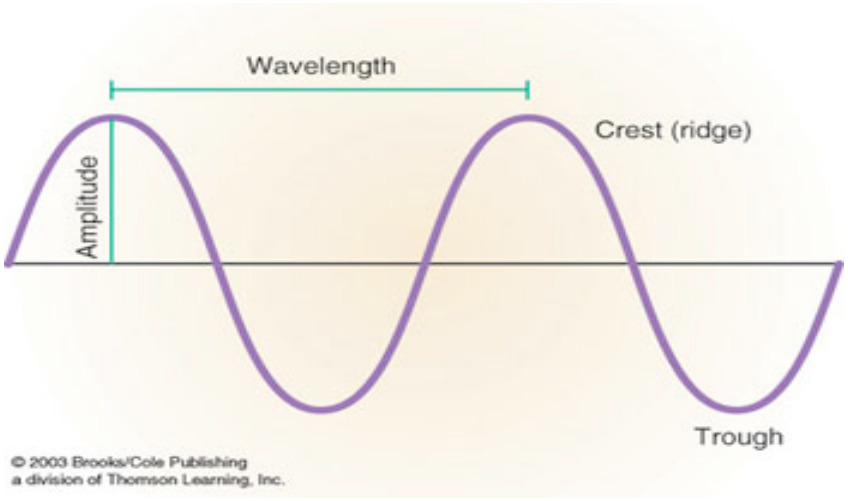
Chapter 7
Waves

Waves -- no individual molecule travels very far, but way to transport energy long distances without transporting matter



TYPE	PARTICLE MOVEMENT	EXAMPLES	ADDITIONAL INFORMATION
Longitudinal or compressional	Same direction as wave	Sound	• speed of sound in air = 1 mile/5 seconds • speed of sound is faster in solids and liquids
Shear or transverse	Perpendicular to wave	Light	
Both transverse and longitudinal	In a circle	Water	• deep water: longer wavelength water waves travel faster than shorter wavelengths one • shallow water: speed only depends on depth of water

Tsunamis (often generated by underwater earthquakes/landslides)

- usually high velocity, long wavelength
- in deep ocean, low amplitude…but slowed down as they approach land, where depth decreases and amplitude increases and there is a huge rise
- are fast traveling, but slow to rise and fall
    - like a rapid tide
- you are able to outrun a tsunami

Waves tend to change their direction by bending their motion towards the side that has a slower wave velocity.

This is true for all waves (Hyugen's Principle)

In a "normal atmosphere,"

COLD

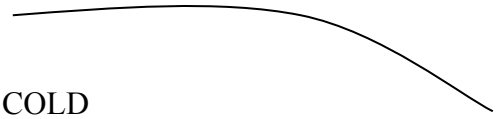
WARM

GROUND

The sound travels upwards, towards the colder air. It creates a shadow zone because the sound travels upwards and there are quiet mornings because sound from far away cannot get there.

In a "temperature inversion,"

WARM



COLD

GROUND

At night, there is a temperature inversion because the ground cools much faster than the air, and the cold air is near the ground. The sound then bends towards the colder ground, and there is no sound shadow zone because the sound is bending towards the ground. But if this temperature inversion happens in the morning, it is a good prediction of a hot day to come. The ground is cold in the morning, and will continue to heat up during the day. But because of this temperature inversion, as the ground warms up, it has nowhere to rise because there is already the layer of warm air above. That is why it will be a hot day. A good way indication of a hot day to come and this temperature inversion is if you can hear traffic or far away sounds in the morning, due to the lack of the shadow zone.

This same principle helps us to think about the sound channel.

FAST

SLOW

FAST

Always bending back towards the slow…

Underwater sound channel

In ocean, ~ 1 kilometer depth

As you go below the ocean surface, the water gets colder, which would cause the sound to travel slower. But at the same time, the pressure gets higher, which would cause the sound to travel faster. Both of these are in effect.

- SOFAR – used to save pilots in WWII; underwater implosion of hollow metallic spheres
- Whale songs
- SOSUS – used to locate submarines

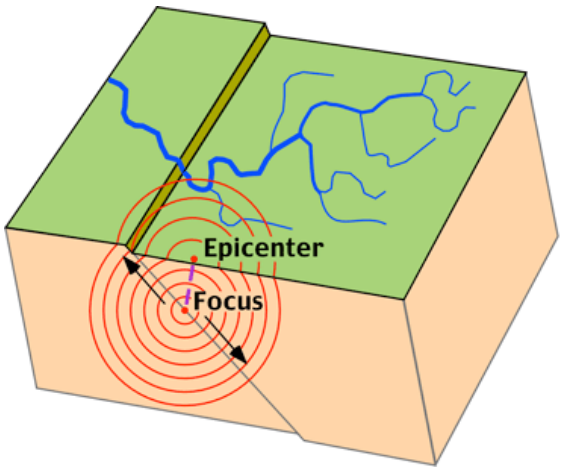
Atmospheric sound channel

~ 50,000 feet it is the ozone layer and middle of the sound channel; area of excess ozone which absorbs much of the UV from the sun

- thunderhead tops – "anvil-shaped" thunderclouds that have a flat top because they are unable to rise anymore because of the warm air
- Project Mogul – disk microphones aka "flying disks" to detect nuclear tests
    - Roswell, NM

Earthquakes

When rocks being stressed suddenly break along a fault and seismic waves are generated



Richter Scale – rough idea of energy released

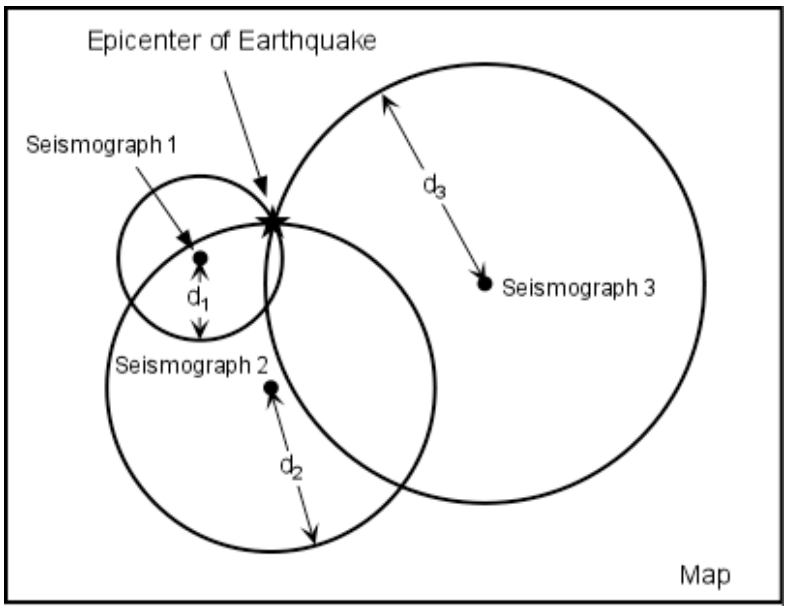
1 point on the Richter Scale is equivalent to about 10-30 times energy released

Earthquakes cause the most damage in soft soil

When waves slow down traveling from rock to soft soil, there is still the same amount of energy and the energy is squeezed, therefore increase amplitude and shaking

	WAVE	TYPE	SPEED	INFO
P	Primary	Compressional or longitudinal	First to arrive ~ 6 km/sec	• travel through solids, liquids and gases • only wave to pass through Earth's core
S	Secondary	Shear or transverse	Second to arrive ~ 3.5 km/sec	• travel only through solids
L	Last	Combination; surface	Last to arriv ~ 3.1 km/sec	• most dangerous/ damaging • travel on surface

Time between P & S wave arrival (1st and 2nd shaking) in seconds X 5 = distance to epicenter in miles

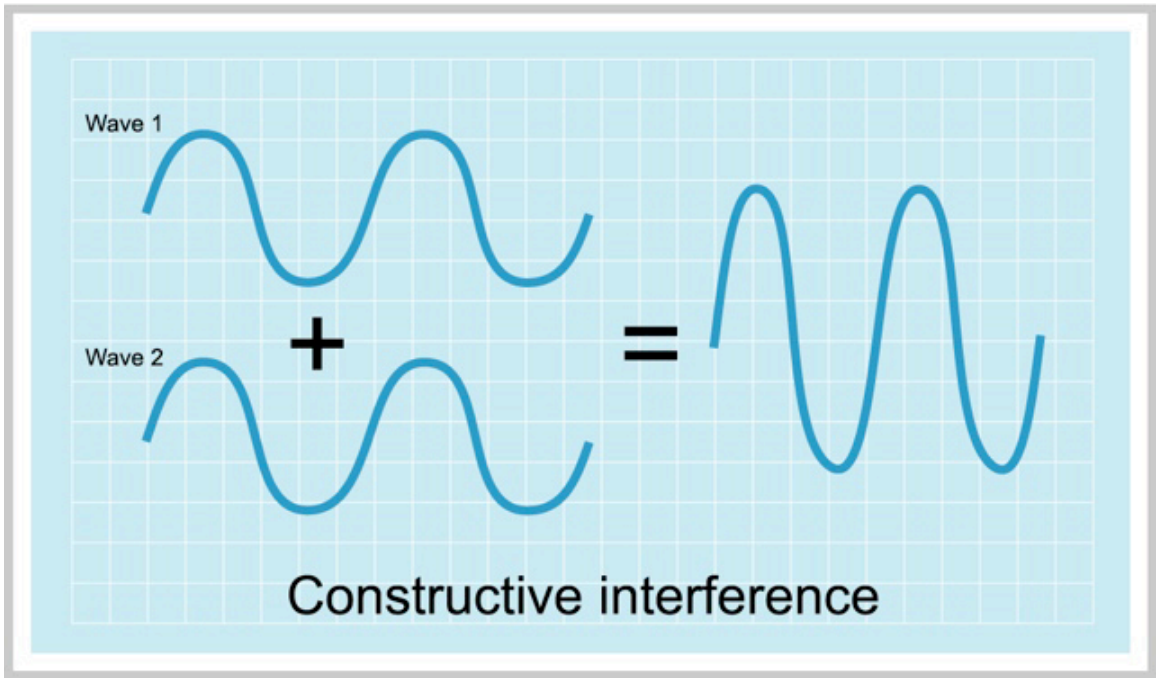


Need 3 distances to locate the epicenter of an earthquake; just like triangulation with GPS

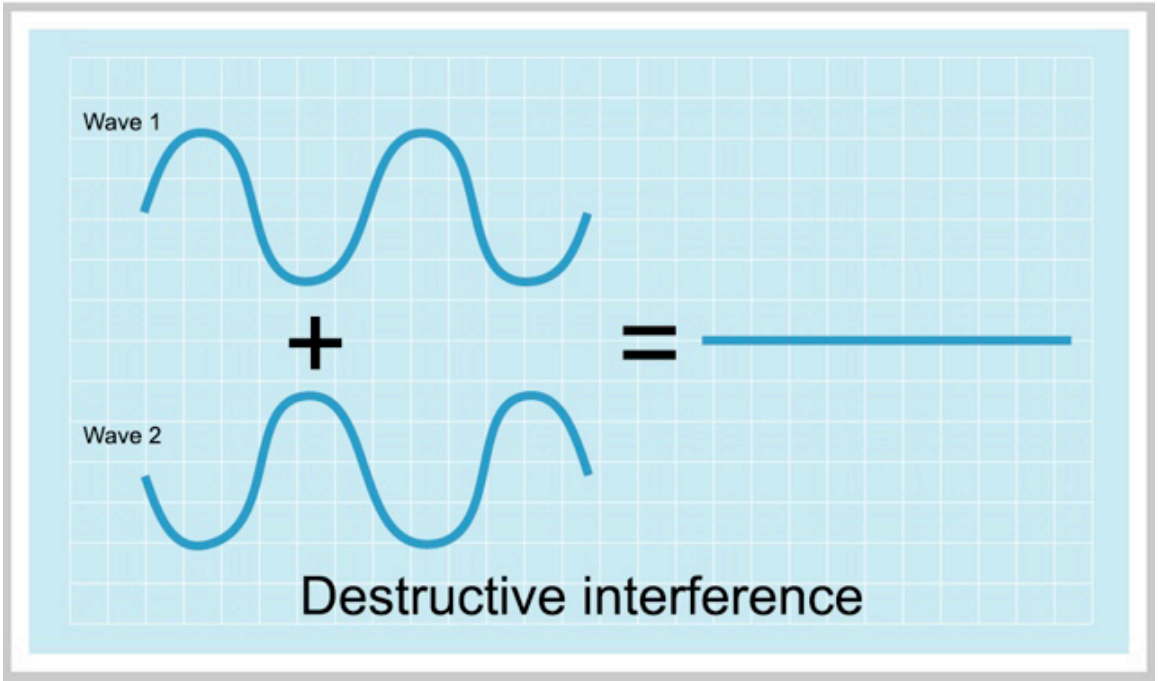
Bullwhips "crack" because the wave speeds up

Bullwhips taper, and the velocity of the wave speeds up and the "crack" is when the wave is greater than the speed of sound = sonic boom

Waves can cancel or reinforce

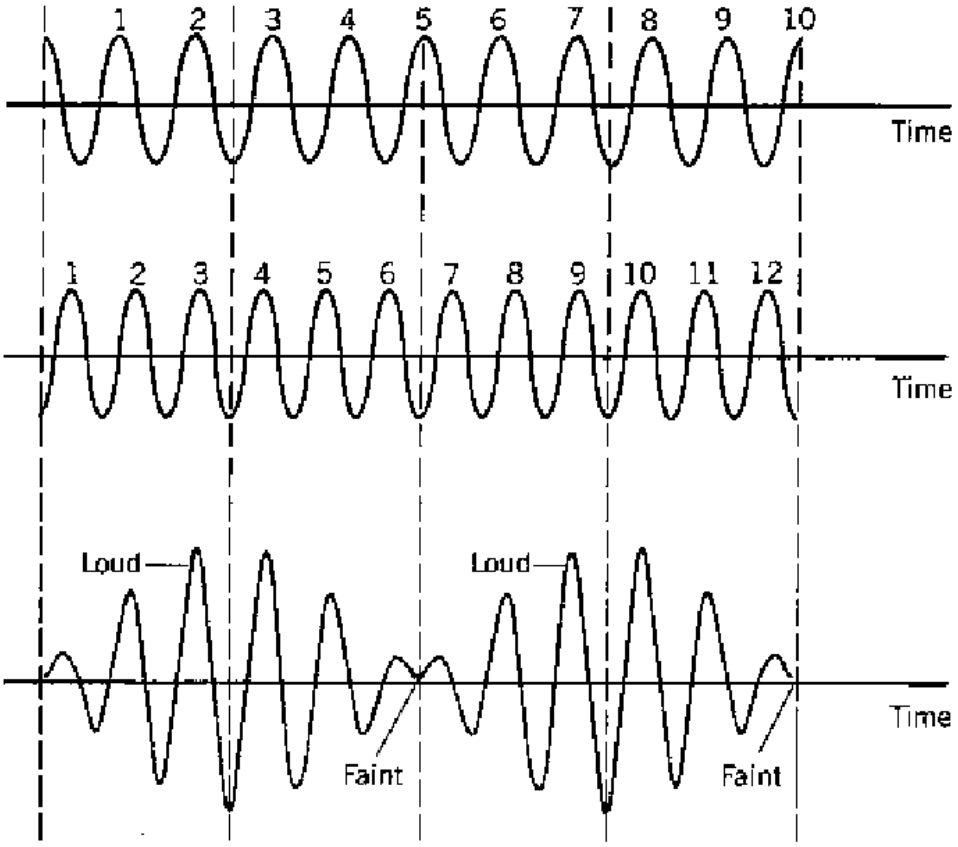


REINFORCE



CANCEL
Wave canceling and reinforcing causes inconsistent earthquake shaking. Some houses get really damaged while others do not.

Also, beats are when two waves with similar frequency interfere with each other; some portions cancel and some portions reinforce.



Musical notes

- sound waves with one dominant frequency
- notes an octave apart, the dominant frequency is exactly doubled

Noise-canceling earphones

- speaker with microphone outside that cancels (by reversing waves exactly) incoming noise

Spreading of waves

- any wave passing through an opening spreads
    - only need to know L of wave and D of opening

Doppler shift

- seen in all waves
- when an object is approaching, higher frequency, higher pitch
    - blue-shifted
- when an object is moving away, lower frequency, lower pitch
    - red-shifted