Sound waves

- Longitudinal
- Speed of sound

\[ V_{\text{sound}} = \sqrt{\frac{B}{\rho}} \]

\[ B = \frac{P}{\Delta V/V} \]
Sound waves

- Velocity of sound in air at 20° is 343 m/s

\[ f = \frac{\nu}{\lambda} = \frac{343 \text{ m/s}}{1 \text{ m}} = 343 \text{ Hz} \]

- Helium is lighter than air

- Velocity of sound in helium at 20° is 972 m/s

\[ f = \frac{\nu}{\lambda} = \frac{972 \text{ m/s}}{1 \text{ m}} = 972 \text{ Hz} \]
Sound tends to travel faster in liquids and solids (the molecules are closer together).

- The velocity of sound in air
  \[ v_{\text{in air}} = 343 \text{ m/s} \]

- The velocity of sound in liquid
  \[ v_{\text{in water}} = 1490 \text{ m/s} \]

- The velocity of sound in a solid
  \[ v_{\text{in Aluminum}} = 5100 \text{ m/s} \]

Cool experiment – make a milkshake!

(c) Dallin S. Durfee
Why do we not hear collisions and explosions from outer space?

- In a vacuum there are not any molecules
  - Without molecules we cannot have a pressure wave
  - Sound cannot travel through a vacuum.
A cricket is chirping. I measure the sound intensity 2 meters from the cricket and find it to be $3 \times 10^{-9} \text{ W/m}^2$. What is the intensity a distance of 20 meters away?

A. $3 \times 10^{-8} \text{ W/m}^2$
B. $1.5 \times 10^{-9} \text{ W/m}^2$
C. $3 \times 10^{-10} \text{ W/m}^2$
D. $3 \times 10^{-11} \text{ W/m}^2$

E. None of the above
Intensity of sound

Intensity depends on the **Distance** from the source and **Power** from the source.

\[ I = \frac{\text{Power}}{\text{Area}} = \frac{\text{Power}}{4\pi r^2} \]
Spherical Waves / Plane Waves

$I = \text{const}$
JOHN 14:27

Peace I leave with you, my peace I give to you: not as the world gives, give I to you. Let not your heart be troubled, neither let it be afraid.
Decibels

\[ \beta = 10 \log \frac{I}{I_0} \]

\[ I_0 = 10^{-12} \text{ W/m}^2 \]

Why use a logarithmic scale?
Review of Logarithms

\[ \log_b(b^x) = x \]

\[ b^{\log_b x} = x \]
Review of Logarithms

\[ y = b^x \]

\[ \log_b y = x \]

Decibels uses base 10

\[ \log x^n = n \log x \]
Review of Logarithms

\[ \log(xy) = \log x + \log y \]

\[ y = b^{x \cdot z} = b^x \cdot b^z \]

\[ \log(x/y) = \log x - \log y \]

\[ \log(x \cdot y') = \log x + \log y' = \log x - \log y \]
At a rock concert a meter placed at 2 m in front of a loudspeaker measures 100 dB. What is the power output of the speaker?

A. $2 \times 10^{-10}$ Watts

B. $0.503 \times 10^{-8}$ Watts

C. $0.251 \times 10^{-8}$ Watts

D. 0.251 Watts

E. None of the above
If you increase the intensity by a factor of 1000, the sound level goes up by . . .

A. 3 dB
B. 10 dB
C. 20 dB
D. 30 dB
E. 60 dB

\[ \beta_1 + ? = \beta_2 \]
If you increase the intensity by a factor of 2, the sound level goes up by . . .

A. 3 dB
B. 10 dB
C. 20 dB
D. 30 dB
E. 60 dB

A. 3 dB is correct.
Can you detect a 3dB difference (50% loss)

At a rock concert a meter placed at 2 m in front of a loudspeaker measures 130 dB. How far away do I need to stand to be at a safer level of 90 dB? Assume that the sound from the speaker is a good approximation to a spherical wave.

A. 4 m
B. 200 m
C. 45.2 m
D. 20,000 m
E. None of the above