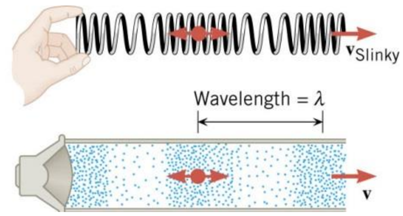
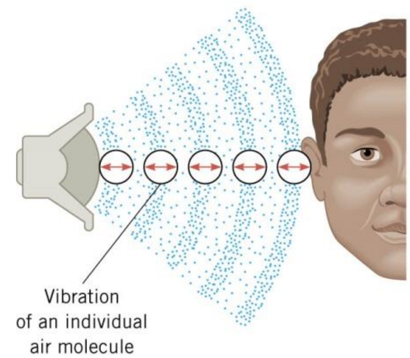
Physics 07-03 Sound, Speed, Frequency, and Wavelength Name: ____________

How Sound Is Made



- Some ____________ object like a speaker moves and ____________ the air
- Air pressure rises called ____________
- Condensation moves ____________ at speed of ____________
- Object moves back creating ____________ air pressure called ____________
- Rarefaction moves ____________ at speed of ____________
- Particles move ____________ and ____________
- Distance between consecutive condensations or rarefactions is ____________



- String or speaker makes air ____________ vibrate
- That molecule pushes the ____________ one to vibrate and so on
- When it ____________ the ear, the ____________ are interpreted as ____________

Pitch

- 1 cycle = 1 ________________ + 1 ____________

$$Frequency = \frac{cycles}{second}$$

- Each frequency has own ____________
    - Sounds with 1 frequency called ____________
- Healthy ____________ people can hear frequencies of ____________ to ____________ Hz
- Brain can interpret frequency as ____________
    - High freq = ____________ pitch
    - ____________ because most people don't have ____________ pitch

Loudness

- The condensations have more ____________ than the rarefactions
- Amplitude = ____________ pressure
- Typical conversation, Amp = ____________ Pa
- Atmospheric air pressure = ____________ Pa
- ____________ is ear's interpretation of ____________ amplitude

Speed of Sound

- For ____________ waves

$$v_w = f\lambda$$

- Sound travels slowest in ____________, faster in ____________, and fastest in ____________
- Air at 20 °C → 343 m/s

- Speed of sound depends on properties of ____________
- In gases
    - Sound is transmitted only when molecules ____________
    - So we derive formula from speed of ____________
    - And speed changes with ____________

For air

$$v_w = \left(331\frac{m}{s}\right)\sqrt{\frac{T}{273\ K}}$$

- where T is in ____________Kelvin

Table 17.1 Speed of Sound in Various Media

Medium	v_w(m/s)
Gases at 0°C	
Air	331
Carbon dioxide	259
Oxygen	316
Helium	965
Hydrogen	1290
Liquids at 20°C	
Ethanol	1160
Mercury	1450
Water, fresh	1480
Sea water	1540
Human tissue	1540
Solids (longitudinal or bulk)	
Vulcanized rubber	54
Polyethylene	920
Marble	3810
Glass, Pyrex	5640
Lead	1960
Aluminum	5120
Steel	5960

What wavelength corresponds to a frequency of concert A which is 440 Hz if the air is 25 °C?

How far away is a ship if it takes 3.4 s to receive a return signal in seawater?

Homework

1. How do sound vibrations of atoms differ from thermal motion?
2. When sound passes from one medium to another where its propagation speed is different, does its frequency or wavelength change? Explain your answer briefly.
3. A loudspeaker produces a sound wave. Does the wavelength of the sound increase, decrease, or remain the same, when the wave travels from air into water? Justify your answer.
4. When poked by a spear, an operatic soprano lets out a 1200-Hz shriek. What is its wavelength if the speed of sound is 345 m/s? (OpenStax 17.1) **0.288 m**
5. What frequency sound has a 0.10-m wavelength when the speed of sound is 340 m/s? (OpenStax 17.2) **3400 Hz**
6. Calculate the speed of sound on a day when a 1500 Hz frequency has a wavelength of 0.221 m. (OpenStax 17.3) **332 m/s**
7. (a) What is the speed of sound in a medium where a 100-kHz frequency produces a 5.96-cm wavelength? (b) Which substance in the table is this likely to be? (OpenStax 17.4) $\mathbf{5.96 \times 10^{3}}$ **m/s, steel**
8. Show that the speed of sound in 20.0 °C air is 343 m/s, as claimed in the text. (OpenStax 17.5) **343 m/s**
9. Air temperature in the Sahara Desert can reach 56.0 °C (about 134 °F). What is the speed of sound in air at that temperature? (OpenStax 17.6) **363 m/s**
10. Dolphins make sounds in air and water. What is the ratio of the wavelength of a sound in air to its wavelength in seawater? Assume air temperature is 20.0 °C. (OpenStax 17.7) **0.223**
11. A sonar echo returns to a submarine 1.20 s after being emitted. What is the distance to the object creating the echo? (Assume that the submarine is in the ocean, not in fresh water.) (OpenStax 17.8) **924 m**
12. (a) If a submarine's sonar can measure echo times with a precision of 0.0100 s, what is the smallest difference in distances it can detect? (Assume that the submarine is in the ocean, not in fresh water.) (b) Discuss the limits this time resolution imposes on the ability of the sonar system to detect the size and shape of the object creating the echo. (OpenStax 17.9) **7.70 m**
13. For research purposes a sonic buoy is tethered to the ocean floor and emits an infrasonic pulse of sound. The period of this sound is 71 ms. Determine the wavelength of the sound. (Cutnell 16.30) **110 m**
14. The distance between a loudspeaker and the left ear of a listener is 2.70 m. (a) Calculate the time required for sound to travel this distance if the air temperature is 20 °C. (b) Assuming that the sound frequency is 523 Hz, how many wavelengths of sound are contained in this distance? (Cutnell 16.31) $\mathbf{7.87 \times 10^{-3}}$ **s, 4.12**