

Sound Intensity

- Sound waves carry _____ that can do _____
- Amount of _____ transported per _____ = _____
- As sound moves away from a _____, it spreads out over a _____ and larger _____
- As the areas get _____, intensity at any 1 point is _____

$$I = \frac{P}{A}$$

- Units: W/m²

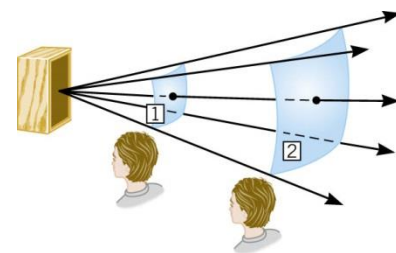
- If sound is transmitted _____ in all directions, the areas are the surfaces of _____.

$$A_{sphere} = 4\pi r^2$$

- Intensity is proportional to _____

$$I = \frac{(\Delta p)^2}{2\rho v_w}$$

- Where Δp = pressure amplitude, ρ = density of the medium, v_w = speed of the wave



You and a friend are watching fireworks that are launching from the observatory. You are standing right in front of Berman Hall (150 m) and your friend is across campus at AA (700 m). The sound intensity at AA is 0.2 W/m². What is the sound intensity at your location, and how much power is the firework emitting?

Sound Level and Decibels

- Unit of measure to _____ two sound _____.
- Based on how human ear perceives _____.
- If you _____ the intensity, I, the sound is _____ twice as loud.
- Use a _____ scale
- Intensity Level

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

- where β = intensity level β , I and I_0 are intensities of two sounds

- I_0 is usually _____ W/m²
 - Unit: dB (decibel)
- An intensity level of _____ only means that $I = I_0$ since $\log(1) = 0$
- Intensity can be _____
- Loudness is simply how ear _____
- Doubling _____ does not double _____

Table 17.2 Sound Intensity Levels and Intensities

| Sound intensity level β (dB) | Intensity I(W/m ²) | Example/effect |
|------------------------------------|--------------------------------|---|
| 0 | 1×10^{-12} | Threshold of hearing at 1000 Hz |
| 10 | 1×10^{-11} | Rustle of leaves |
| 20 | 1×10^{-10} | Whisper at 1 m distance |
| 30 | 1×10^{-9} | Quiet home |
| 40 | 1×10^{-8} | Average home |
| 50 | 1×10^{-7} | Average office, soft music |
| 60 | 1×10^{-6} | Normal conversation |
| 70 | 1×10^{-5} | Noisy office, busy traffic |
| 80 | 1×10^{-4} | Loud radio, classroom lecture |
| 90 | 1×10^{-3} | Inside a heavy truck; damage from prolonged exposure ^[1] |
| 100 | 1×10^{-2} | Noisy factory, siren at 30 m; damage from 8 h per day exposure |
| 110 | 1×10^{-1} | Damage from 30 min per day exposure |
| 120 | 1 | Loud rock concert, pneumatic chipper at 2 m; threshold of pain |
| 140 | 1×10^2 | Jet airplane at 30 m; severe pain, damage in seconds |
| 160 | 1×10^4 | Bursting of eardrums |

You double the intensity of sound coming from a stereo. What is the change in loudness?

- Experiment shows that if the intensity level increases by _____, the sound will seem _____ as loud.

See Table 17.2

What is the intensity of a 20 dB sound?

Homework

1. A source is emitting sound uniformly in all directions. There are no reflections anywhere. A *flat* surface faces the source. Is the sound intensity the same at all points on the surface? Give our reasoning.
2. If two people talk simultaneously and each creates an intensity level of 65 dB at a certain point, does the total intensity level at this point equal 130 dB? Account for your answer.
3. A typical adult ear has a surface area of $2.1 \times 10^{-3} \text{ m}^2$. The sound intensity during a normal conversation is about $3.2 \times 10^{-6} \text{ W/m}^2$ at the listener's ear. Assume that the sound strikes the surface of the ear perpendicularly. How much power is intercepted by the ear? (Cutnell 16.48) **$6.7 \times 10^{-9} \text{ W}$**
4. What is the intensity in watts per meter squared of 85.0-dB sound? (OpenStax 17.12) **$3.16 \times 10^{-4} \text{ W/m}^2$**
5. The warning tag on a lawn mower states that it produces noise at a level of 91.0 dB. What is this in watts per meter squared? (OpenStax 17.13) **$1.26 \times 10^{-3} \text{ W/m}^2$**
6. A sound wave traveling in 20 °C air has a pressure amplitude of 0.5 Pa. What is the intensity of the wave? (OpenStax 17.14) **$3.04 \times 10^{-4} \text{ W/m}^2$**
7. What intensity level does the sound in the preceding problem correspond to? (OpenStax 17.15) **85 dB**
8. What sound intensity level in dB is produced by earphones that create an intensity of $4.00 \times 10^{-2} \text{ W/m}^2$? (OpenStax 17.16) **106 dB**
9. (a) What is the intensity of a sound that has a level 7.00 dB lower than a $4.00 \times 10^{-9} \text{ W/m}^2$ sound? (b) What is the intensity of a sound that is 3.00 dB higher than a $4.00 \times 10^{-9} \text{ W/m}^2$ sound? (OpenStax 17.19) **$8.00 \times 10^{-10} \text{ W/m}^2$, $8.00 \times 10^{-9} \text{ W/m}^2$**
10. People with good hearing can perceive sounds as low in level as -8.00 dB at a frequency of 3000 Hz. What is the intensity of this sound in watts per meter squared? (OpenStax 17.21) **$1.58 \times 10^{-13} \text{ W/m}^2$**
11. If a large housefly 3.0 m away from you makes a noise of 40.0 dB, what is the noise level of 1000 flies at that distance, assuming interference has a negligible effect? (OpenStax 17.22) **70.0 dB**
12. An 8-hour exposure to a sound intensity level of 90.0 dB may cause hearing damage. What energy in joules falls on a 0.800-cm-diameter eardrum so exposed? (OpenStax 17.26) **$1.45 \times 10^{-3} \text{ J}$**
13. The bellow of a territorial bull hippopotamus has been measured at 115 dB above the threshold of hearing. What is the sound intensity? (Cutnell 16.59) **0.316 W/m^2**
14. Humans can detect a difference in sound intensity levels as small as 1.0 dB. What is the ratio of the sound intensities? (Cutnell 16.61) **1.3**