Answer on Question 72117, Physics, Other

Question:

A tiny sound source sends sound equally in all directions. If the intensity is $4.5 \cdot 10^{-4}\ W/m^2$, $4\ m$ from the source:

(a) How much does sound energy the source emit each second?

(b) What is the intensity $3\ m$ from the source?

Solution:

(a) As we know from the condition of the question, the sound waves from the tiny sound source propagates uniformly in all directions. So, let's write the formula for intensity of the sound wave at the surface of the sphere:

$$I = \frac{P}{A_{surf}} = \frac{P}{4\pi r^2},$$

here, P is the sound power emitted (or the sound energy of the source that emits each second), $A_{surf} = 4\pi r^2$ is the surface area of the sphere, and r is the radius of the sphere.

Then, from this formula we can find the sound energy of the source that emits each second:

$$P = I \cdot A_{surf} = I \cdot 4\pi r^2 = 4\pi \cdot 4.5 \cdot 10^{-4}\ \frac{W}{m^2} \cdot (4\ m)^2 = 0.09\ \frac{J}{s}.$$

b) As we know, the intensity of the sound obeys the inverse square law (it decreases inversely proportional to the squared distance):

$$I \propto \frac{1}{d^2}.$$

Then, we can express the intensity of the sound wave at reference distance $d_2 = 3\ m$ from the source in terms of the intensity of the sound wave at reference distance $d_1 = 4\ m$ from the source:

$$\frac{I_2}{I_1} = \left(\frac{d_1}{d_2}\right)^2$$

$$I_2 = I_1 \cdot \left(\frac{d_1}{d_2}\right)^2,$$

$$I_2 = I_1 \cdot \left(\frac{4\ m}{3\ m}\right)^2 = I_1 \cdot \left(\frac{4}{3}\right)^2 = \frac{16}{9} \cdot I_1.$$

Finally, we get:

$$I_2 = \frac{16}{9} \cdot I_1 = \frac{16}{9} \cdot 4.5 \cdot 10^{-4}\ \frac{W}{m^2} = 8.0 \cdot 10^{-4}\ \frac{W}{m^2}.$$

Answer:

(a) $P = 0.09\ \frac{J}{s}$.

(b) $I_2 = 8.0 \cdot 10^{-4}\ \frac{W}{m^2}$.