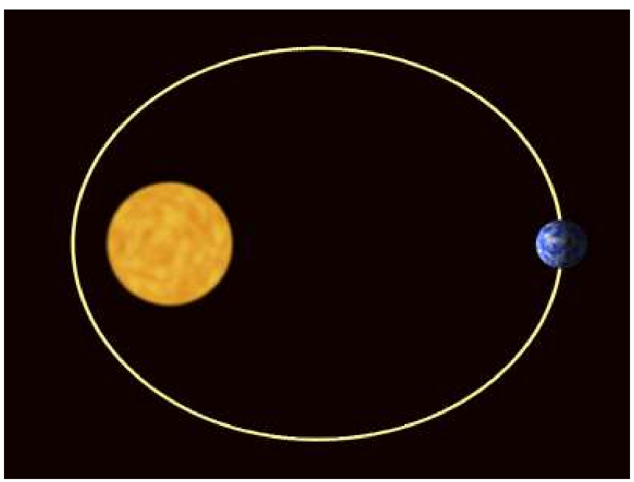
11 Notes

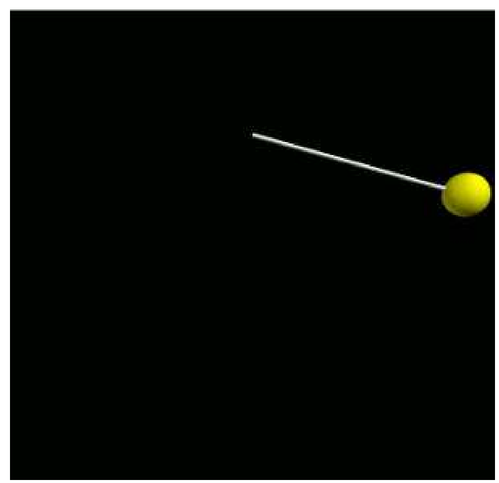
Vibrations and Waves

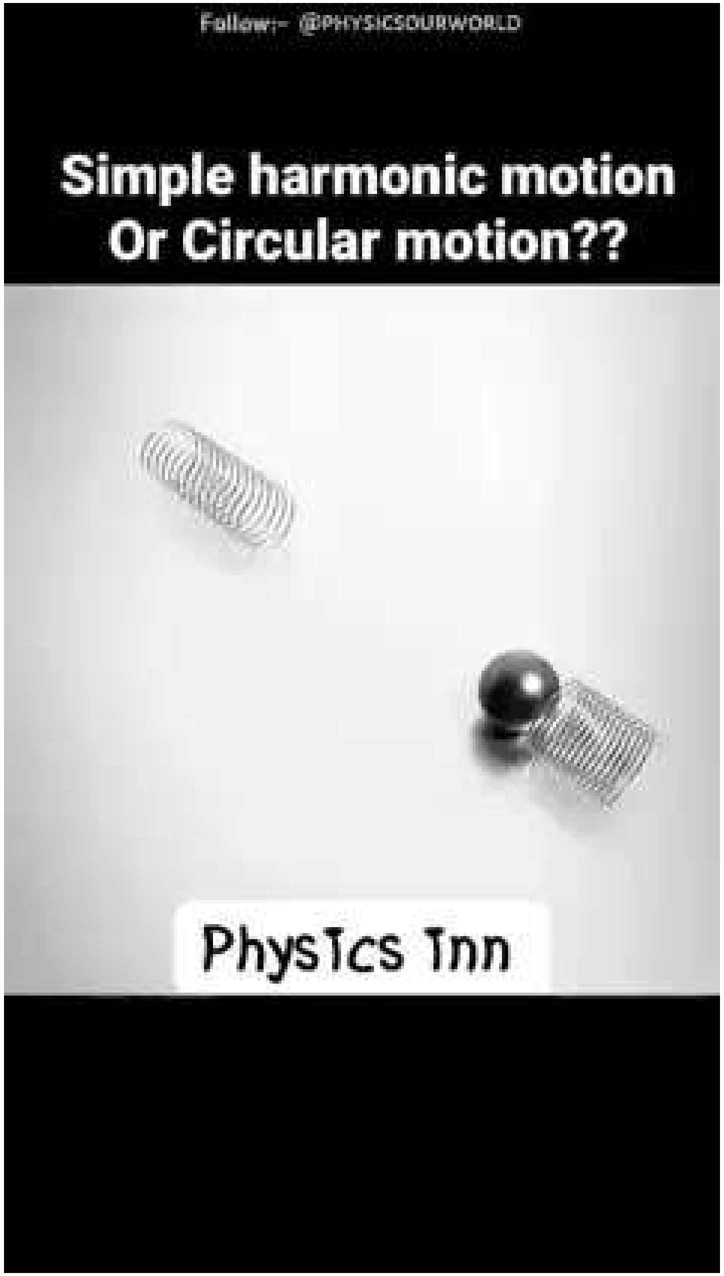
- A repeated motion, such as an acrobat swinging, is called a periodic motion.
- Any periodic motion that is the result of a restoring force is called **simple harmonic motion**.

Oscillations

- *Periodic Motion*: Movement that repeats in cycles with regular intervals.
- Examples:
  - A planet orbiting the Sun
  - Mass swinging on the end of a string (pendulum)
  - Mass oscillating on the end of a spring






Follow:- @PHYSICSOURWORLD
Simple harmonic motion
Or Circular motion??
PhysIcs Inn

Metronome

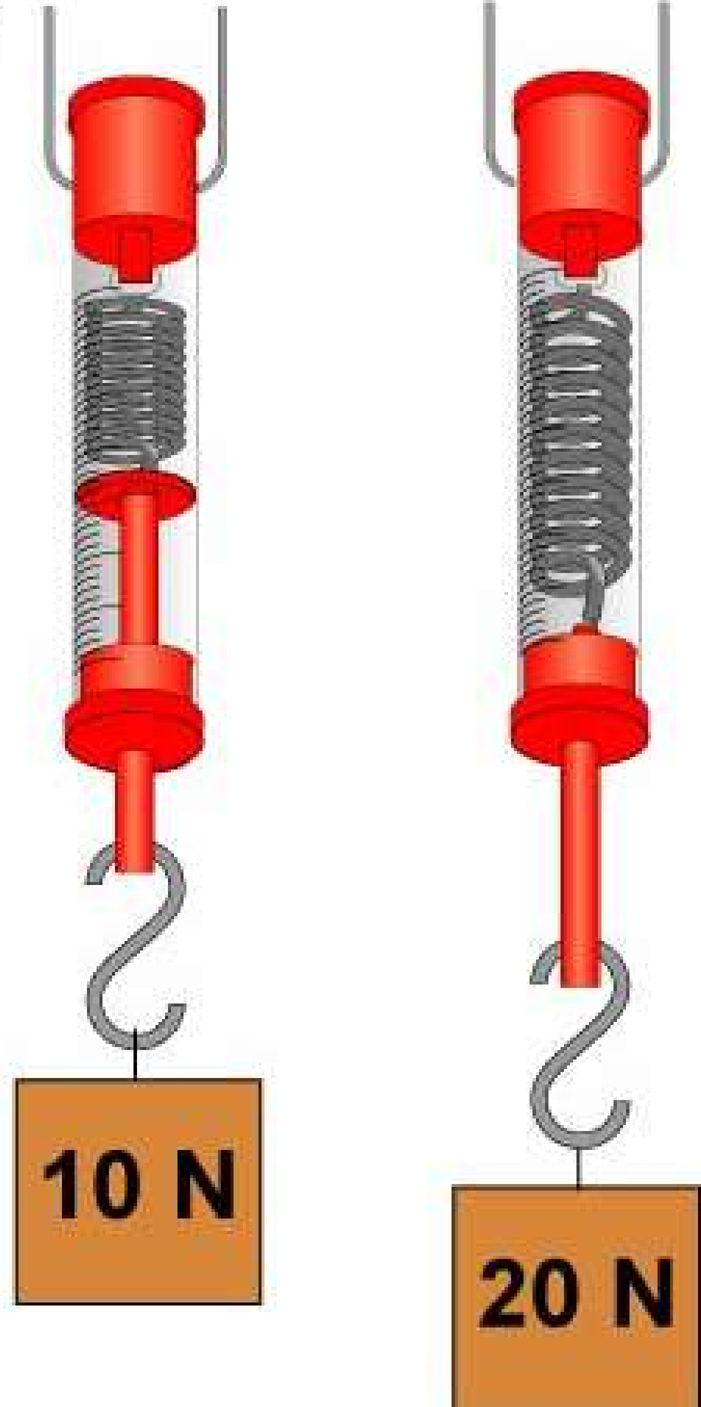
Hooke's Law

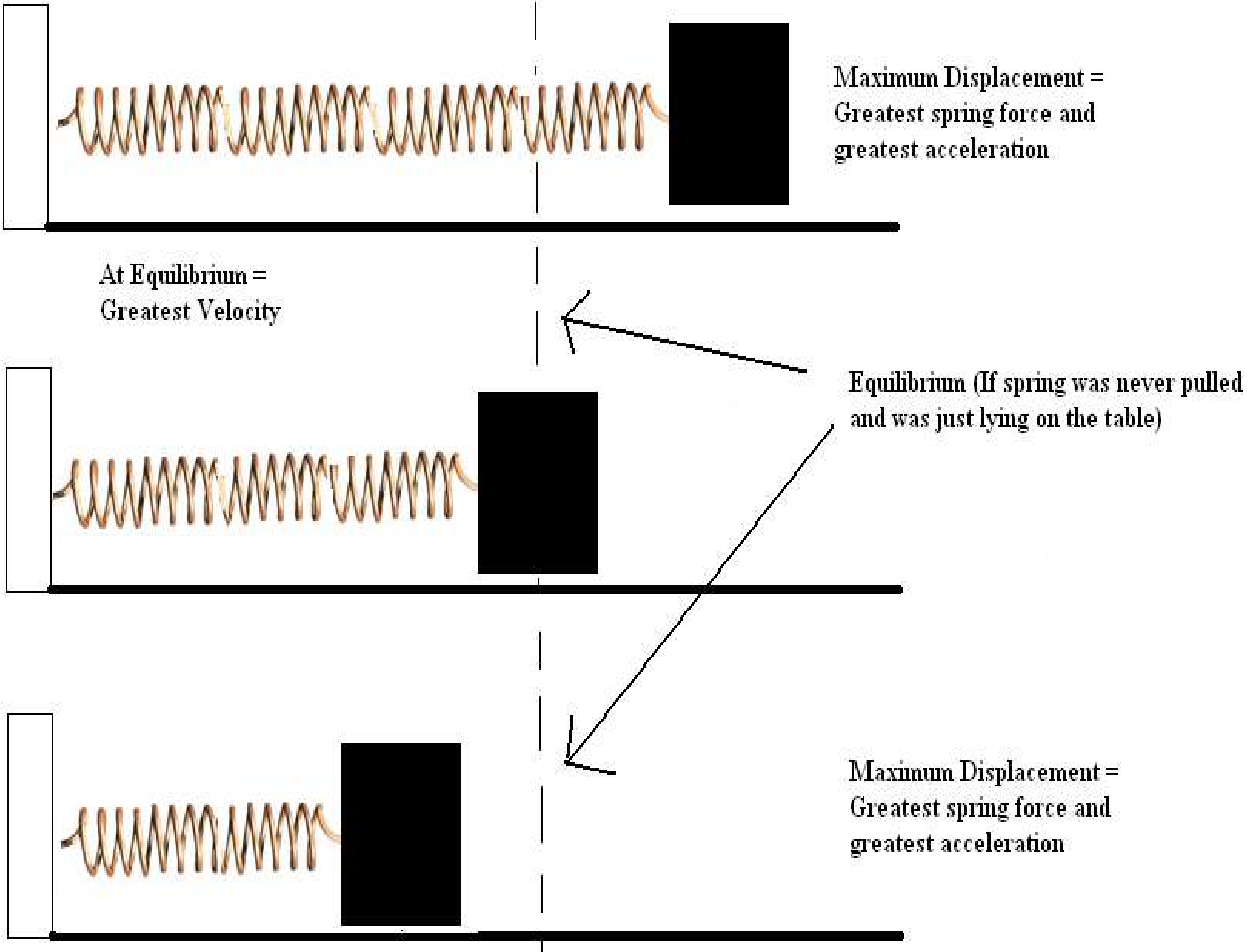
Force
(newtons)

Extension or compression
(meters)

$$F = -kx$$

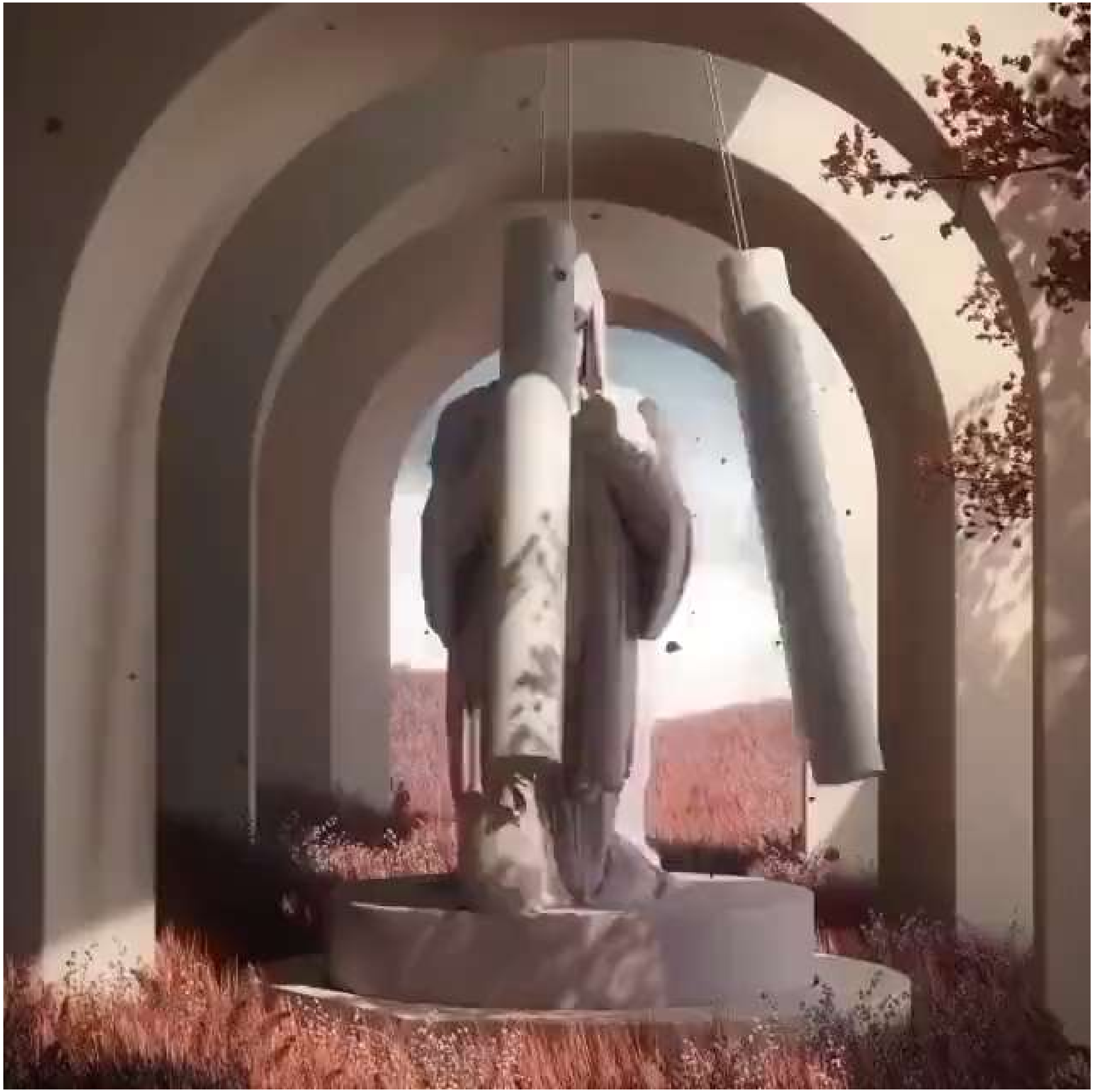
Spring constant
(newtons/meters)



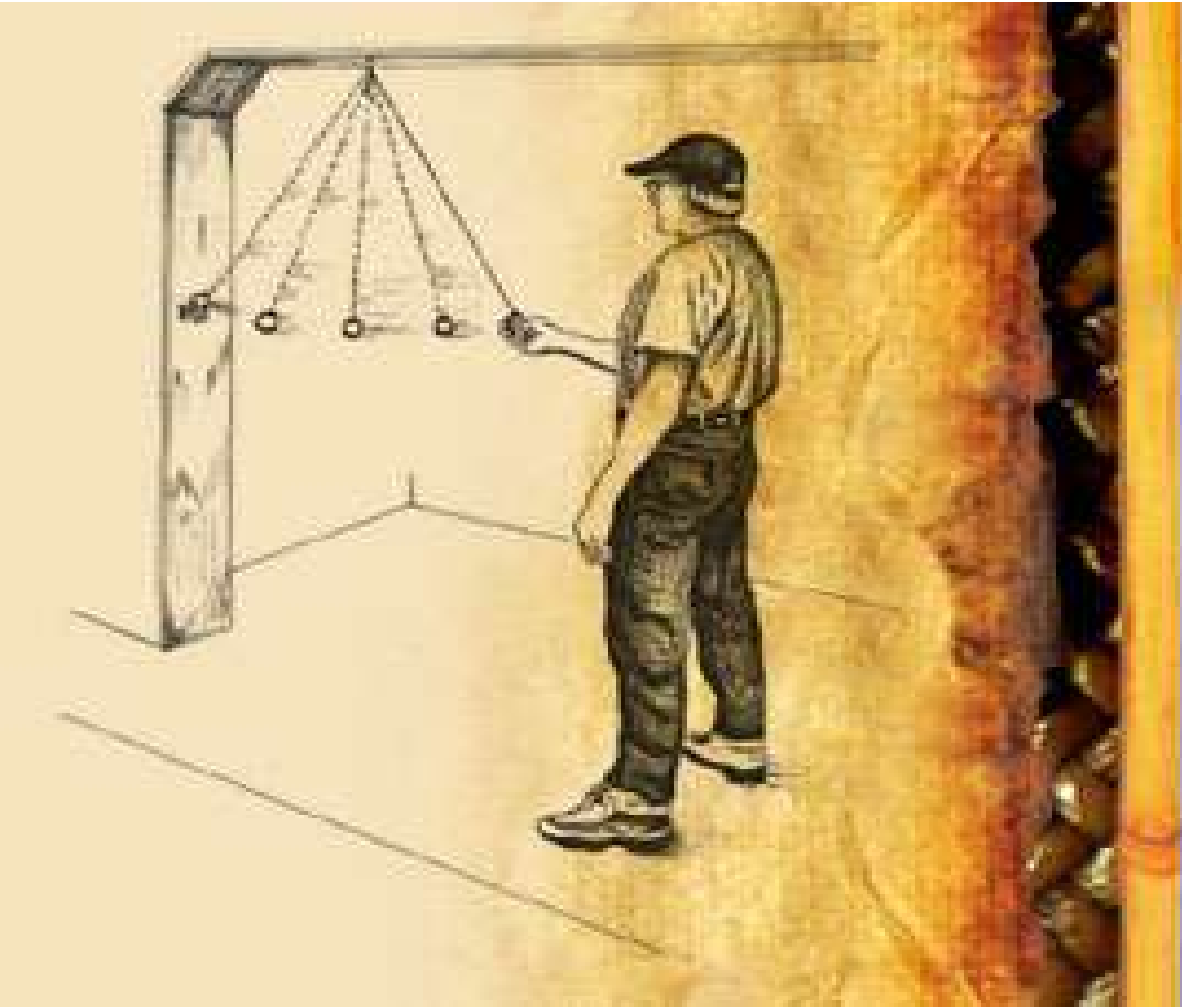

Maximum Displacement =
Greatest spring force and
greatest acceleration
At Equilibrium =
Greatest Velocity
Equilibrium (If spring was never pulled
and was just lying on the table)
Maximum Displacement =
Greatest spring force and
greatest acceleration

Simple Pendulum

- A simple pendulum consists of a mass called a bob, which is attached to a fixed string.
- When working with a simple pendulum, we assume the mass of the bob is concentrated at a point and the mass of the string is negligible.
- Also, we disregard friction and air resistance.



Pendulum Demos



- The **period** is the time it takes for a complete cycle.
- Period units = **seconds**
- Period = 1/Frequency

- The period depends on **string length** and free-fall acceleration (**gravity**).
- Period = $2\pi \sqrt{L/g}$

- Mass and amplitude don’t affect the period of a pendulum.
- This is similar to objects in free fall, which all have the same acceleration (gravity).

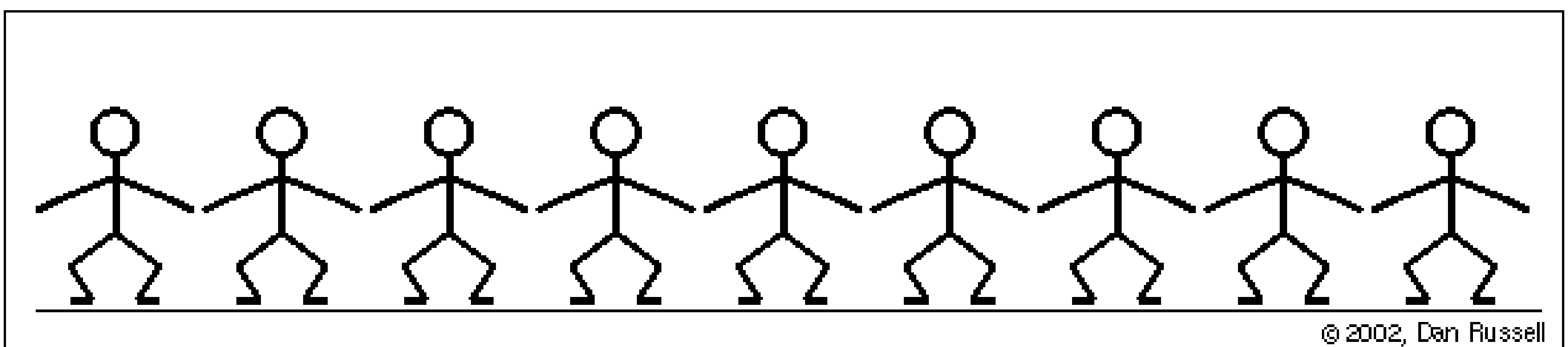
- Period of a mass spring system depends on **mass** and **spring constant**.
- Period = $2\pi \sqrt{m/k}$

Wave Types

- A wave that consists of a single traveling pulse is called a **pulse wave**.
- If you have more than one wave, it is called a **periodic wave**.

Waves

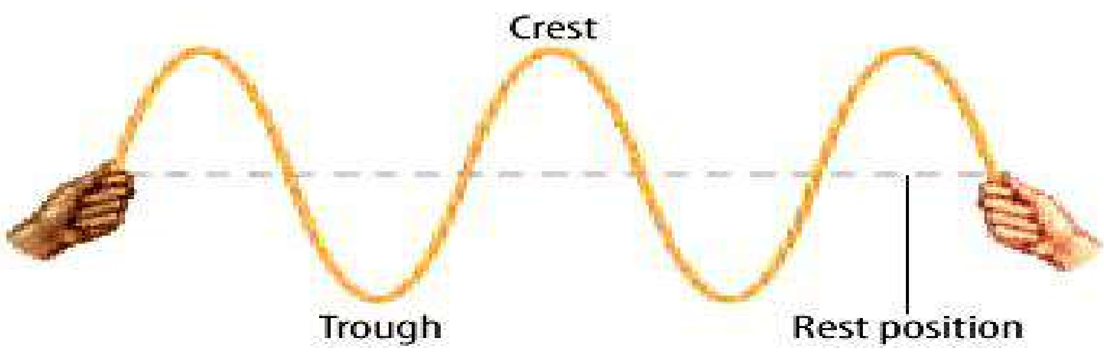
- A <u>wave</u> is a rhythmic disturbance in which energy is conveyed through a medium
- In the case of electromagnetic waves (i.e. light), the medium is space itself.
- Though the energy of pulse or wave propagates through space, matter itself does NOT travel with the wave.



Wave properties:

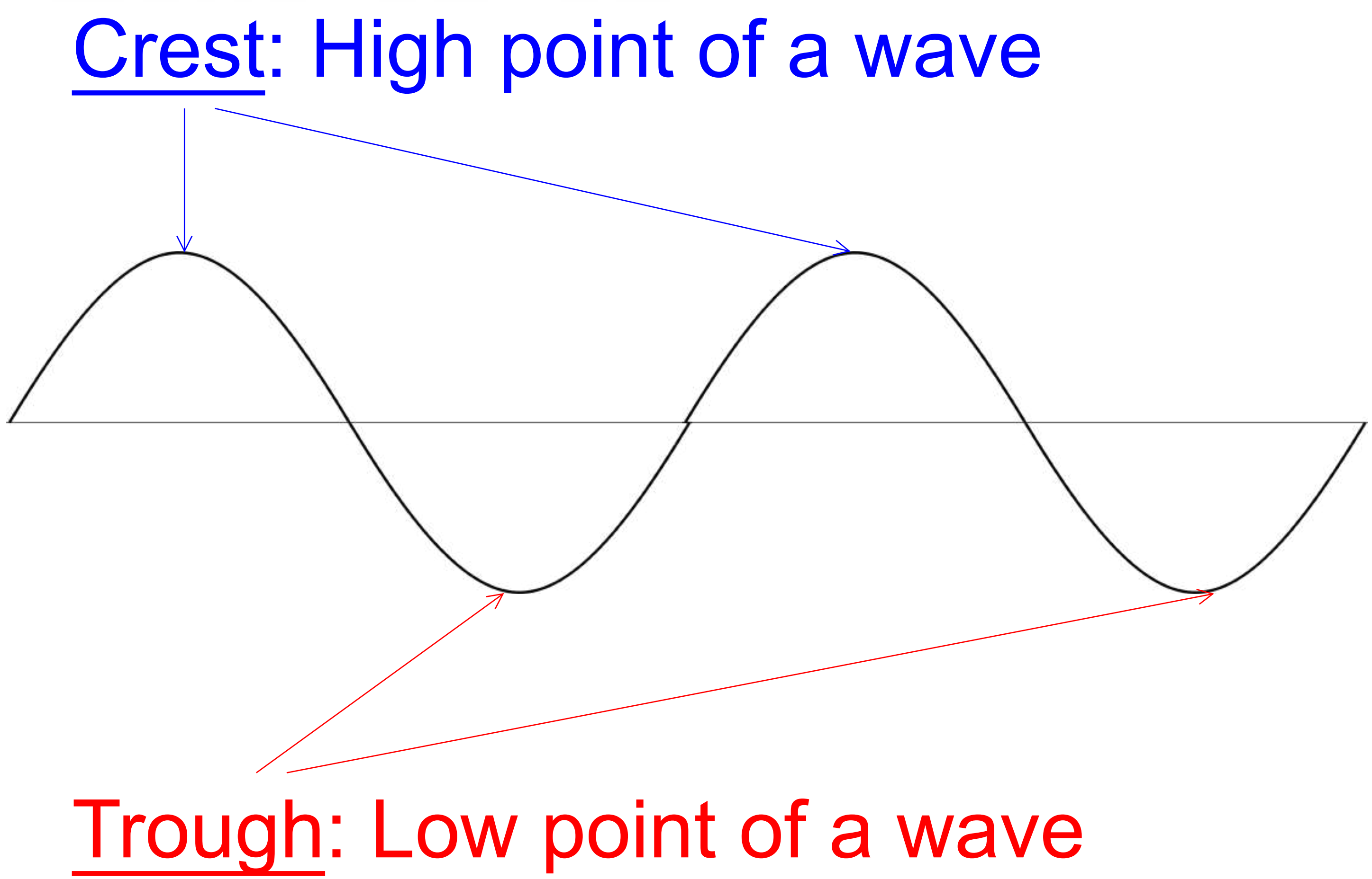
a. <u>Wavelength</u> – (meters)

Lambda λ

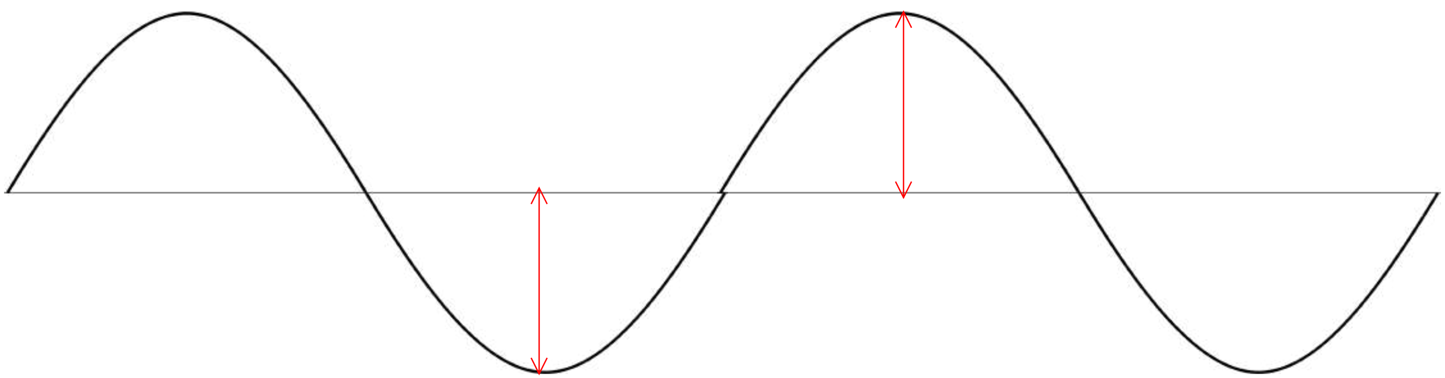


b. <u>Frequency</u> - # of waves that pass per second (Hertz Hz).

Representing Waves with Sine Curves

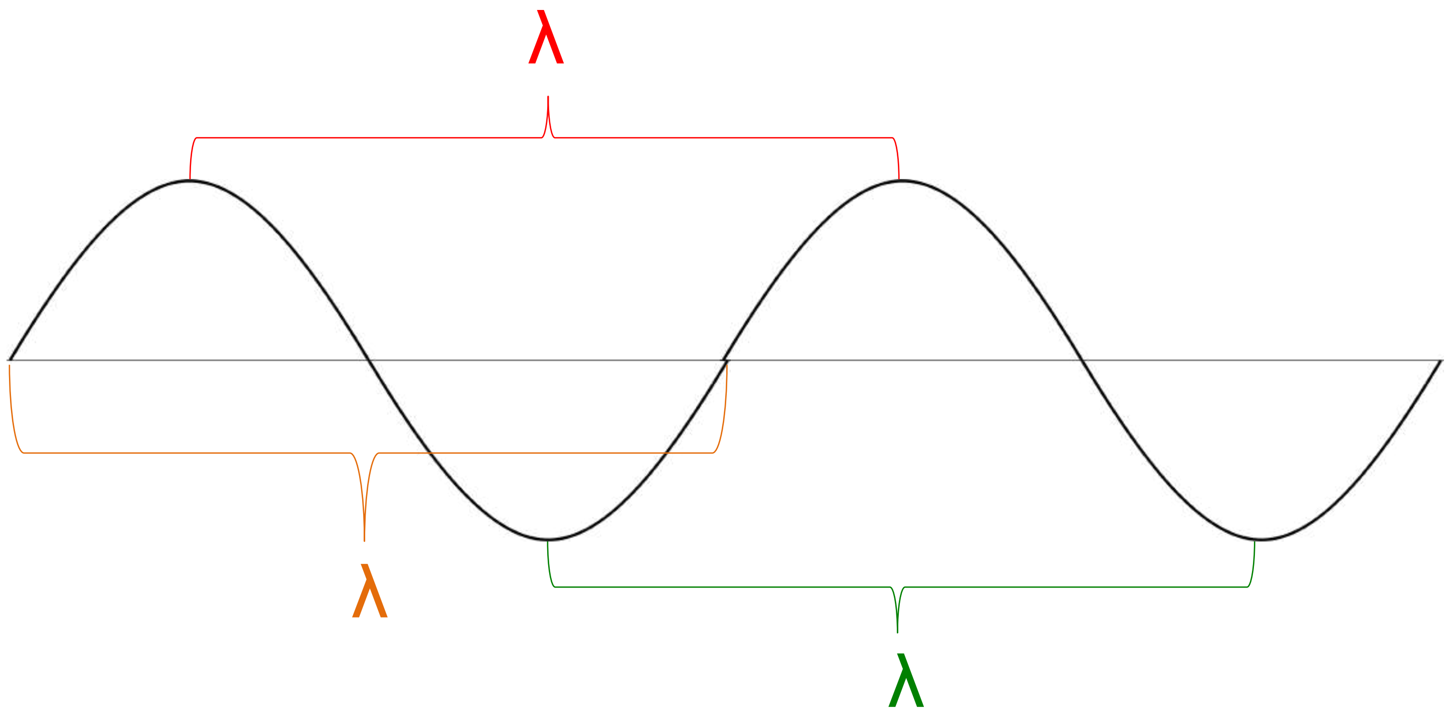


Representing Waves with Sine Curves



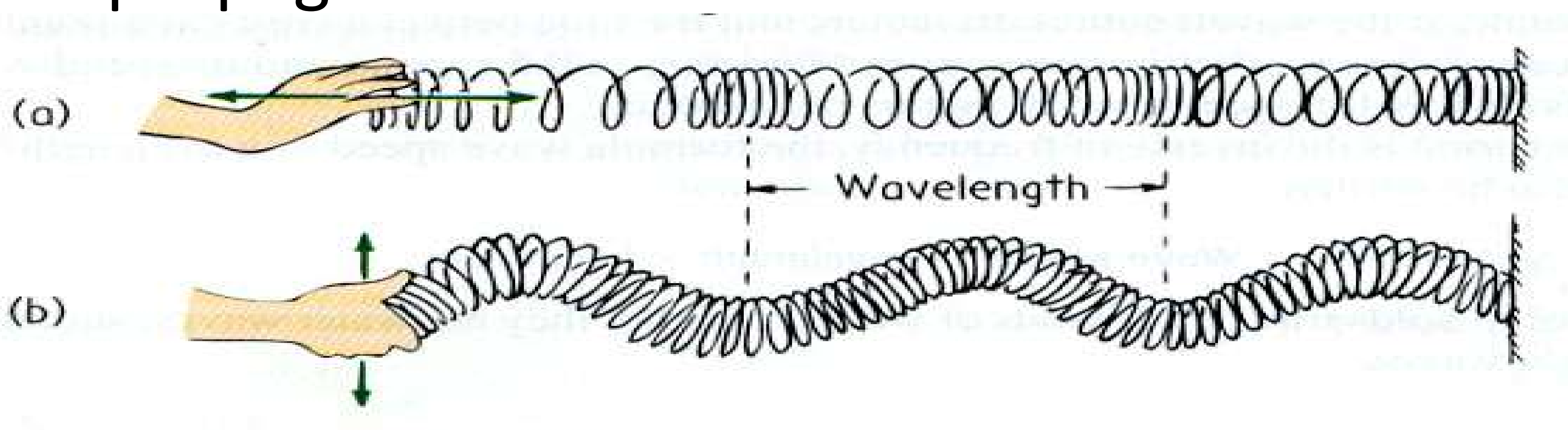
Amplitude: Distance from wave's midpoint to either crest or trough

Representing Waves with Sine Curves

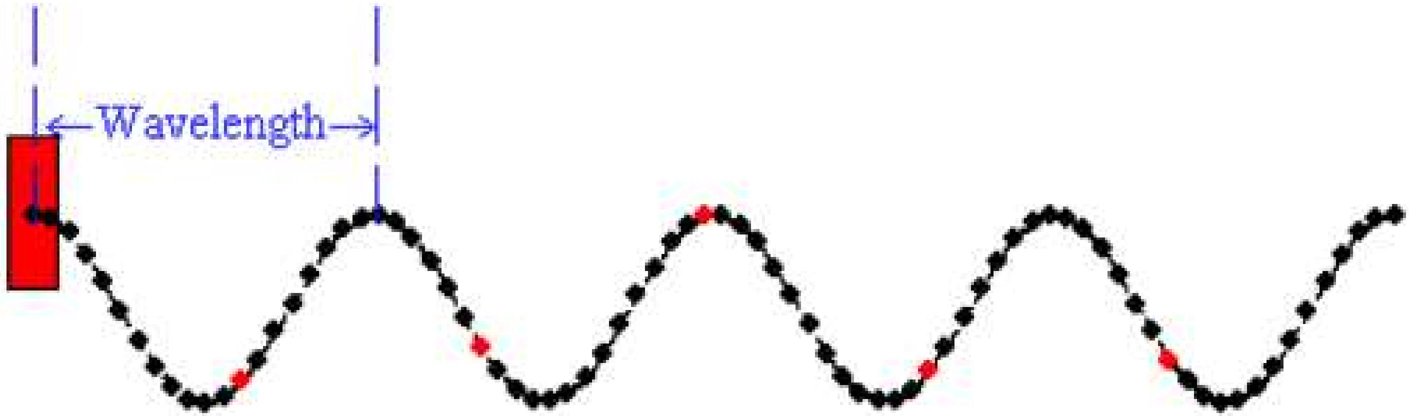


Wavelength: Length of one complete cycle

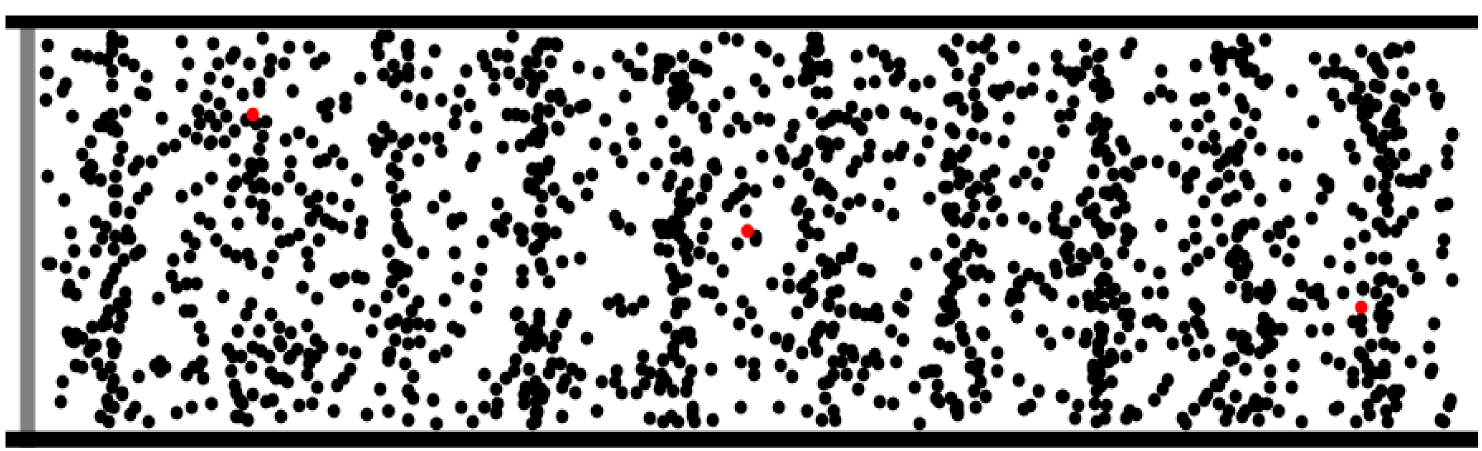
- Longitudinal Wave: Wave in which particles in the medium vibrate in a direction *parallel* to the direction of wave propagation
- Transverse Wave: Wave in which particles in the medium vibrate in a direction *perpendicular* to the direction of wave propagation.



Transverse Wave



isvr

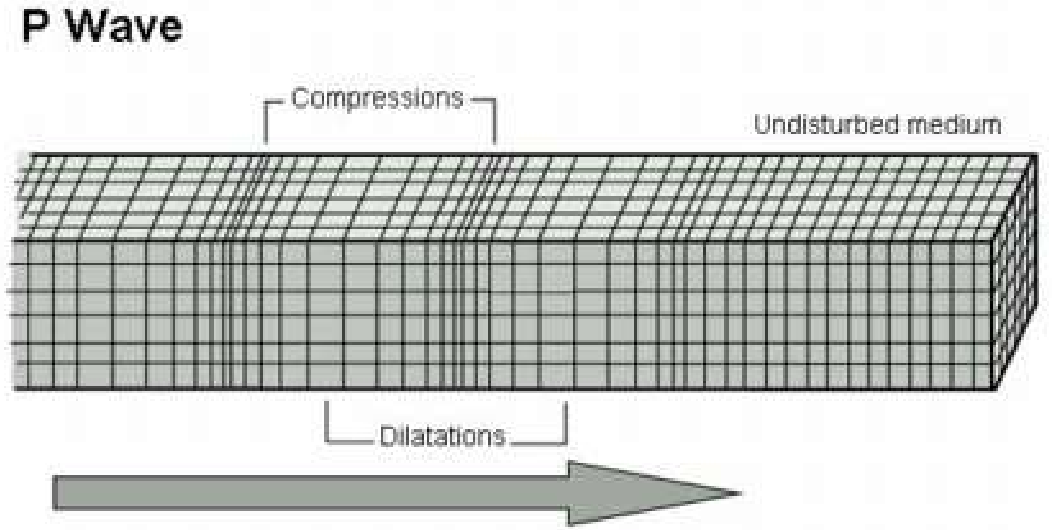


Earth Science Connection:

Whether earthquake waves are longitudinal or transverse provides a window into Earth's interior.

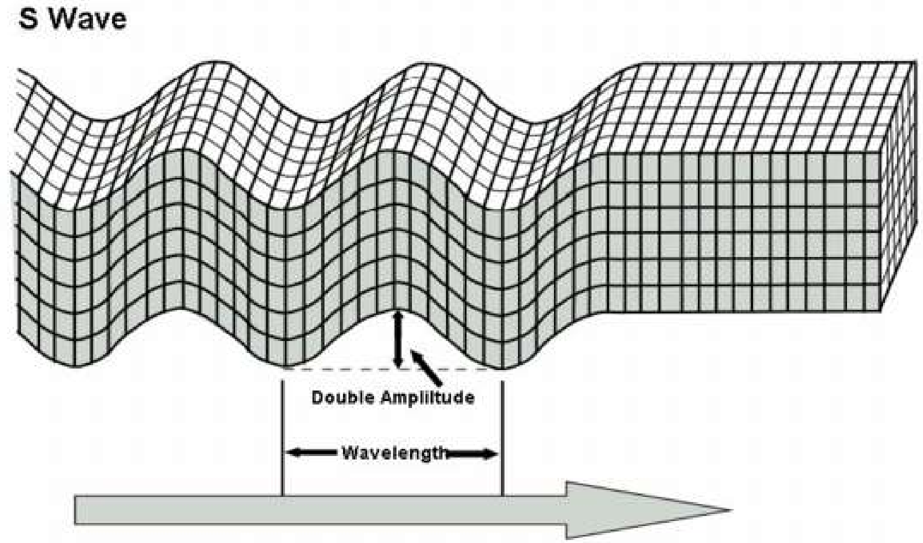
- P-waves, which are pressure waves, can travel through liquid, but s-waves cannot.
- Thus, when an earthquake occurs somewhere on Earth, if geologists around the world monitor the event and share their data, they can deduce the size of Earth's liquid center!

P-Waves

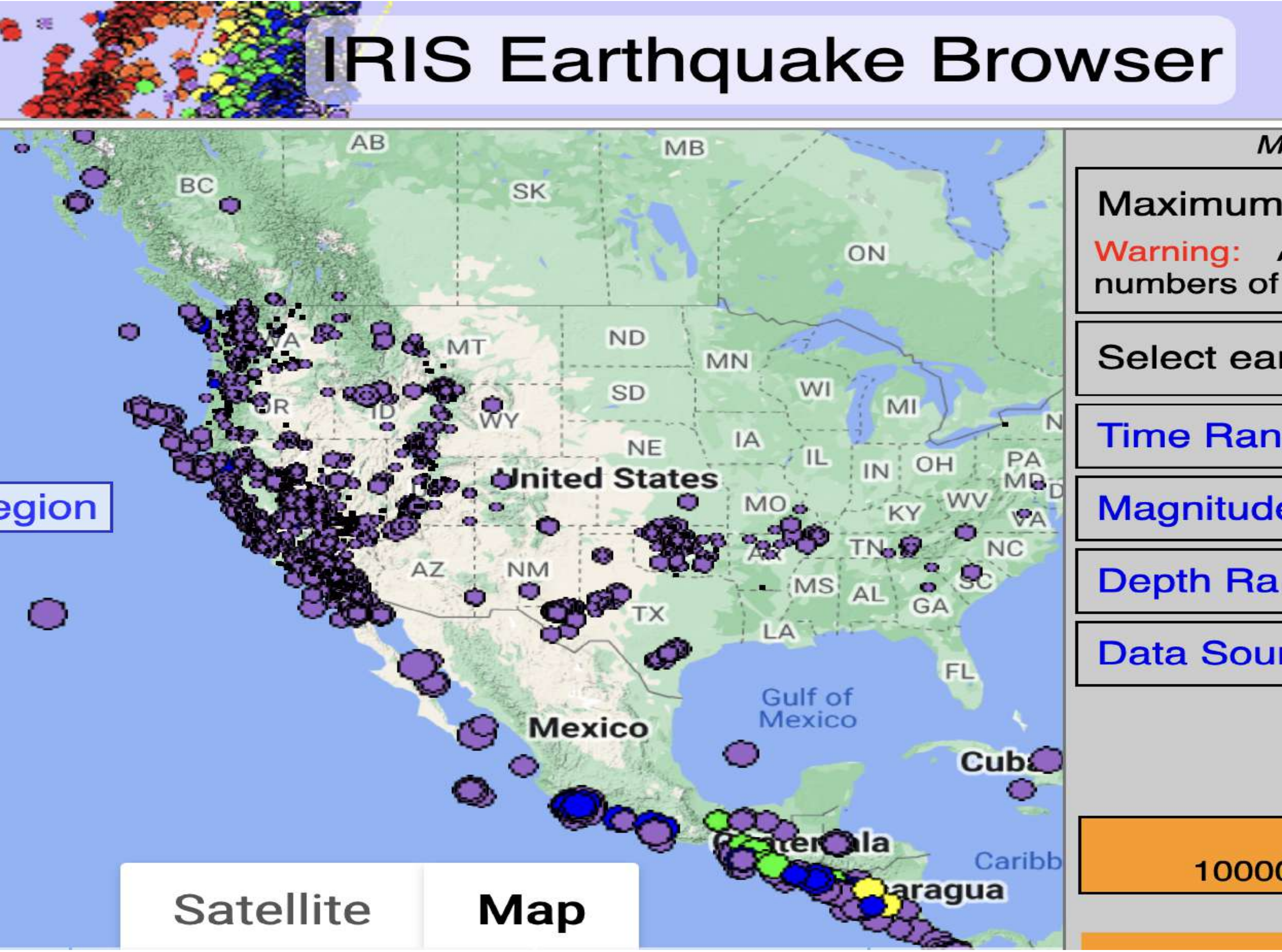


- P stands for “primary” or “pressure”.
- These are *longitudinal waves*. This means that disturbed particles vibrate in the same direction as the motion of the wave.
- In other words, the crests travel as compressions.
- Sound waves are another example of longitudinal waves.

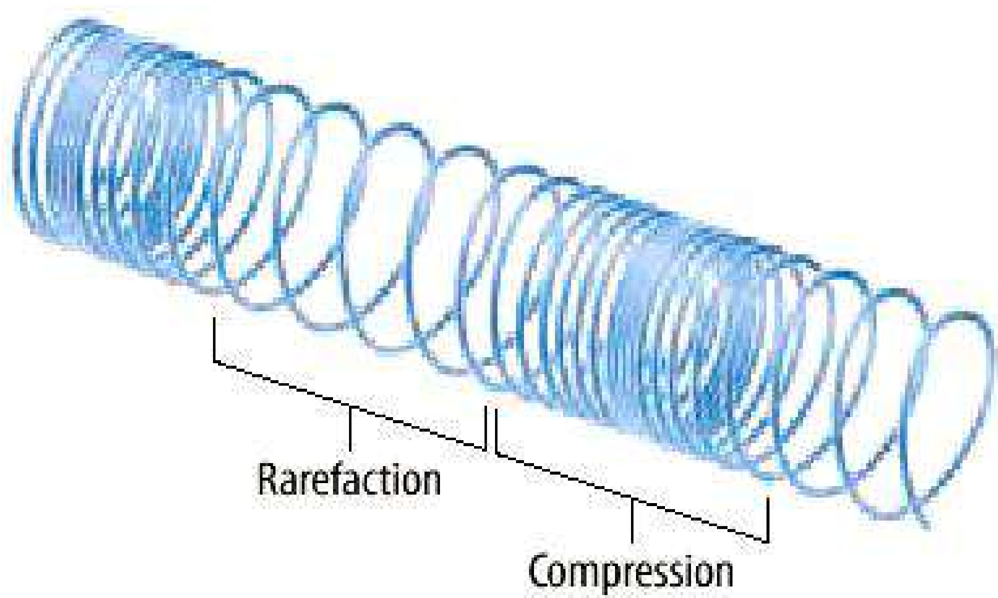
S-Waves



- S stands for “secondary” or “seismic”.
- S-waves are *transverse waves*, which means that disturbed particles vibrate in a direction perpendicular to the direction of wave travel, like ripples in a pond, or people “doing the wave” in a stadium.


IRIS Earthquake Browser
Maximum
Warning:
numbers of
Select ea
Time Ran
Magnitude
Depth Ra
Data Sour
1000
egion
Satellite
Map
AB
MB
BC
SK
ON
ND
MN
MT
WI
SD
MI
OR
ID
WY
IA
NE
IL
IN
OH
PA
United States
MO
KY
WV
VA
TN
NC
AZ
NM
MS
AL
GA
SC
TX
LA
FL
Gulf of Mexico
Mexico
Cuba
Caribb

Compressional - Sound
v = 343 m/s
Must have a medium!! (air)



[redacted]

- A sound is a vibration.
- The vibrating causes the air molecules near the movement to be forced closer. This is called compression.
- As the vibration moves on, the density and air pressure becomes lower than normal and this is called rarefaction.

Synesthesia

- Synesthesia is when you hear music, but you see shapes.
- Kandinsky’s Abstract Art

Music Box & Speaker

Chicken in a cup or box
Spinning Sound
(Australian, Bees, African)

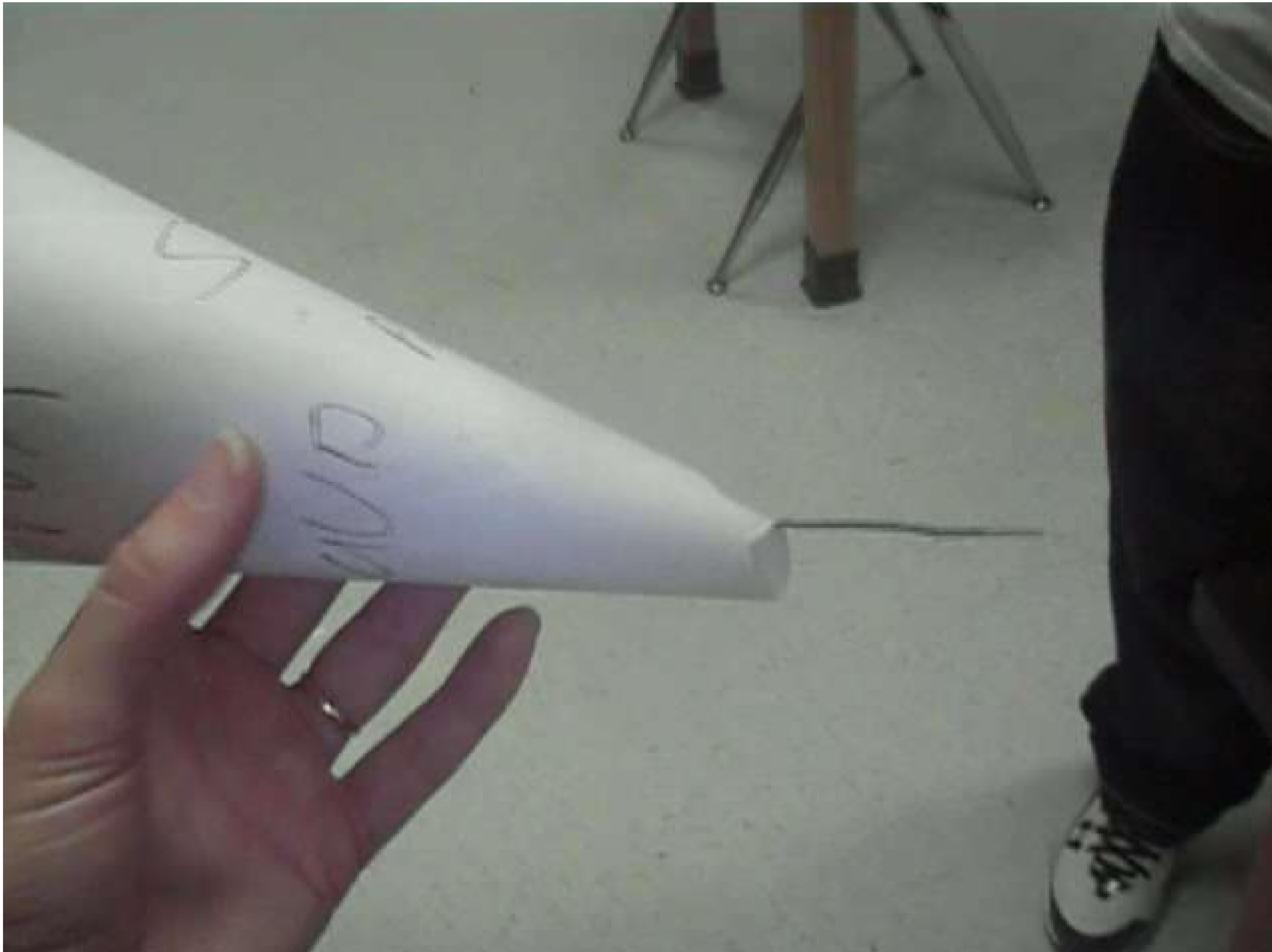
Demos –
Musical Instruments
(Accordion, Tongue Drum, Chimes)
Whistles (Death, Duck, Dog)
Slinkies with Cups


When a sound

Mario Bros.

Musical Road Video

Tuning Fork and Salt



- Sound waves that the average ear can hear, called audible sound waves, have frequencies between 20 and 20,000 Hz.
- Sound waves with frequencies less than 20 Hz are called **infrasonic waves**.
- Those above 20,000 Hz are called **ultrasonic waves**.

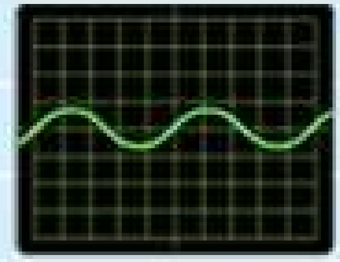
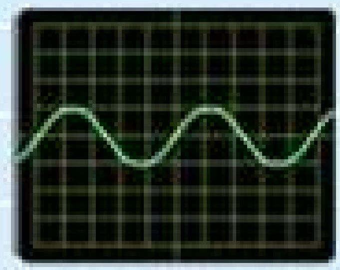
- http://onlinetonegenerator.com/

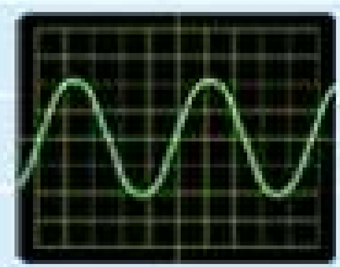
- Intensity – the rate at which energy flows through a unit of area perpendicular to the direction of wave motion.
- Intensity = Power / Area
- Area of a spherical wave = $4\pi r^2$

- Intensity and frequency determine which sounds are audible.
- Humans hear 20 to 20,000 Hz.
- The softest sound a human can hear is called the threshold of hearing.
- The loudest sound a human can tolerate is known as the threshold of pain.

- Relative intensity is measured in decibels.
- The intensity of a wave determines the loudness.
- Relative intensity is the human perception of loudness.
- A difference in 10 db means the sound is twice as loud.

Some Common Decibel Levels

Sound	Decibel level
The softest sounds you can hear	0
Whisper	20
Purring cat	25
Normal conversation	60
Lawn mower, vaccum cleaner, truck traffic	80
Chain saw, snowmobile	100
Sandblaster, loud rock concert, automobile horn	115
Threshold of pain	120
Jet engine 30 m away	140
Rocket engine 50 m away	200

Chapter 12 Notes

Sound and Resonance

- Frequency determines the pitch.
- As the frequency increases, so does the pitch.
- Pitch is how high or low it sounds.
- Amplitude = Energy
- Uses for Ultrasonic waves:
- Ultrasound – See inside humans
- Dolphins – echolocation
- Ship Radar – Find other subs

Demos

- Electric Guitar
- Theremin
- Horn with pvc pipe
- Wooden Flute
- Electronic Music toy
- PVC tube (different length)
- Boomwackers

Christmas Boomwhackers

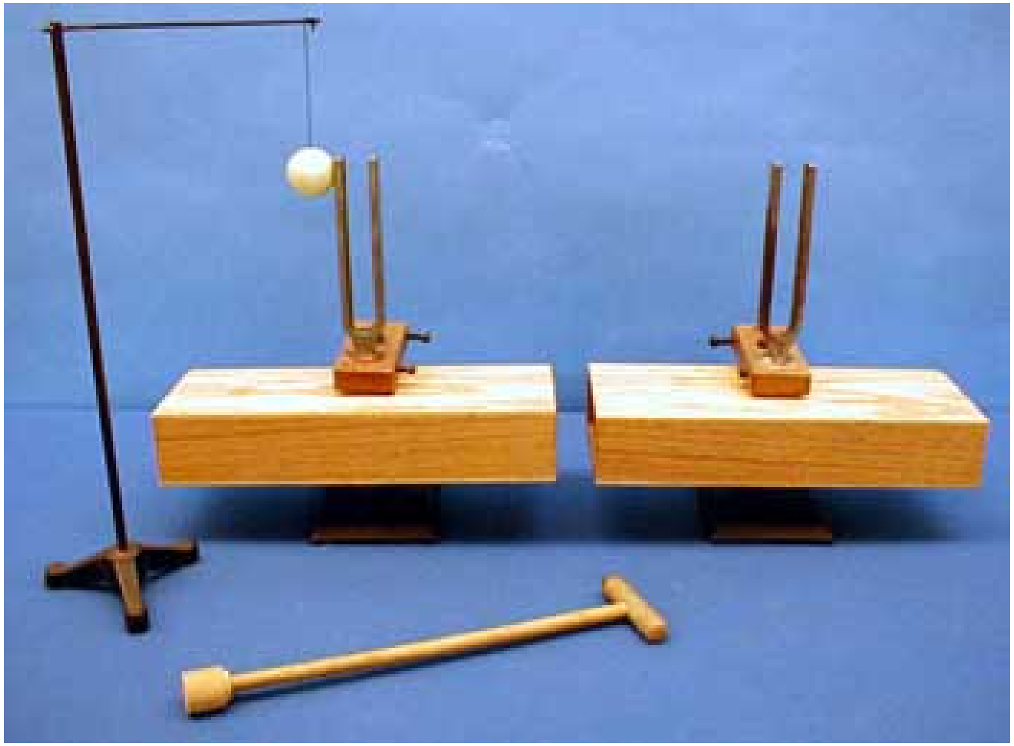
$$v = \lambda \times f$$

Velocity = wavelength x frequency

A wave is traveling at a speed of 18 m/s and its wavelength is 3 m. Calculate the wave frequency.

- Speed of waves depends on the medium and temperature.
- Solid particles respond more quickly to a disturbance than a gas particle because the molecules are closer together in a solid.
- Sound waves travel fastest in solids and slowest in gases.
- As temperature increases, particles collide more frequently which makes sound travel faster.

Resonance - **When an object vibrates at it's *natural frequency*.**



Demos

- Tibetan Bowl
- Resonance Bowl
- Tuning Forks
- Spinning Tube
- Singing tube (Bunsen burner)
- Singing Rod
- Resonance Sticks

- All objects have natural frequencies.
- Every object will vibrate at a certain frequency.
- Resonance – a condition that exists when the frequency of a force applied to a system matches the natural frequency of vibration of the system.

Tacoma Narrows

Bridge in Russia

July 19th, 2011

07:51 AM ET

Scientist: Tae Bo workout sent skyscraper shaking

Seventeen people performing a vigorous Tae Bo workout caused tremors that forced **the evacuation of a South Korean skyscraper** earlier this month, the building's owners say.

Prime Group, owner of the 39-story TechnoMart commercial-residential high-rise in Seoul, said 17 middle-aged people were working out to the pop song **"The Power" by Snap** on July 5 when their movements set the upper floors of the tower shaking for 10 minutes, according to a **report from the Korea JoongAng Daily**.

Scientists recreated the event in the 12th floor gym, according to a **report in the Korea Times**.

"We observed the vibrometer while performing the same kind of aerobic exercise that was performed at the time of the shaking which occurred on July 5. We noticed that the shaking was felt in the upper floors while the exercise was being performed while no other place showed signs of tremor," Chung Lan, a professor of architectural engineering at Dankook University, told the Korea Times.

"It just happens to be that the vibration cycle caused by Tae Bo collided with the vertical vibration cycle unique to the building," Chung told the Korea Times. The action amplified the building's vibration and caused the shaking, he said.

Wineglass and Straw demo

Salt on Speaker

Playing a wineglass demo

[redacted]

[redacted]

- Example 1 – Tacoma Narrows bridge. The wind blowing through the canyon matched the natural frequency of the bridge and caused the bridge to oscillate and eventually crumble.
- Example 2 - A kid on a swing, pumps their legs at the same frequency each time to cause them to swing higher each time. They are matching the natural frequency of the swing.
- Example 3 - A wine glass has a natural frequency. A singer can sing at the same frequency and cause the glass to vibrate until it shatters.

- When a string on a guitar is plucked, the intensity of the sound increases dramatically. This is called forced resonance.
- The vibrating of the strings of a guitar force the bridge of the guitar to vibrate.
- The forced vibrations are called sympathetic vibrations.

Chapter 12-3

Harmonics

- The **fundamental frequency** is the lowest possible frequency of a standing wave.
- The series of frequencies of a standing wave are called the **harmonic series**.

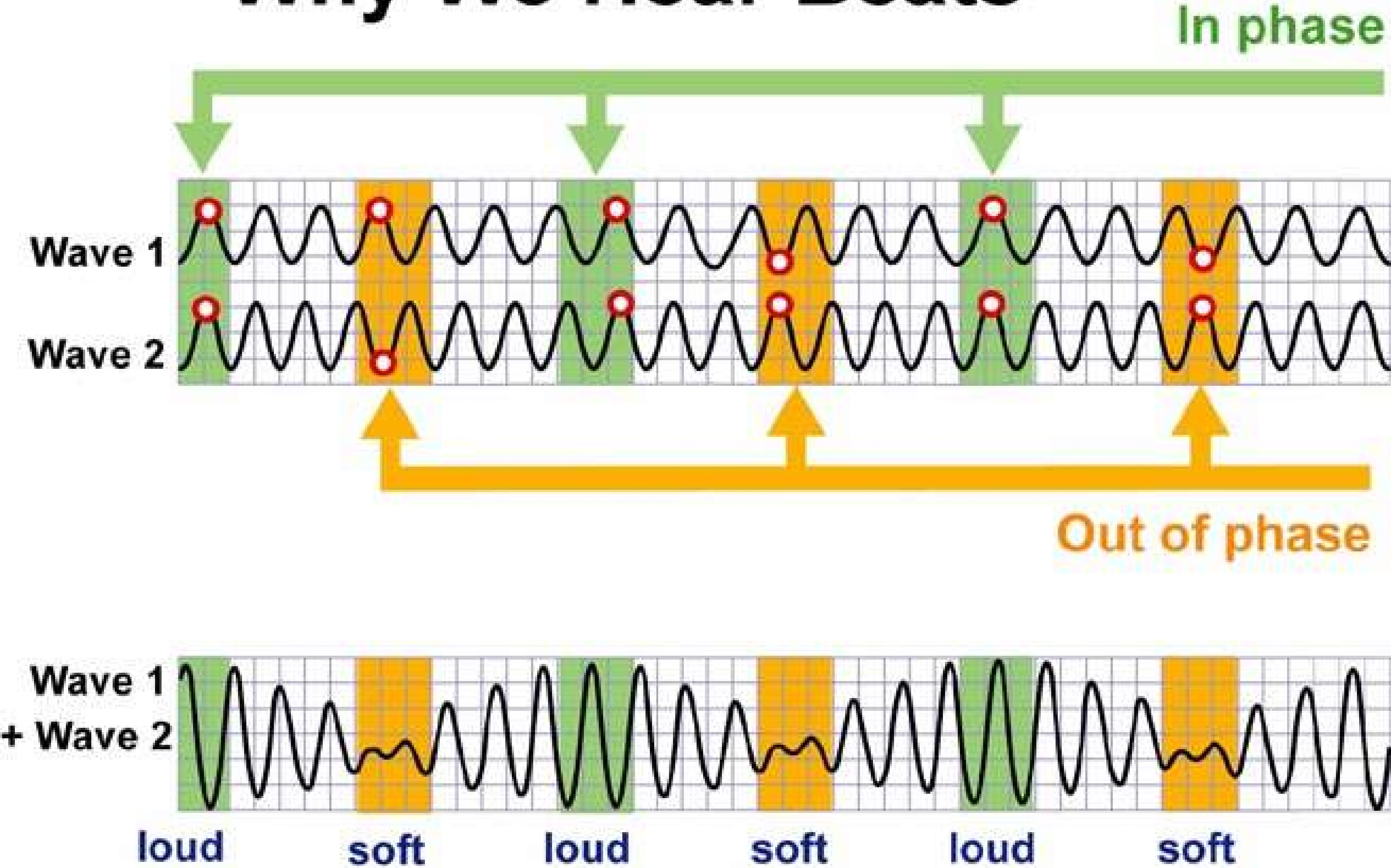
- Frequency = harmonic number x (speed / 2 Length)
- $f = n\,(v/2L)$

- Both ends open:
- Frequency = harmonic number x (speed/2L)
- $f = n(v/2L)$
- One end is closed:
- Frequency = harmonic number x (speed/4L)
- $f = n(v/4L)$

- In music, the mixture of harmonics that produces the characteristic sound of an instrument is referred to as the spectrum of sound, which results in a response in the listener called sound quality or **timbre**.

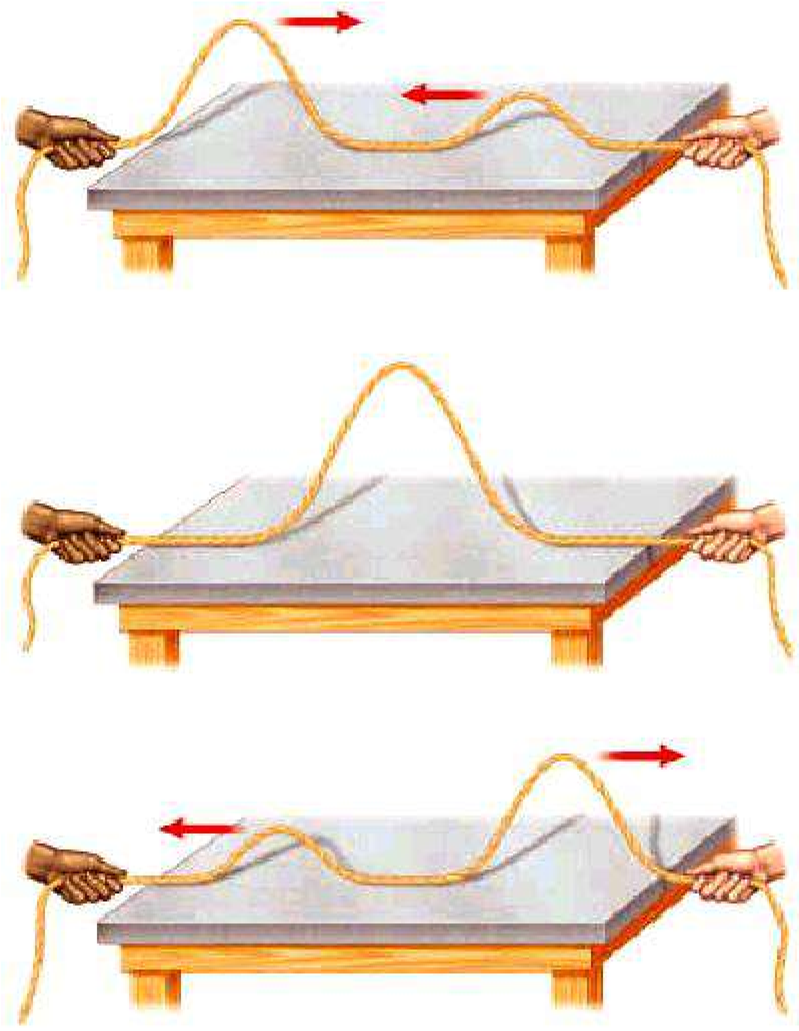
- When two waves of the same frequency interact, you get either constructive or destructive interference.
- If waves are opposite to each other they are said to be out of phase and destructive interference occurs. No sound is heard.
- If waves match up it is in phase and constructive interference occurs. The sound gets louder
- However, if waves with slightly different frequencies interact, a variation creates a soft to loud sound called beat.
- https://academo.org/demos/wave-interference-beat-frequency/

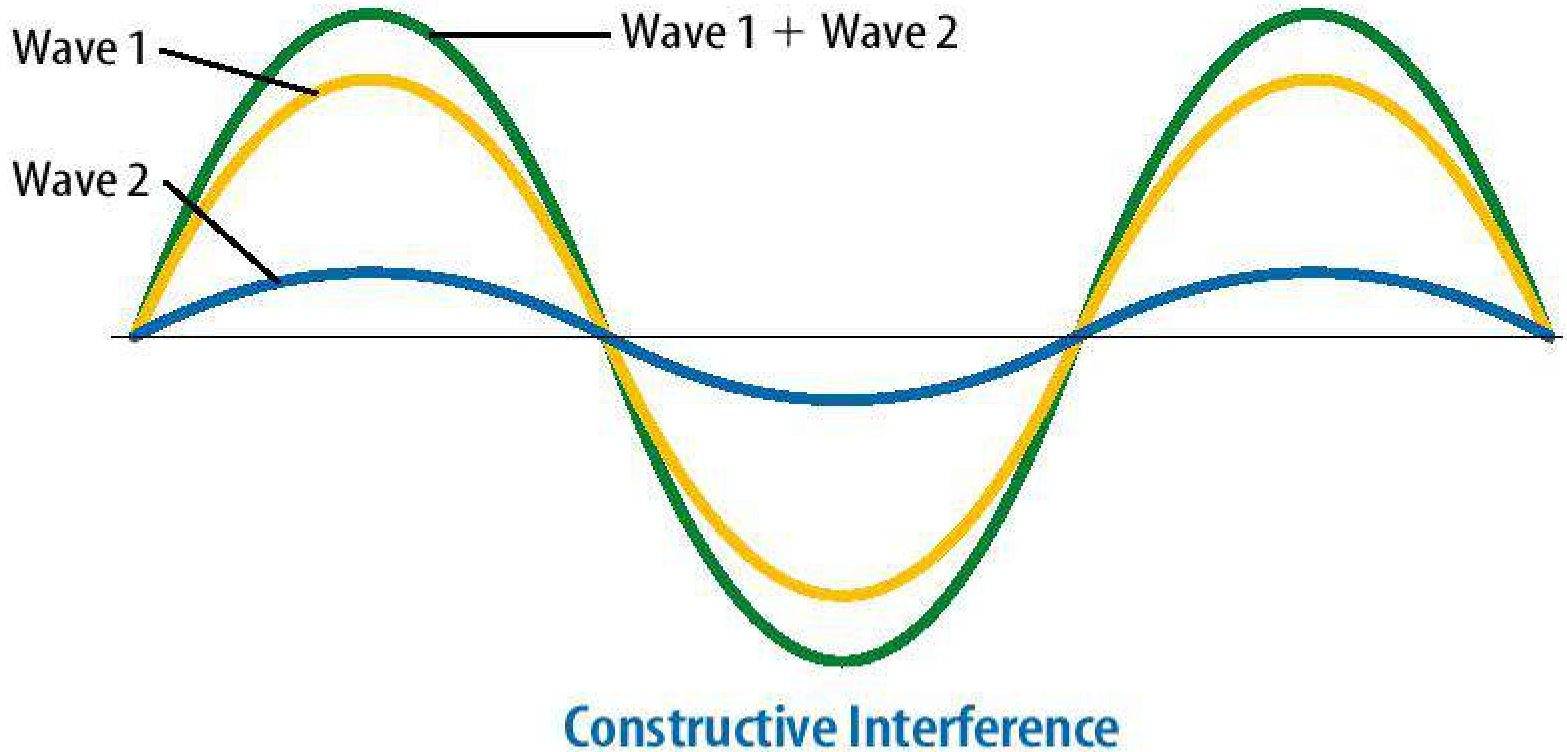
Why We Hear Beats



Interference

- two waves combine to form a new wave.





1) Constructive (in phase)

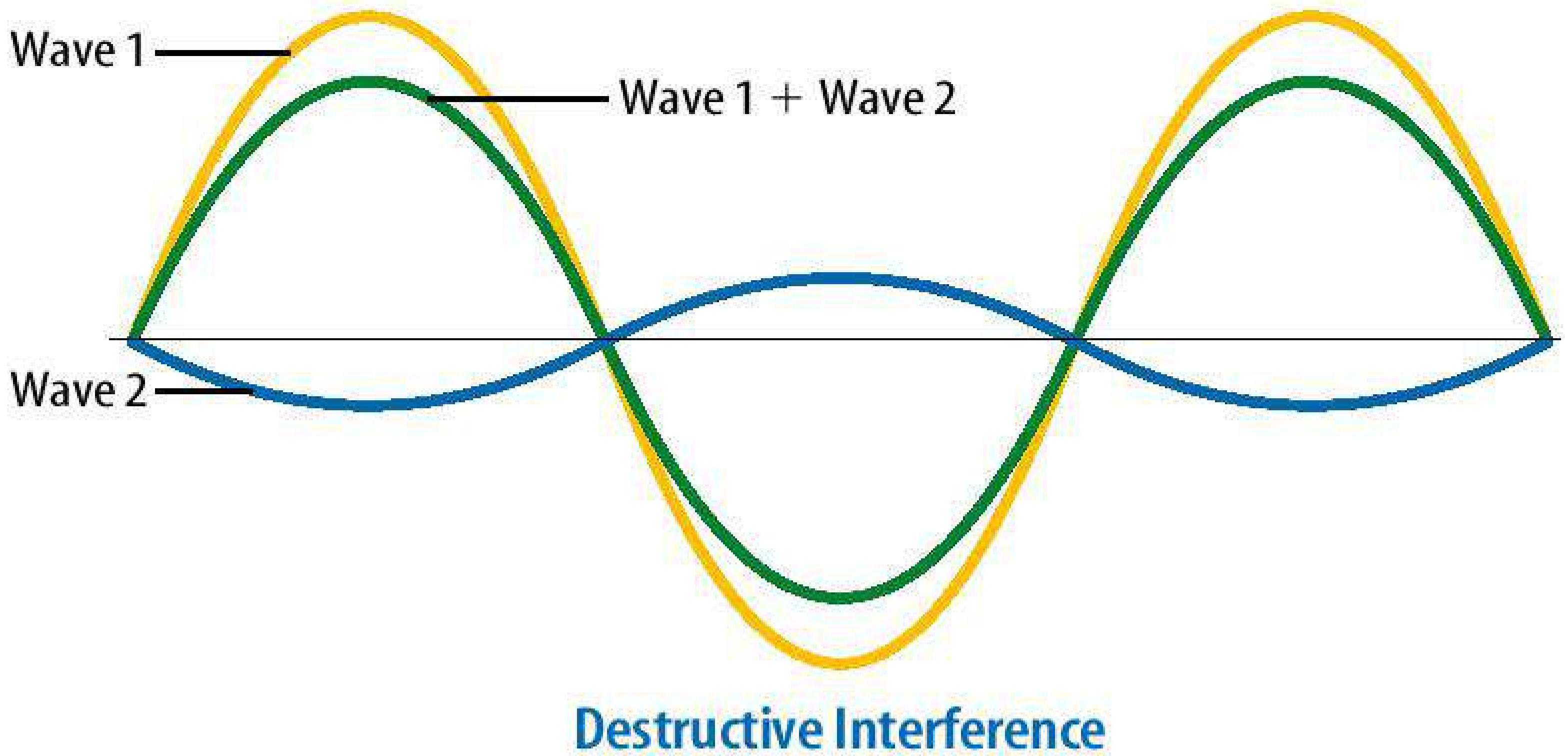
Sound waves that constructively interfere are louder

Amazing Physics @amazing_physics · 2d

Austrian Felix Baumgartner becomes the first skydiver to break the speed of sound, reaching a maximum velocity of 833.9mph (1,342 km/h)📸 Jean-Pierre Tessari

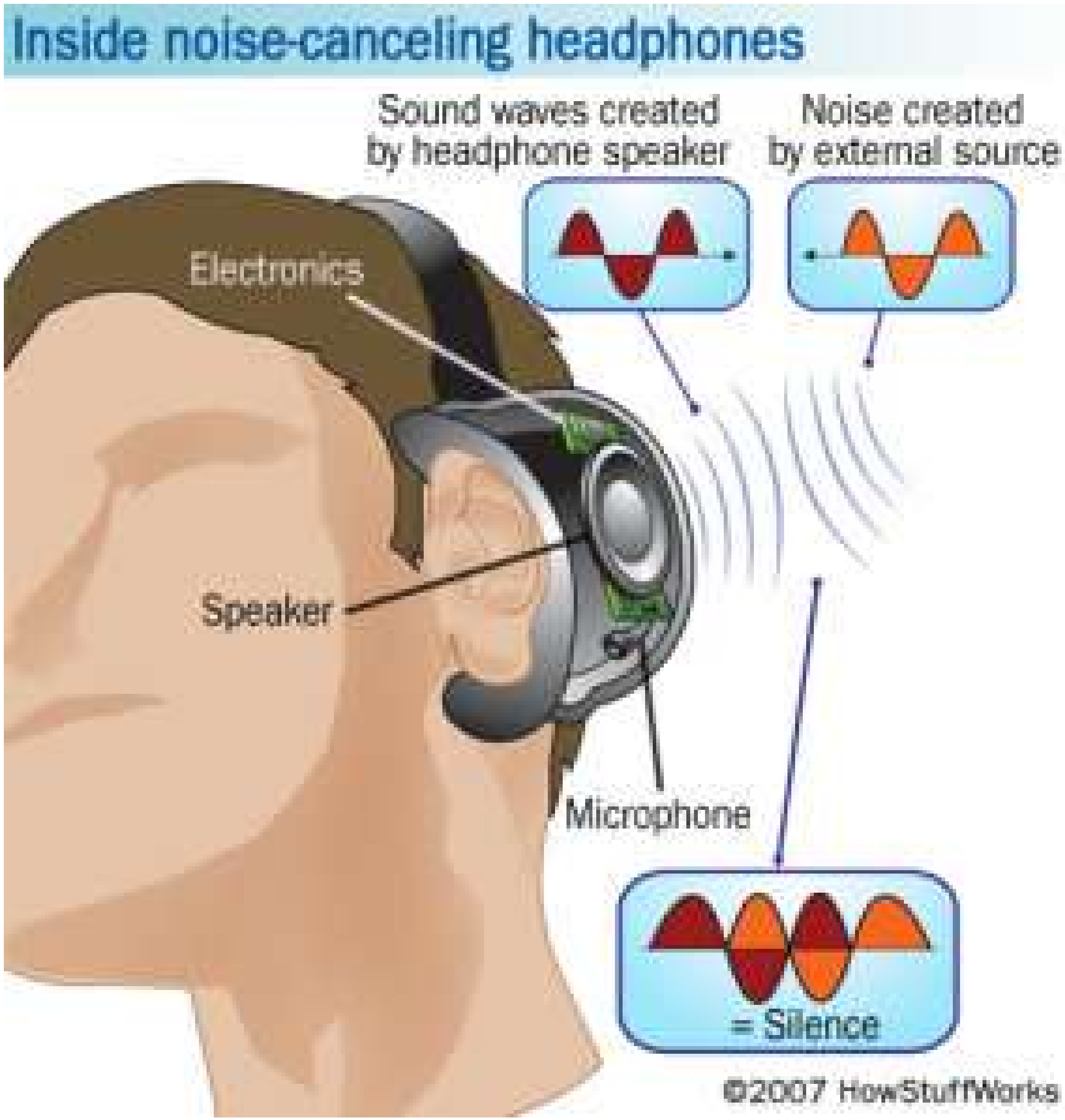
Sonic Booms

- If a sound emitting object is moving at the speed of sound (“mach 1”) then it is exactly keeping pace with the crests of the sound waves it has emitted.
- Where these crests overlap, constructive interference occurs.
- Where constructive interference occurs, amplitude increases.
- Where amplitude increases, loudness intensifies.
- This creates a “sonic boom”



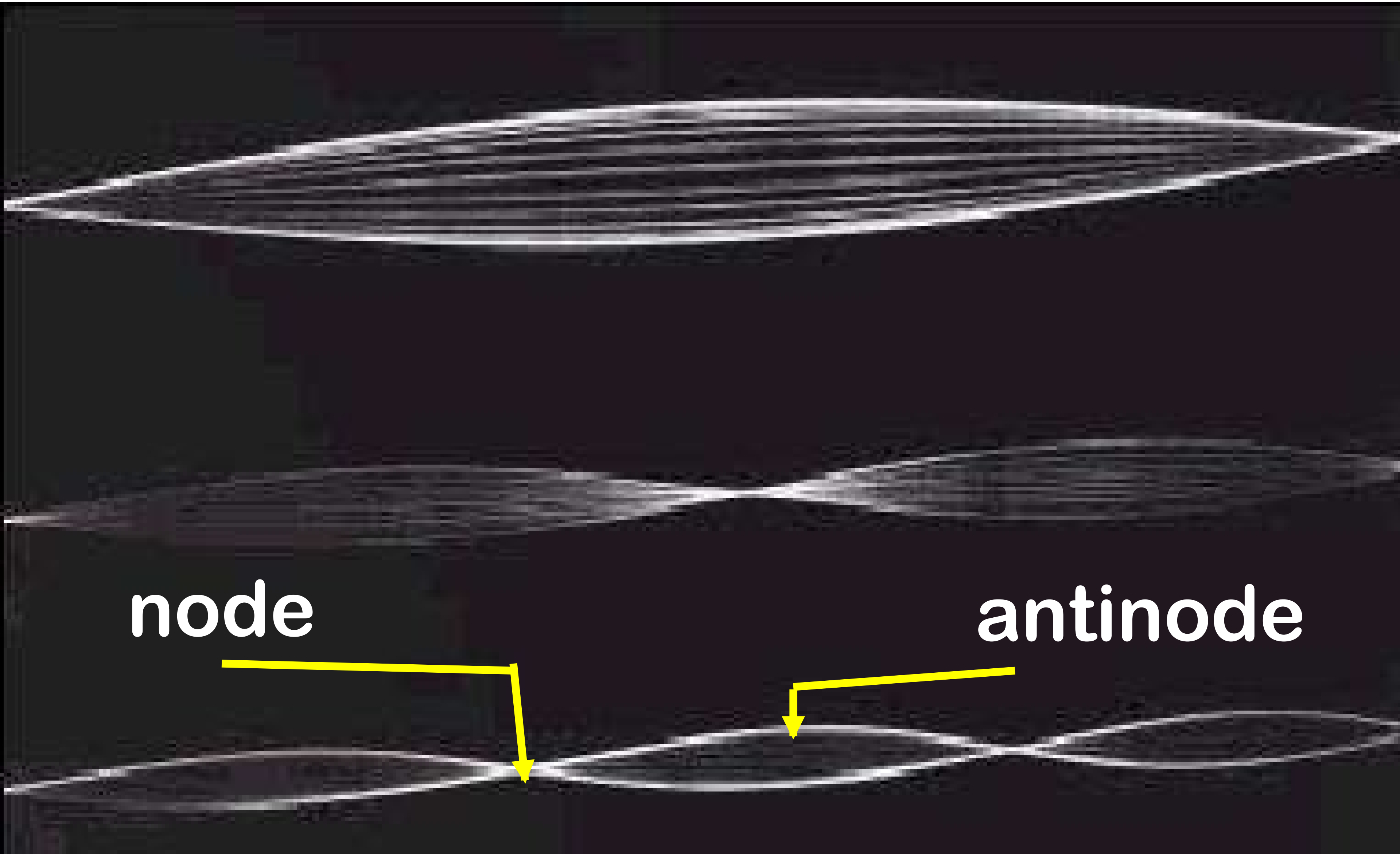
2) Destructive (out of phase)

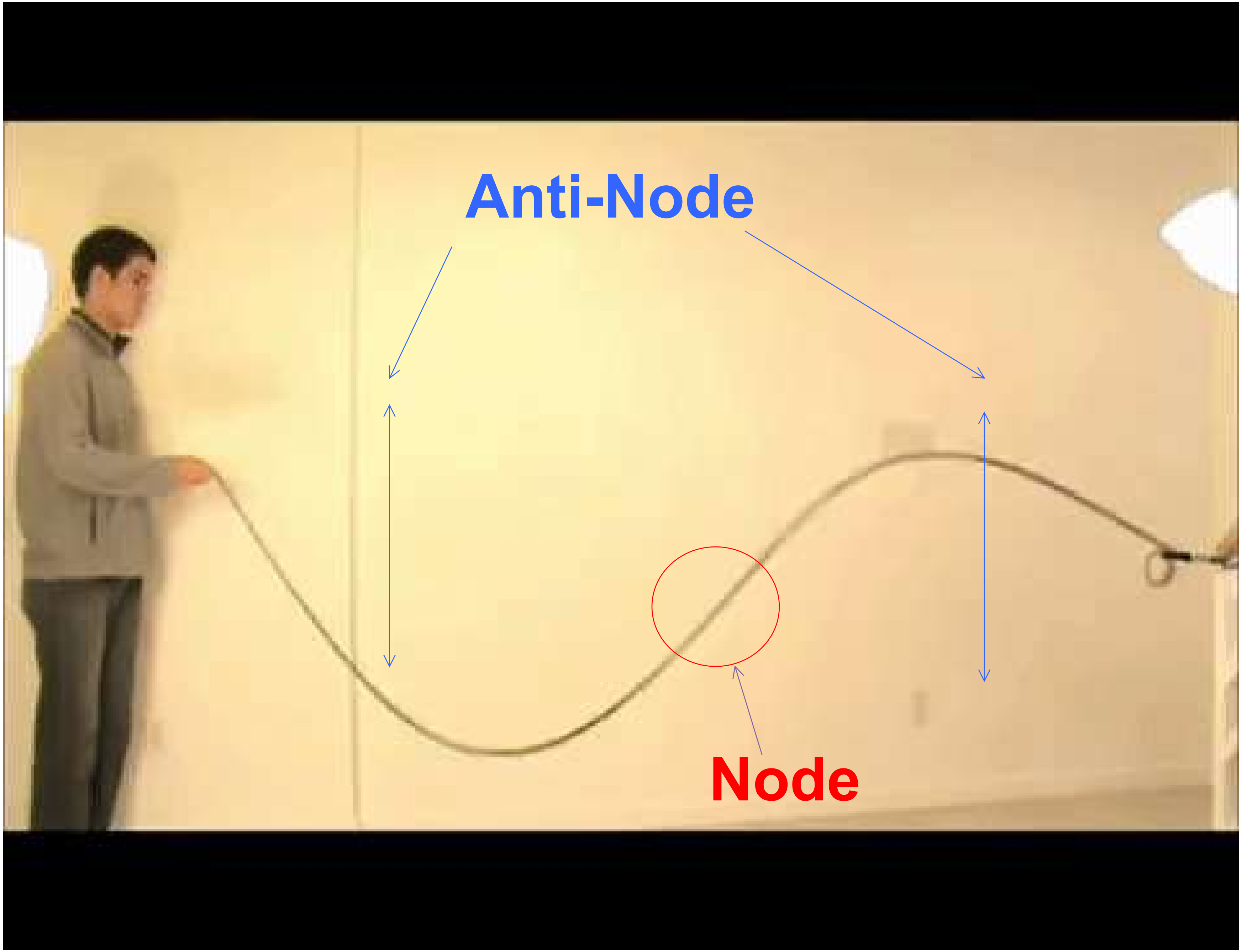
Sound waves that destructively interfere are not as loud



Inside noise-canceling headphones
Sound waves created by headphone speaker
Noise created by external source
Electronics
Speaker
Microphone
= Silence
©2007 HowStuffWorks

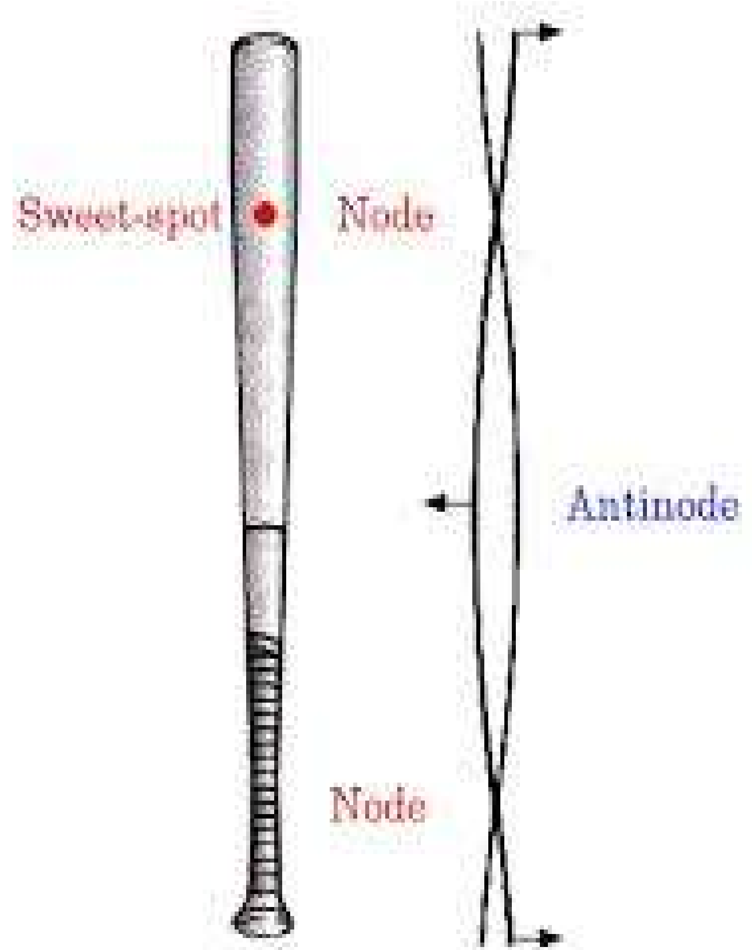
Standing wave




Anti-Node
Node

Standing Waves

- Consists of a node (where the waves come together) and an antinode (where the waves are farthest apart).



Standing Wave Demo

[redacted]

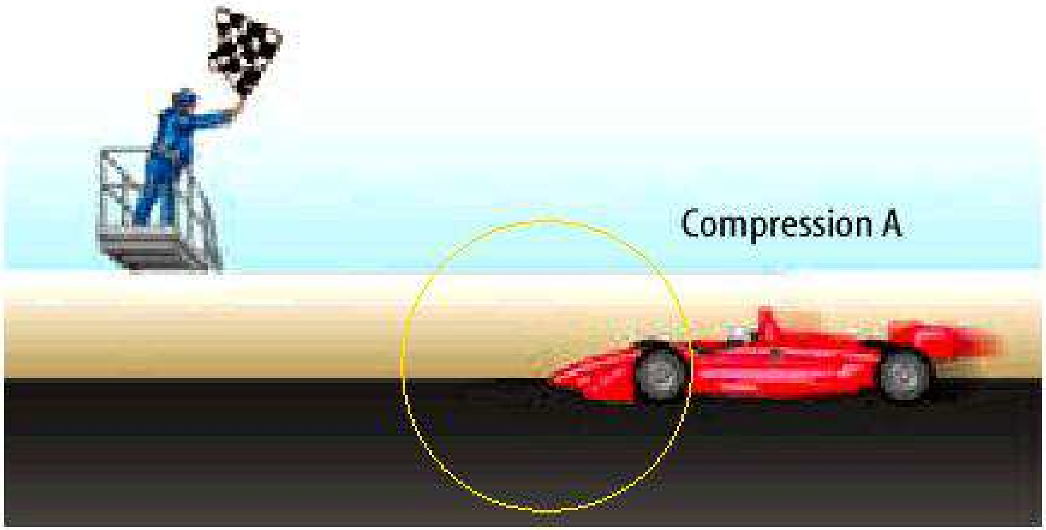
Acoustics – the study of sound.

Soft materials dampen sound; hard materials reflect it (echoes and reverberations).

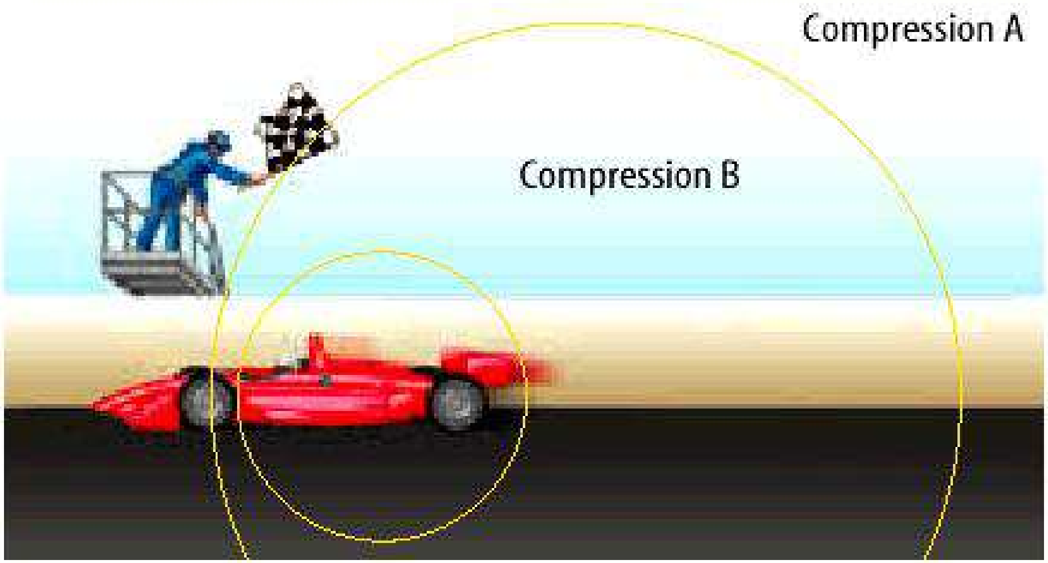
The Doppler Effect

– the change in pitch due to a ***<u>moving wave source</u>***.

The Doppler effect occurs when the source of a sound wave is moving relative to a listener.



A The race car creates compression A.



B The car is closer to the flagger when it creates compression B. Compressions A and B are closer together in front of the car, so the flagger hears a higher-pitched sound.

Doppler Effect – Big Bang