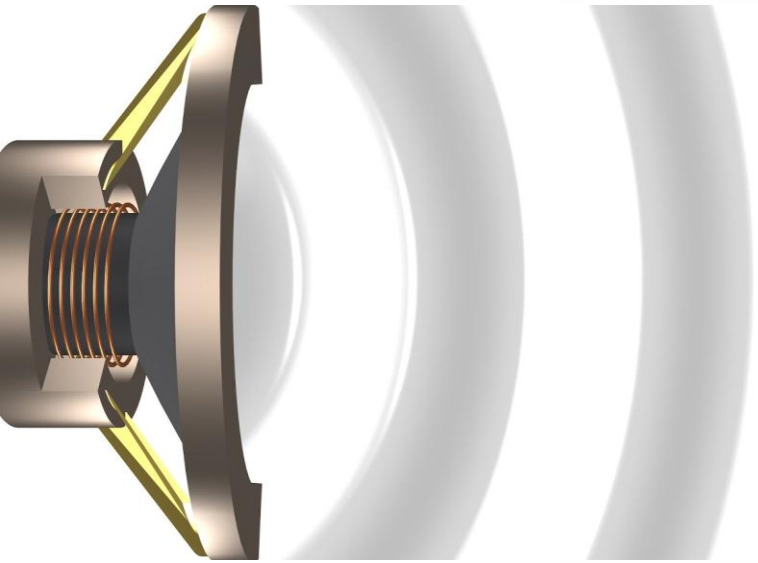
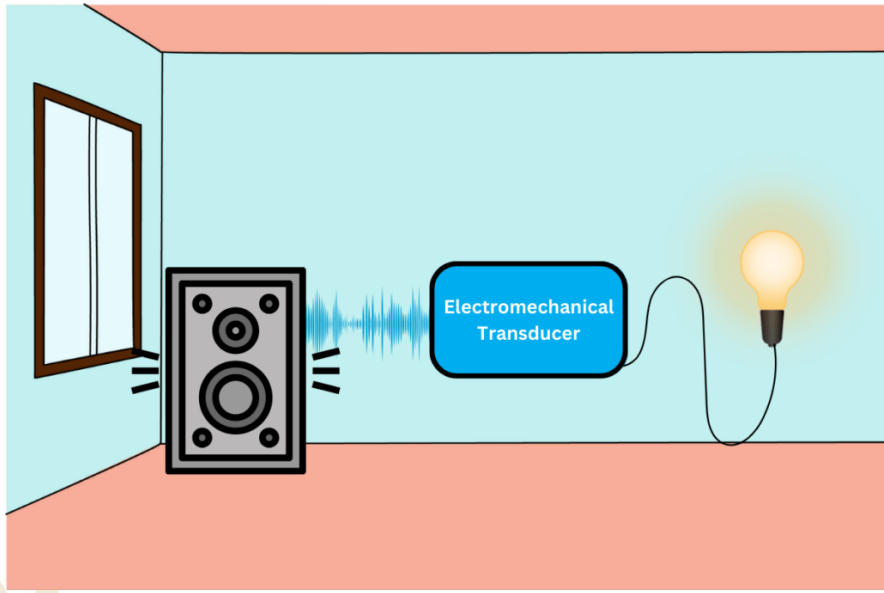
Unit One



Chapter 5

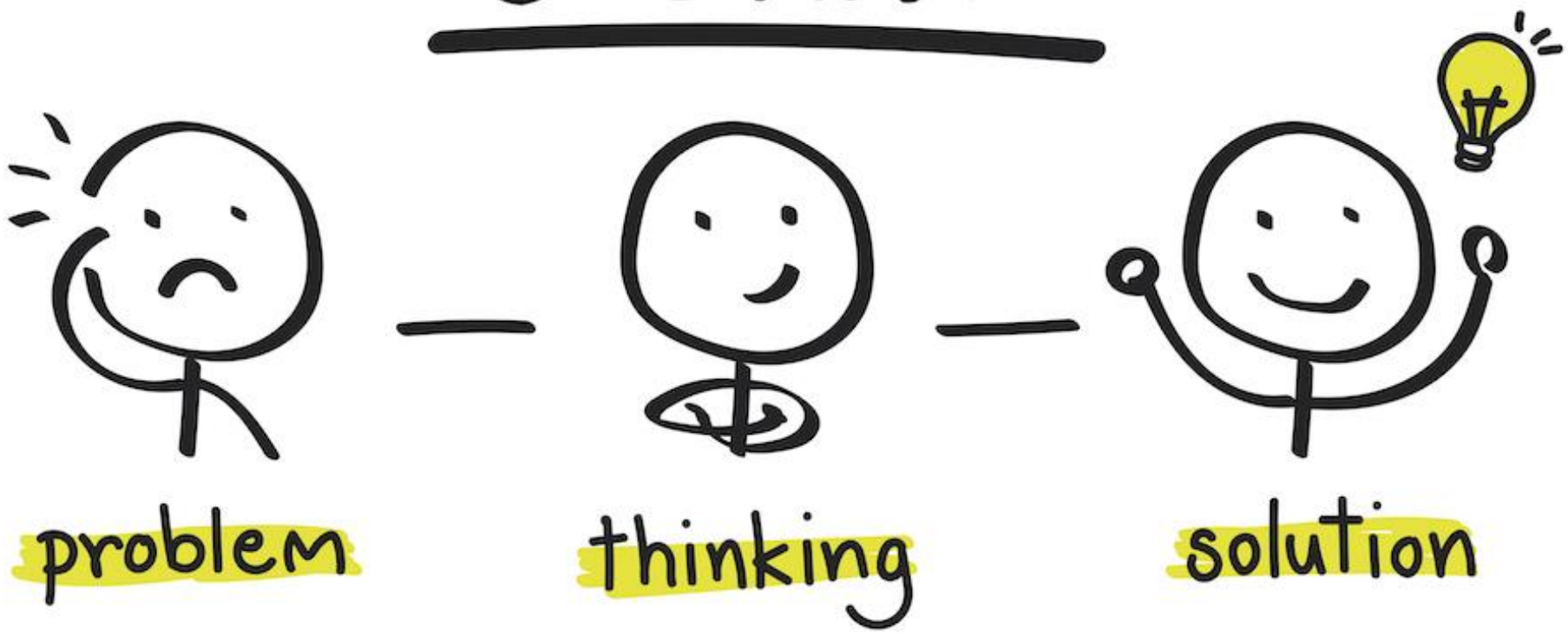


Sound Energy

Prepared and presented by: Mr. Mohamad Seif

Be Smart ACADEMY

PROBLEM SOLVING



Exercise 1 intensity of sound

In the table below, the values of the sound intensity level L and the logarithm of sound intensity log(I) are given

$logI$ in $(W\ /\ m^2)$	1	1.2	1.4	1.6	1.8	2
$L[dB]$	130	132	134	136	138	140

1) Plot the graph that represents the variation of L as a function of log I. Deduce the shape of the obtained graph.

Scale: $\begin{cases} \text{Horizontal axis: } 1\text{div} \rightarrow 0.2\text{W}\ /\ m^2 \\ \text{Vertical axis: } 1\text{ div} \rightarrow 10\text{dB} \end{cases}$

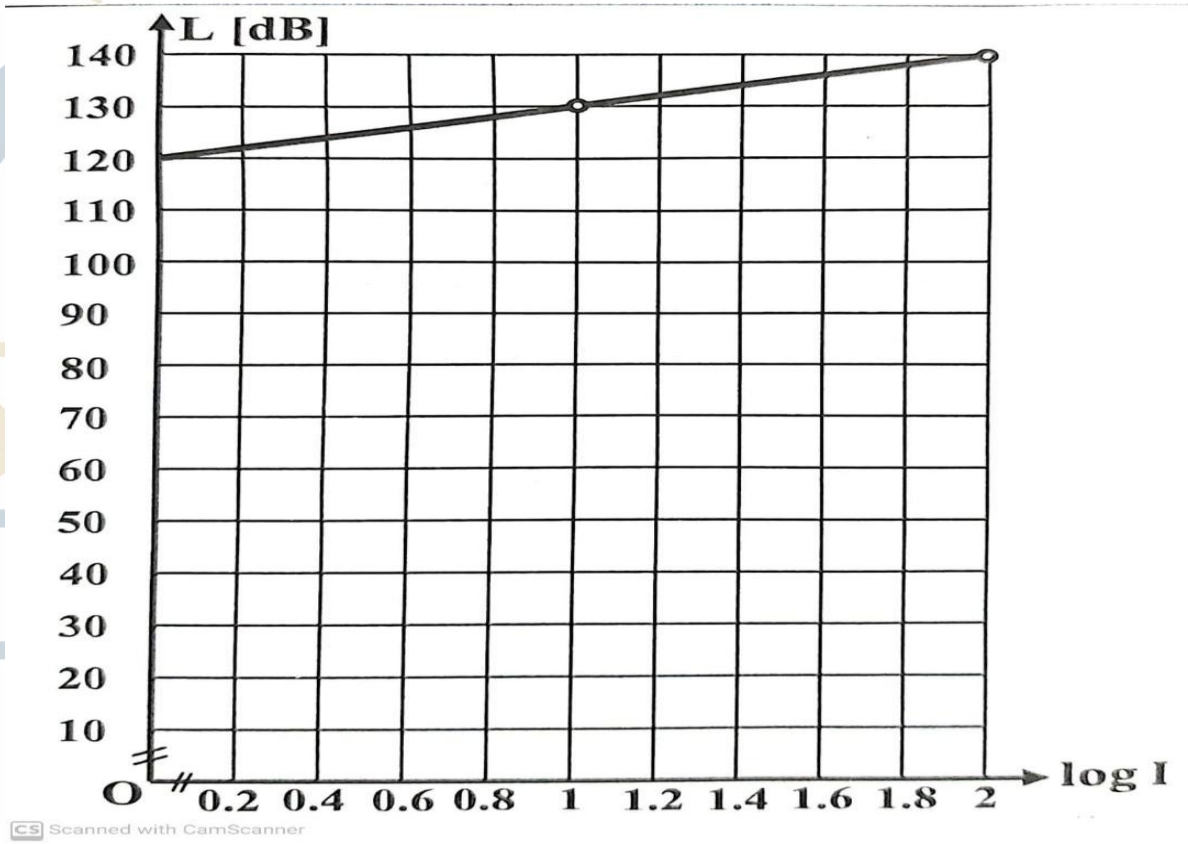
2) Find the equation of the obtained graph.

3) Determine the threshold of hearing L_0

Exercise 1 intensity of sound

1) Plot the graph that represents the variation of L as a function of log I. Deduce the shape of the obtained graph. x– axis: 1div $\rightarrow$ 0.2W / m^2 and y – axis: 1 div $\rightarrow$ 10dB

The obtained graph is St. line of increasing positive slope



Exercise 1 intensity of sound

2) Find the equation of the obtained graph.

The general equation of the obtained graph is $L = a\log I + b$

$$a = \frac{\Delta L}{\Delta \log I} = \frac{136 - 130}{1.6 - 1} = 10 dBm^2 / W$$

$L = 10\log I + b$ **The point (logI = 1; L=130) belong to the straight line:**

$130 = 10 \times 1 + b \Rightarrow b = 120$

The equation of the obtained graph is: $L = 10\log I + 120$

Exercise 1 intensity of sound

3)Determine the threshold of hearing I_0.

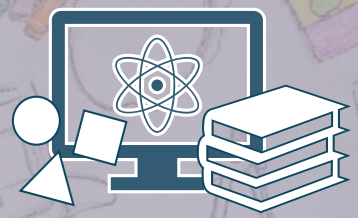
$$L = 10log\frac{I}{I_0} \Rightarrow L = 10logI - 10logI_0$$

Compare it with $L = 10logI + 120$

$$-10logI_0 = 120 \Rightarrow logI_0 = -12$$

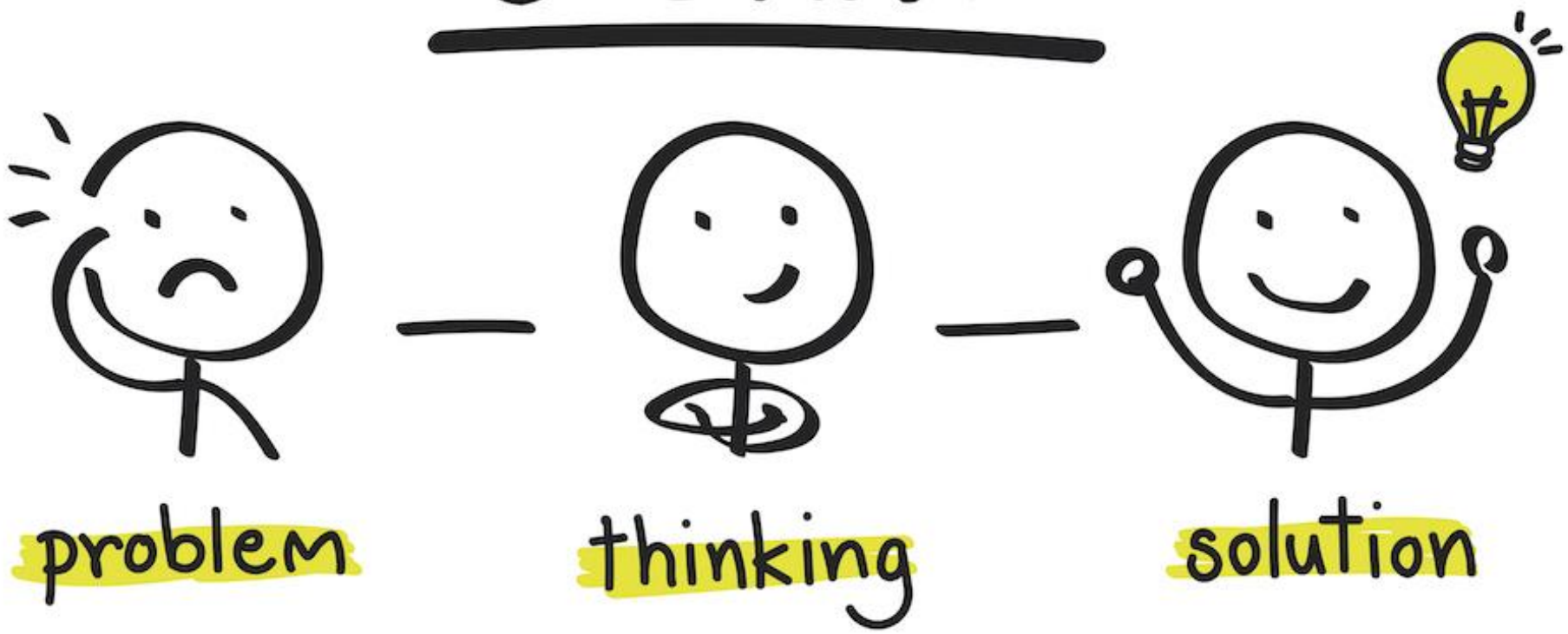
$$I_0 = 10^{-12} W/m^2$$

The End



Be Smart ACADEMY

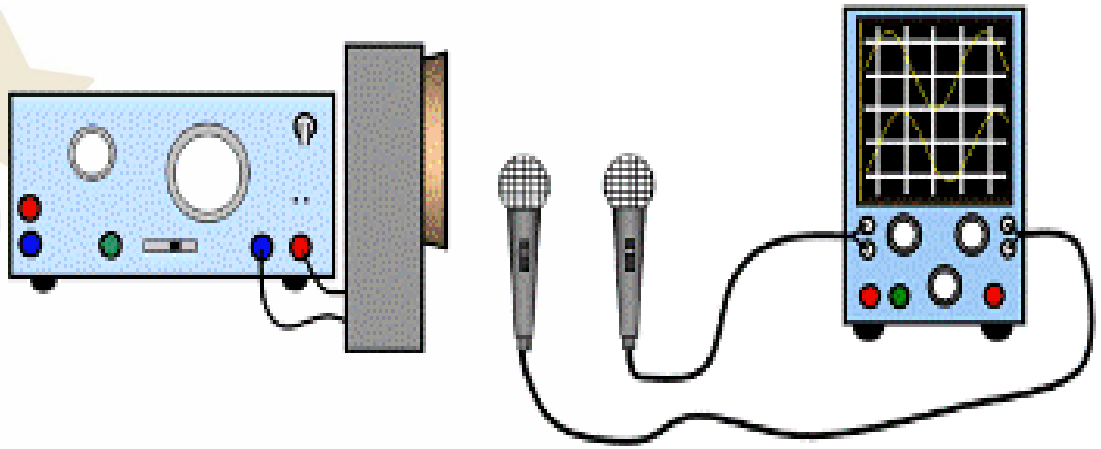
PROBLEM SOLVING



Exercise 2

A loudspeaker, connected to a LFG, produces pure sound waves of frequency f = 1000Hz.

Two microphones, labeled M_1, and M_2 , are connected to an oscilloscope.



M_1, and M_2 are initially at the same distance from the loudspeaker; then, M_2 is moved away from M_1 that remains at its initial position as shown in the figure.

At a certain distance d=17cm between M_1, and M_2, the two oscillograms become, as shown in figure 2 for the first time.

Exercise 2

1) Give the type and the nature of sound waves.

2) Tell, referring to figure 2, how are the air particles close to M_1, and M_2 vibrating? Justify.

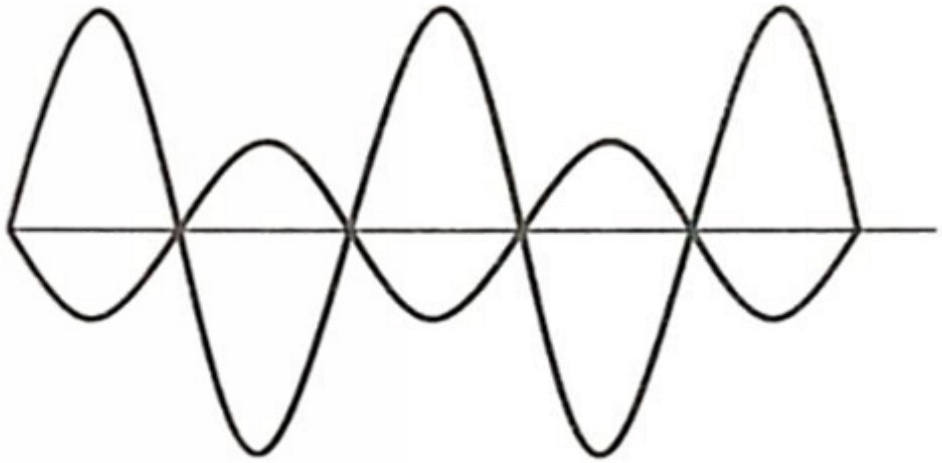


Figure 2

3) Calculate the wavelength of the sound waves.

4) Deduce the speed of sound in air.

1)Give the type and the nature of sound waves.

Sound wave is longitudinal wave and its nature is mechanical wave.

2)Tell, referring to figure 2, how are the sound particles close of M_1, and M_2 vibrating? Justify

They are vibrating in antiphase.

The first sound reaches its maximum, while the second one reaches its minimum

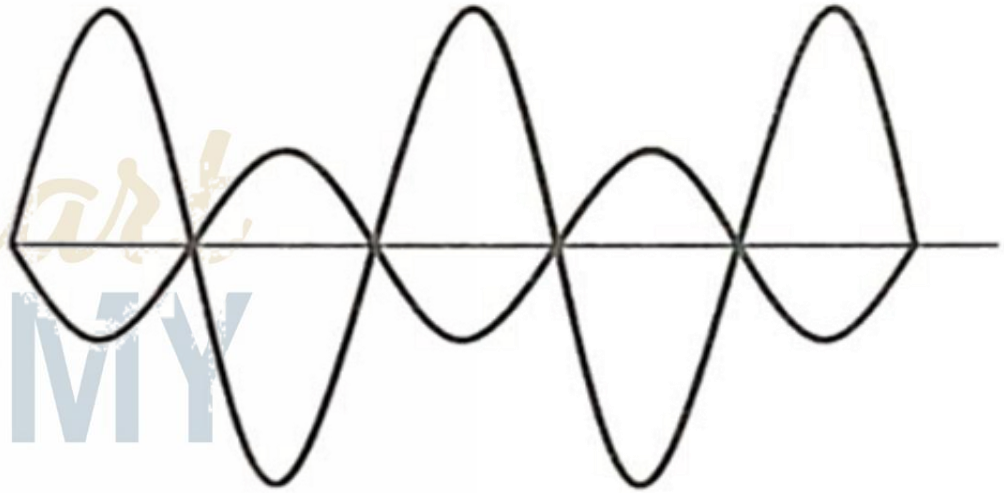


Figure 2

f = 1000Hz; d=17cm.

3)Calculate the wavelength of the sound waves.

$$d = (2k + 1)\frac{\lambda}{2}$$

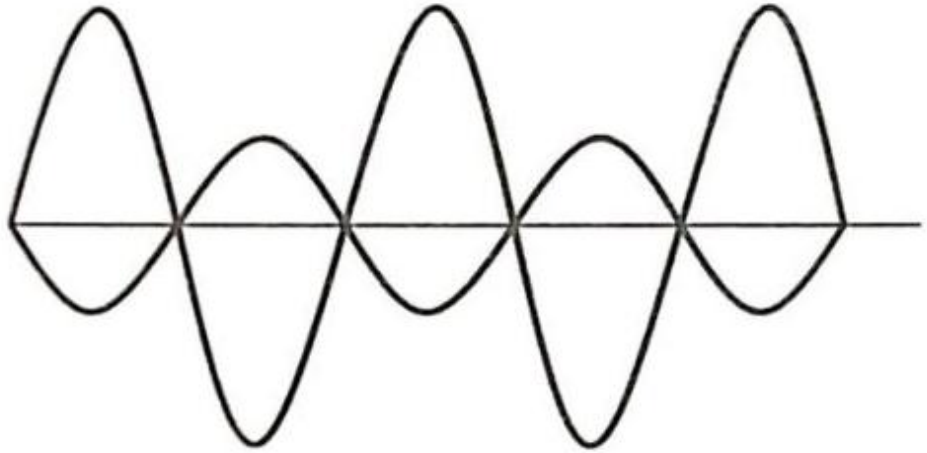


Figure 2

$k_{min} = 0$ ➡ $d = (0 + 1)\frac{\lambda}{2}$

$\lambda = 2d = 2 \times 17$ ➡ $\lambda = 34cm$

4)Deduce the speed of sound in air

$v = \lambda \times f$ ➡ $v = 0.34 \times 1000$ ➡ $v = 340m/s$

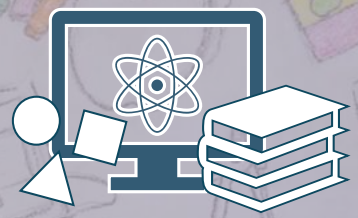
The amplitude of the wave produced by the LFG is increased so that the acoustic (sound) power supplied by the loudspeaker to be $P = 2 \times 10^{-2} W$. Take: $I_0 = 10^{-12} W/m^2$.

5) Show that the value of the sound intensity at a point D, 4 m away from the loudspeaker is $I = 10^{-4} W/m^2$. Deduce the sound intensity level L at this point.

$$I = \frac{P}{S} = \frac{P}{4\pi d^2} \Rightarrow I = \frac{2 \times 10^{-2}}{4\pi (4)^2} \Rightarrow I = 10^{-4} W/m^2$$

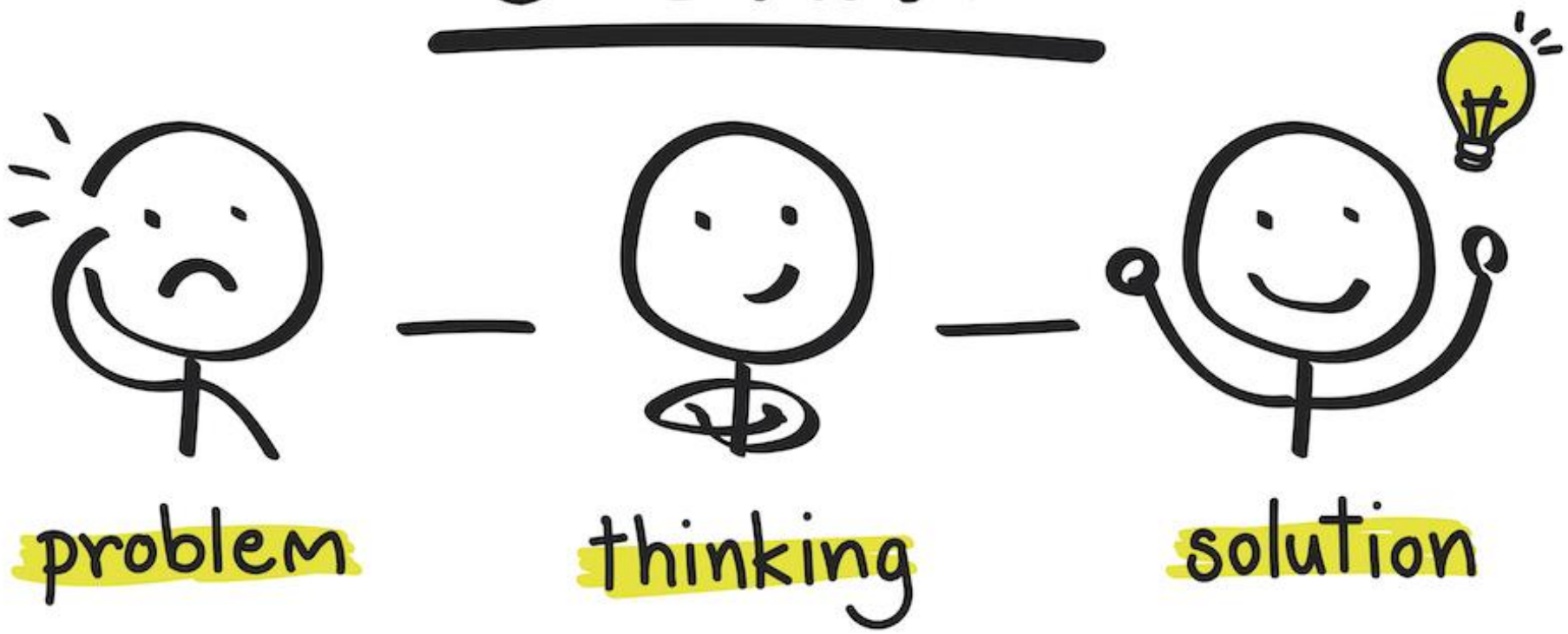
$$L = 10 log \left[\frac{I}{I_0}\right] \Rightarrow L = 10 log \left[\frac{10^{-4}}{10^{-12}}\right] \Rightarrow L = 80 dB$$

The End



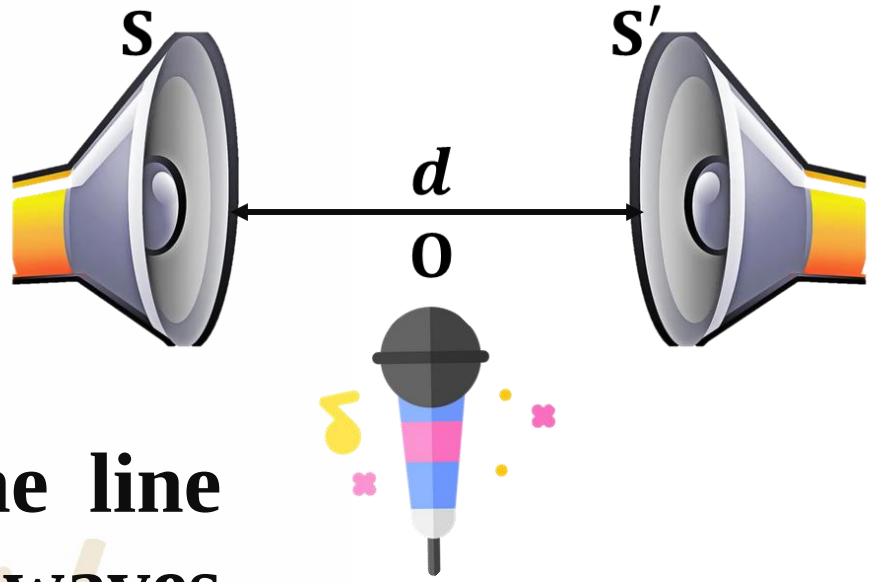
Be Smart ACADEMY

PROBLEM SOLVING



Exercise 3

Two identical loud speakers S and S' are separated by a distance of 1m.



Each speaker has a power of $P = 200W$, and the emitted sound by the speakers has a frequency $f = 1700Hz$.

A small microphone placed at O, along the line joining S and S', captures the sound waves produced by the two speakers.

The membrane of the microphone has an area $S = 2cm^2$.

The sound propagates in all directions and energy absorption by surroundings is neglected. Take $\pi = 3.14$.

Exercise 3

1) Two energy converters are mentioned in the above text. Name them and specify the energy conversions that take place.
2) Is the sound produced by the speakers audible? Justify.
3) Specify the nature of sound waves according to medium and according to the direction of vibration of particles of the medium.
4) Calculate the sound intensity I at point O of the membrane of the microphone when placed at O.
5) Deduce the sound power received by the membrane of the microphone.
6) Calculate the sound intensity level at a point of the membrane of the microphone

Exercise 3

$SS' = 1m$; $P_{speaker} = 200W$; $f = 1700Hz$; area $S = 2cm^2$.

1)Two energy converters are mentioned in the above text. Name them and specify the energy conversions that take place.

For loudspeaker: Electric energy to sound energy

For microphone: sound energy to electric energy

2)Is the sound produced by the speakers audible? Justify.

Yes it is audible since $20Hz < f = 1700Hz < 20000Hz$

Exercise 3

$SS' = 1m$; $P_{speaker} = 200W$; $f = 1700Hz$; area $S = 2cm^2$.

3)Specify the nature of sound waves according to medium and according to the direction of vibration of particles of the medium.

Nature: Mechanical since it needs a material medium to propagate in.

Types: Longitudinal since the direction of propagation of sound is parallel to the direction of displacement of the particles of the medium.

Exercise 3

4) Calculate the sound intensity I at point O of the membrane of the microphone when placed at O.

$$I_S = \frac{P}{S} = \frac{P}{4\pi d^2} \Rightarrow I_S = \frac{200}{4 \times 3.14 \times (0.5)^2}$$

$$I_S = 63.69 W / m^2$$

$$I_{S'} = I_S = 63.69 W / m^2$$

O belong to the line joining S and S′ then the total intensity at O is:

$$I = I_{S'} + I_S = 127.38 W / m^2$$

Exercise 3

5) Deduce the sound power received by the membrane of the microphone.

$$P_{mic} = I \times S_{mic} = 127.38 \times 2 \times 10^{-4}$$

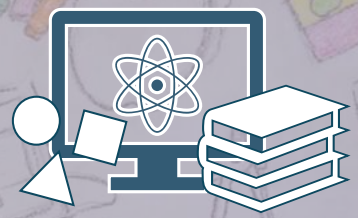
$$P_{mic} = 254.76 \times 10^{-4} W$$

6) Calculate the sound intensity level at a point of the membrane of the microphone.

$$L = 10log\left[\frac{I}{I_0}\right] \Rightarrow L = 10log\left[\frac{127.38}{10^{-12}}\right]$$

$$L = 141dB$$

The End



Be Smart Academy