Sound wave – example problems.

1. What is the sound speed in argon ($m = 40u$) at $T = 100K$?

$$v_s = \sqrt{\frac{\gamma kT}{m}}, \quad \gamma = 5/3 \text{ for Ar.}$$

$$= \sqrt{\frac{(5/3)(1.38\times10^{-23})\times100}{40\times 1.66\times10^{-27}}} = 186 \text{ m/s}$$

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2. An explosion (point source of sound) produces 10^{15} W of sound energy per sec. What is the sound intensity and sound intensity level at a distance of 1 km from this explosion?

$$I = \frac{P_0}{4\pi r^2} = \frac{10^{15} W}{4\pi (10^3 m)^2} \simeq 8\times10^7 W/m^2$$

$$\beta = 10 dB \log_{10}(I/I_0)$$

$$= 10 dB \log_{10}\left(\frac{8\times10^7}{1\times10^{-12}}\right) = 10 \times 19.9 dB$$

$$\simeq 200 \text{ dB}$$

3. The sound intensity at a distance of 1m from a sound source is $1000\ W/m^2$. What is the difference in sound intensity levels at 1m from the source compared to the value at 5m from the source?

$I_1 = 1000 W/m^2 \quad @ \quad r = 1m$

$I_2 = ? \quad @ \quad r = 5m$

$$\frac{I_2}{I_1} = \left(\frac{r_1}{r_2}\right)^2$$

$$I_2 = \left(\frac{r_1}{r_2}\right)^2 \cdot I_1 = \left(\frac{1}{5}\right)^2 \times 1000$$

$$I_2 = \frac{1000}{25} = 40\ W/m^2$$

$\beta_1 = 10 \log (I_1/I_0)$

$\beta_2 = 10 \log (I_2/I_0)$

$\beta_2 - \beta_1 = 10 \log (I_2/I_0) - 10 \log (I_1/I_0)$

$= 10 \log (I_2/I_1) = 10 \log \left(\frac{40}{1000}\right)$

$= -14\ dB$