The sound intensity level of a sound wave is 90-dB at a distance of 10-m from the sound source. What is the sound intensity level of the sound wave at a distance of 40-m from the sound source?

Given:

sound intensity level of sound wave at distance 10 m: $\beta_1 = 90$ dB

Determine: sound intensity level of sound wave at distance 40 m: β_2

To find the intensity of sound at distance of 10-m , use formula:

$$\beta_1 = (10\text{dB})\log_{10}(I_1 / I_0) \text{ ----------(1)}$$

I_0 is the threshold of human hearing or the lowest intensity of sound that can be heard by a human ear in a quiet room. Its value is 1.0×10^{-12} W/m^2.

Substituting for β_1 and I_0 in (1):

$$90 = (10\text{dB})\log_{10}(I_1 / 1.0 \times 10^{-12}) \text{ ----------(2)}$$

Simplifying & rearranging (2) and finding the antilog on both sides of (2):

$$I_1 / 1.0 \times 10^{-12} = 10^9 \text{ ----------(3)}$$

Simplifying (3):

$$I_1 = 1.0 \times 10^{-12} \times 10^9 = 10^{-3} \text{ W/m}^2$$

To find intensity of sound at a distance of 40 m, use equation:

$$(I_2 / I_1) = (d_1^2 / d_2^2) \text{ ----------(4)}$$

Rearranging (4) and substituting for I_1, d_1 and d_2 in (4):

$$I_2 = I_1 \times (d_1^2 / d_2^2) = 10^{-3} \times (10^2 / 40^2) = 0.0000625 \text{ W/m}^2$$

To find the sound intensity level of sound wave at distance 40 m, use formula:

$$\beta_2 = (10\text{dB})\log_{10}(I_2 / I_0) \text{ ----------(5)}$$

Substituting for I_2 and I_0 in (5):

$$\mathbf{\beta_2 = (10dB)\log_{10}(6.25 \times 10^{-5} / 1.0 \times 10^{-12}) = 78\ dB}$$