Chapter 14 Problem 67 †

Given
$r_1 = 2.0\ m$
$\beta_1 = 75\ dB$
$\beta_2 = 65\ dB$

Solution
Find the distance for a decibel level of 65 dB.

Assuming the sound spreads uniformly out into 3 dimensions of space, the intensity will drop off as $1/r^2$. This happens because the initial power of the sound source is spread out over the surface of a sphere.

$$P = 4\pi r^2 I$$

Assuming no absorption of power from the source to the observer, the intensity at any location is related to the power of the source.

$$P = 4\pi r_1^2 I_1 = 4\pi r_2^2 I_2$$

Solving for the distance to the second intensity level gives

$$r_2 = \sqrt{\frac{4\pi r_1^2 I_1}{4\pi I_2}} = \sqrt{\frac{r_1^2 I_1}{I_2}}$$

The intensity is related to the decibel level as follows.

$$\beta = 10 \log\left(\frac{I}{I_0}\right)$$

Solving for the intensity gives

$$I = I_0 10^{\beta/10}$$

The ratio of the two intensities is then

$$\frac{I_1}{I_2} = \frac{I_0 10^{\beta_1/10}}{I_0 10^{\beta_2/10}} = \frac{10^{\beta_1/10}}{10^{\beta_2/10}} = 10^{(\beta_1-\beta_2)/10}$$

The distance to the second intensity level is then

$$r_2 = \sqrt{r_1^2 10^{(\beta_1-\beta_2)/10}}$$

Substituting in the appropriate values gives

$$r_2 = \sqrt{(2.0\ m)^2 10^{(75\ dB-65\ dB)/10}} = 6.32\ m$$

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†Problem from Essential University Physics, Wolfson