Physics 1240: Sound and Music

<u>Today (7/9/19)</u>: Course Details, Units, What Is Sound?

<u>Next time</u>: Hooke's Law, Oscillations, Resonance

Welcome to Physics 1240: Sound and Music

Instructor: Tyler McMaken

Office Hours: Thursdays 2-4p,
Physics Help Room

Class policies:
Cell Phones OFF
iClickers ON
Be respectful and engaging
Enjoy your time!

Canvas site (for grades only):
https://canvas.colorado.edu/courses/50672

Course website (for course schedule, accessing homeworks, lecture slides, & everything else):
https://physicscourses.colorado.edu/phys1240/

Clicker Question 1.1

What's your favorite kind of music?

A) Classical / Jazz / World
B) Electronic / Pop
C) Indie / Rock
D) Hip Hop / Rap
E) Other

BA

Clicker Question 1.2

What's your favorite kind of physics?

A) Quantum Chromodynamics
B) Atomic, Molecular, and Optical Physics
C) Just pure math
D) Astrology
E) Um, what?

SI Units –

Le Système International d'unités

Base units:
meters [m] (3.3 ft), kilograms [kg] (2.2 lb), seconds [s]

Prefixes:

milli (m)	0.001	10^{-3}
centi (c)	0.01	10^{-2}
deci (d)	0.1	10^{-1}
kilo (k)	1000	10^{3}
mega (M)	1,000,000	10^{6}

Example 1: Using Units

Suppose your average speed is 80 km/hr (kilometers per hour), how many hours does it take for you to drive the 1600 km (kilometers) from Denver to Chicago?

a) 12,000 s
b) 40,000 s
c) 16 hrs
d) 20 hrs
e) 24 hrs

Example 1: Using Units

Suppose your average speed is 80 km/hr (kilometers per hour), how many hours does it take for you to drive the 1600 km (kilometers) from Denver to Chicago?

a) 12,000 s
b) 40,000 s
c) 16 hrs
d) 20 hrs
e) 24 hrs

$$\frac{1600\ \text{km}}{80\ \text{km/hr}} = 20\ \text{hr}$$

BA

Clicker Question 1.3

Pressure is given in units of force per unit area (N/m^2). If you exert a force of 5 mN (millinewtons) on a small area of 1 mm^2, what is the pressure, in SI units?

A) 5×10^{6} N/m^2
B) 2×10^{-4} N/m^2
C) 5×10^{3} N/m^2
D) 5×10^{-3} N/m^2
E) 5 N/m^2

Clicker Question 1.3

Pressure is given in units of force per unit area (N/m^2). If you exert a force of 5 mN (millinewtons) on a small area of 1 mm^2, what is the pressure, in SI units?

A) 5×10^{6} N/m^2
B) 2×10^{-4} N/m^2
C) 5×10^{3} N/m^2
D) 5×10^{-3} N/m^2
E) 5 N/m^2

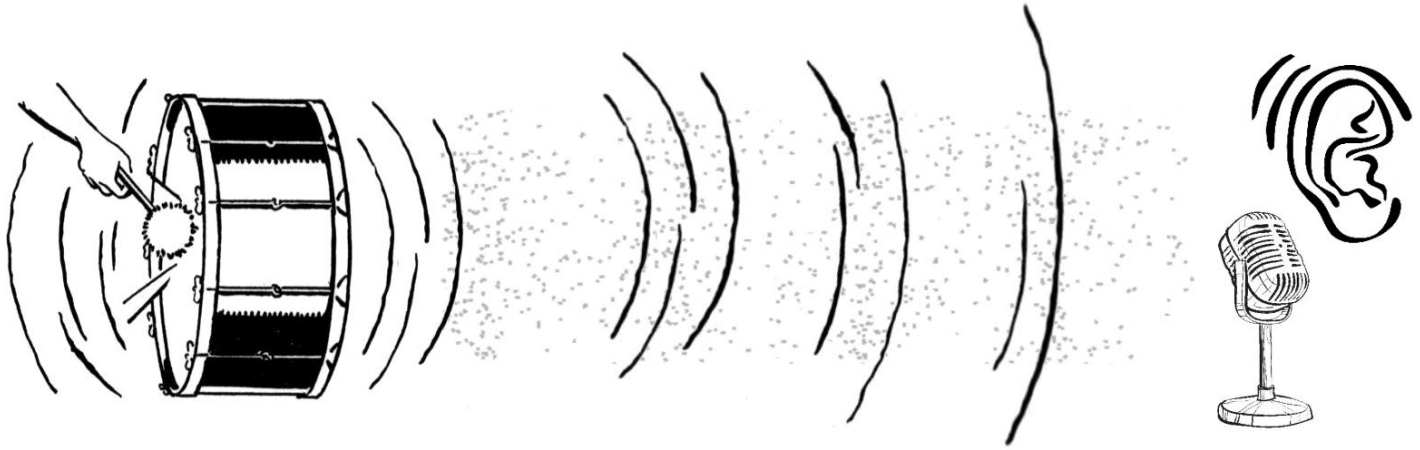
$$5\ \text{mN} = 5\,(10^{-3})\text{N} = 5\times10^{-3}\ \text{N}$$

$$1\,(\text{mm})^2 = 1\left((10^{-3})\text{m}\right)^2 = 1\times10^{-6}\,\text{m}^2$$

$$\frac{5\times10^{-3}\,\text{N}}{1\times10^{-6}\,\text{m}^2} = 5\times10^{3}\ {}^{\text{N}}/_{\text{m}^2}$$

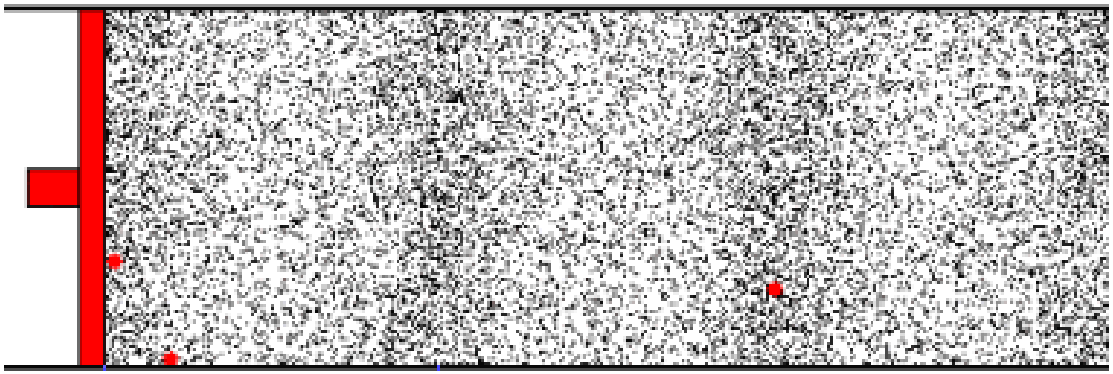
Musical Acoustics – the science of musical sound

Generation Propagation Reception/Perception



What is sound?

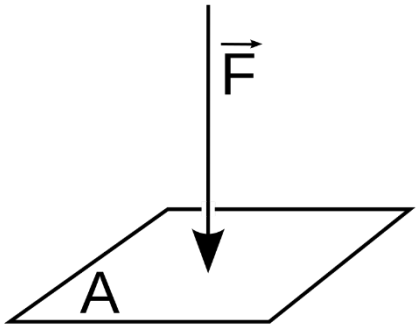
Sound is a mechanical disturbance of the **pressure** in a **medium** that travels in the form of a **longitudinal wave**.



Sound is a mechanical disturbance of the **pressure** in a **medium** that travels in the form of a **longitudinal wave**.

Pressure

- Force per unit area (e.g. thumbtack, gas molecules hitting wall, ears, lungs)



	Unit	Symbol	Conversion
SI	pascal	Pa	1 Pa ≡ 1 N/m^2
other	atmosphere	atm	1 atm = 101325 N/m^2
other	pounds per square inch	psi	14.7 psi = 1 atm

BA

Sound is a mechanical disturbance of the **pressure** in a **medium** that travels in the form of a **longitudinal wave**.

Clicker Question 1.4

Which container of gas molecules has the largest pressure on the bottom surface at the moment shown?

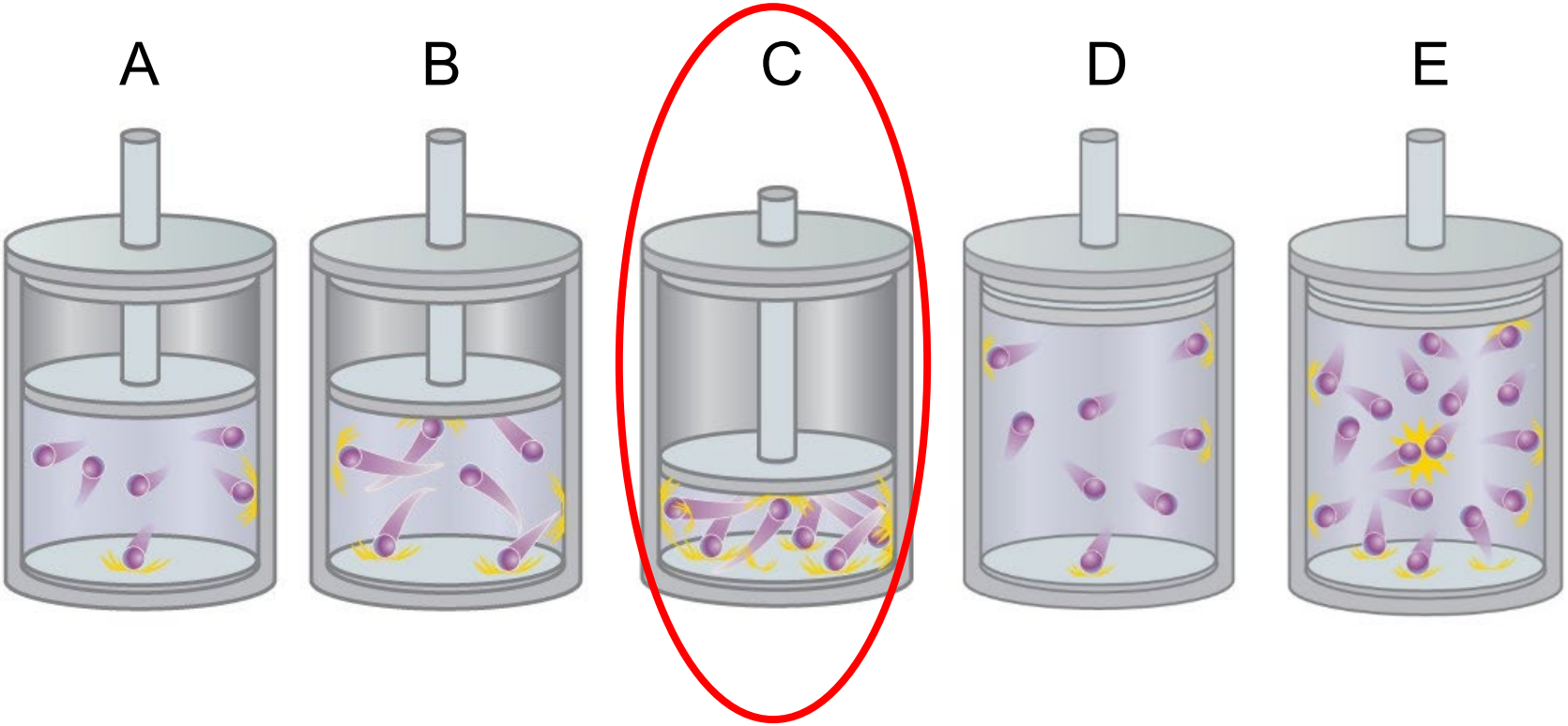
A B C D E

BA

Sound is a mechanical disturbance of the **pressure** in a **medium** that travels in the form of a **longitudinal wave**.

Clicker Question 1.4

Which container of gas molecules has the largest pressure on the bottom surface at the moment shown?



Sound is a mechanical disturbance of the **pressure** in a **medium** that travels in the form of a **longitudinal wave**.

Medium

- Sound requires a medium (gas, liquid, or solid) to travel through (without it, there can't be pressure disturbances)
- What happens to sound when there is no medium? (demo: bell in a vacuum)
- Sound speed depends on the phase of the medium (solid, liquid, or gas)—in what way?

BA

Sound is a mechanical disturbance of the **pressure** in a **medium** that travels in the form of a **longitudinal wave**.

Clicker Question 1.5

If a person does a cannonball on the edge of a pond while you are in the middle, will you hear the sound sooner if you are underwater or above water?

A) Underwater
B) Above water

BA

Sound is a mechanical disturbance of the **pressure** in a **medium** that travels in the form of a **longitudinal wave**.

Clicker Question 1.5

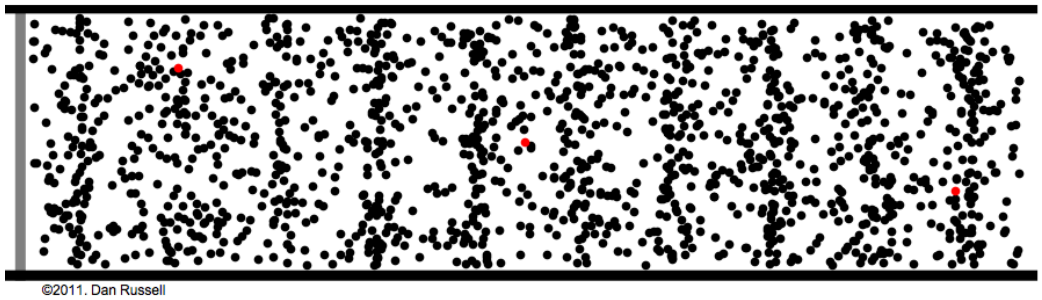
If a person does a cannonball on the edge of a pond while you are in the middle, will you hear the sound sooner if you are underwater or above water?

A) Underwater
B) Above water

Sound in air travels 343 m/s (767 mph)
Sound in water travels 4.3 times faster than air
Sound in iron travels 14 times faster than air

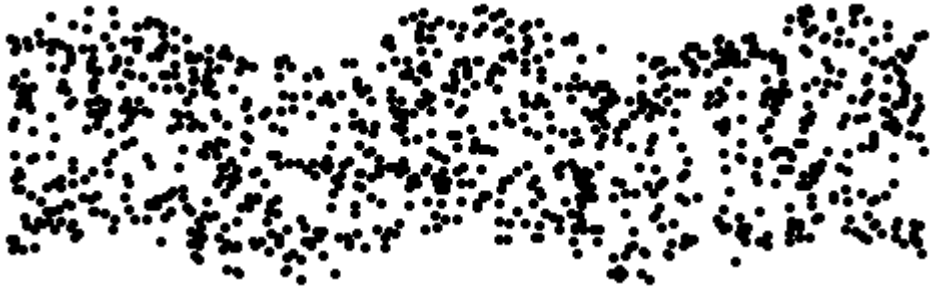
Sound is a mechanical disturbance of the **pressure** in a **medium** that travels in the form of a **longitudinal wave**.

- Longitudinal: particle displacement is **parallel** to the wave's direction of propagation



Compressions & Rarefactions

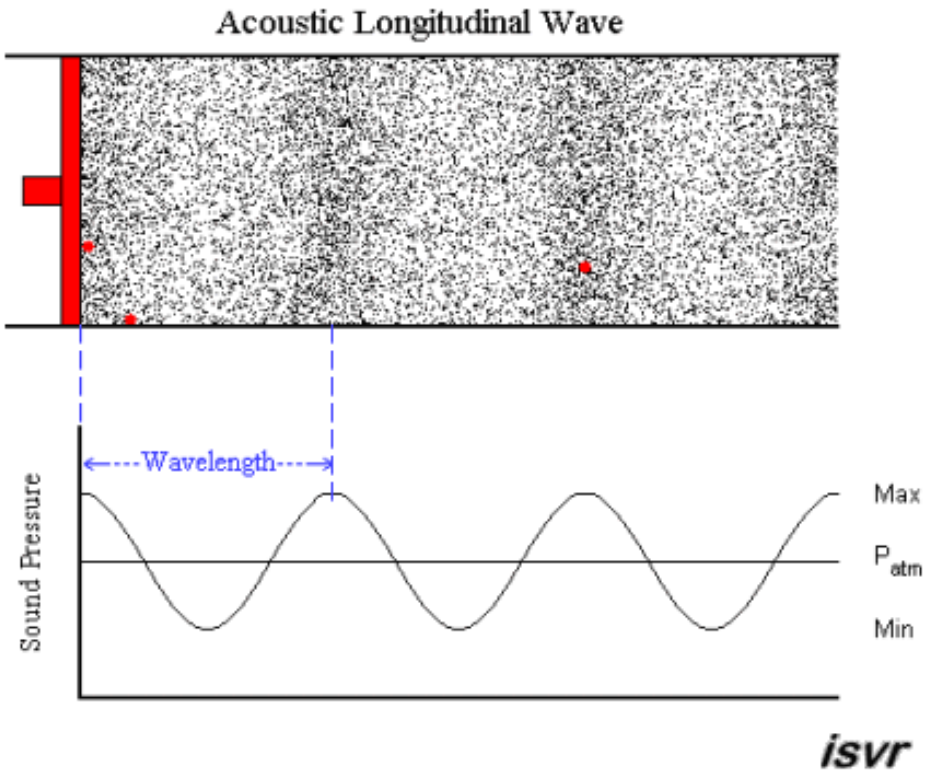
- Transverse: particle displacement is **perpendicular** to the wave's direction of propagation



Peaks & Troughs

Sound is a mechanical disturbance of the **pressure** in a **medium** that travels in the form of a **longitudinal wave**.

- But…. graphs of pressure, particle displacement, or particle velocity look like transverse waves – don't be fooled!



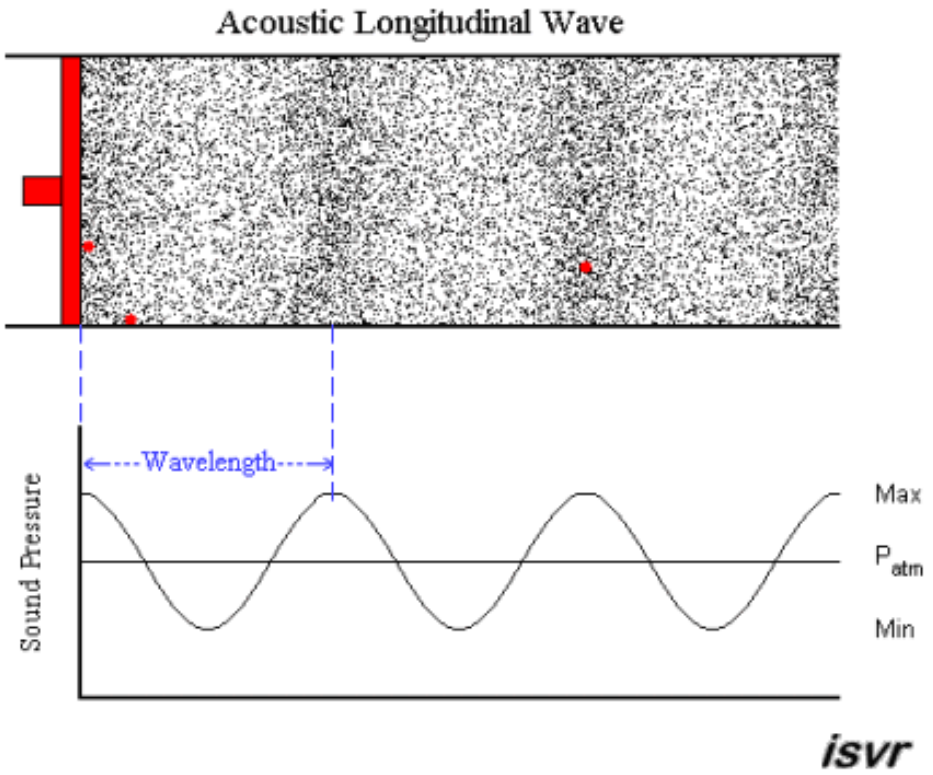
Sound is a mechanical disturbance of the **pressure** in a **medium** that travels in the form of a **longitudinal wave**.

Wave properties:

- Speed (v=343 m/s for air at 20°C and 1 atm)
- Wavelength (λ in meters)
- Frequency (f in hertz)
  - 1 Hz = 1 s^{-1}

$$v = \lambda f$$

[m/s] = [m] [Hz]



isvr