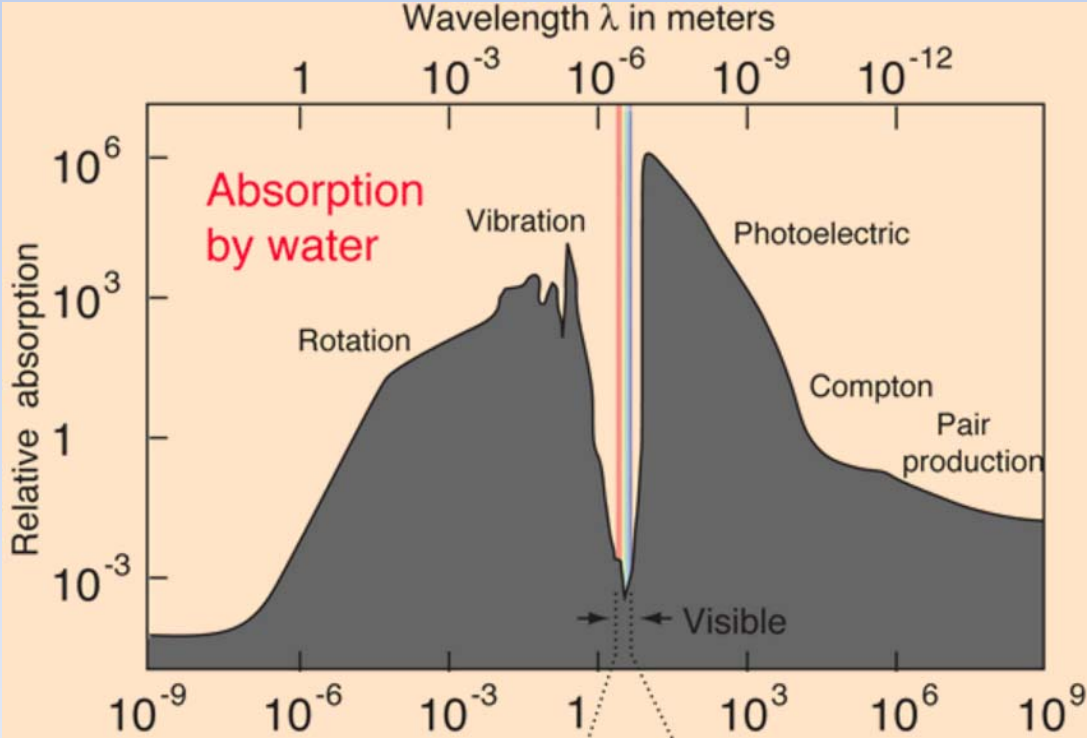
Themed: 02-03

Doppler, Big Bang, Shock Waves & Beats

Research: Absorbing energy

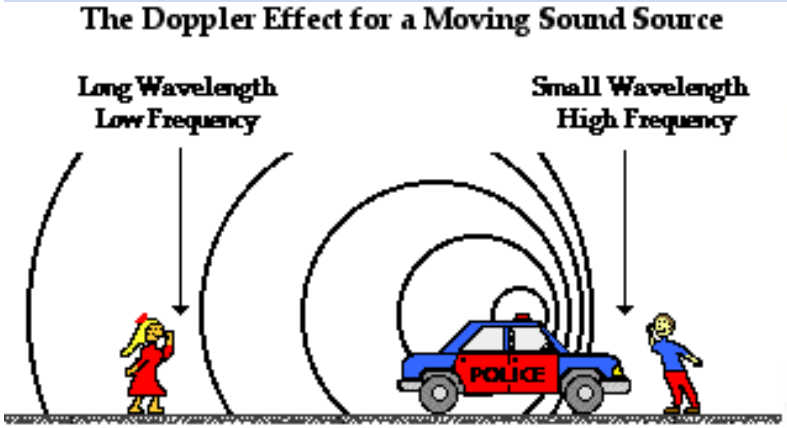
- A slinky only absorbs energy at certain frequencies
  - "natural frequencies", the "harmonics"
- Water absorbs energy at certain frequencies
  - Visible light is very transparent in water; coincidence that we see visible light?
  - Microwave energy: water absorbs 10^6 better than visible light!
- Radio tuners resonate at particular frequencies…how you "tune" a radio
- Do you see any relationships?

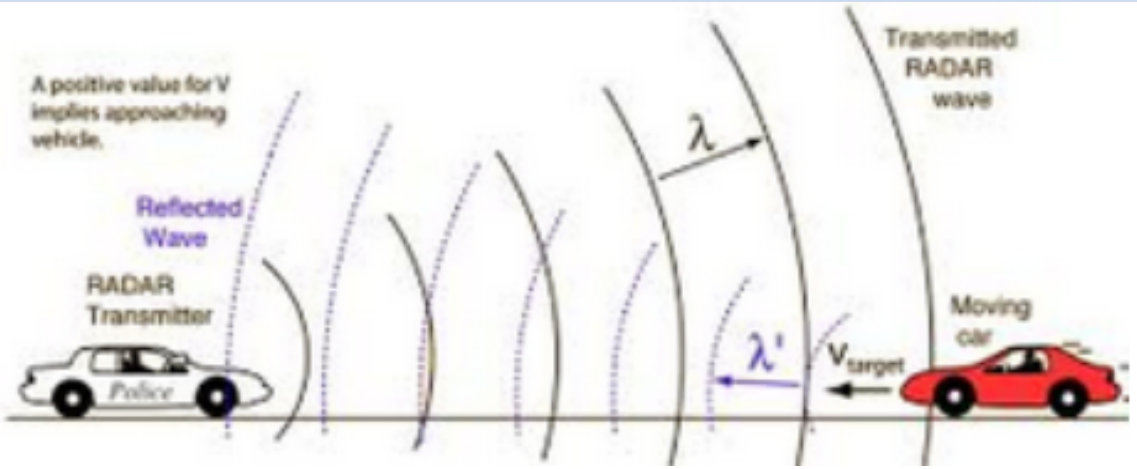


Doppler

Doppler/interference – shock waves, bow waves

- When the "source" moves faster than the wave speed, waves line up and interference makes very large amplitudes
- Source (cop car) catches up partially to frontal wave fronts and leaves rear waves with bigger gaps

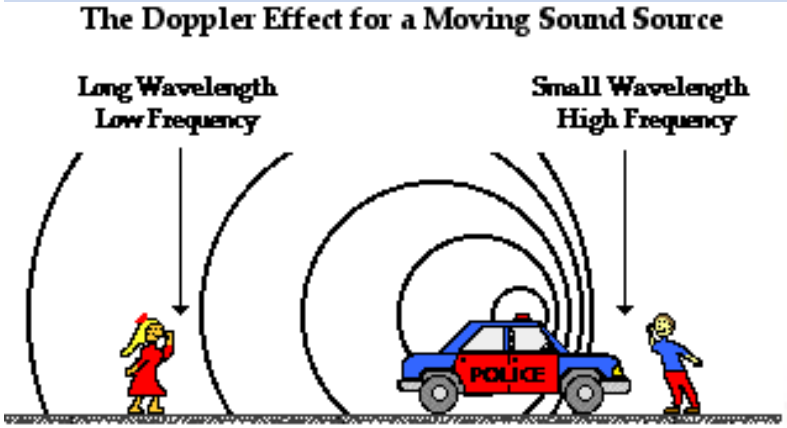


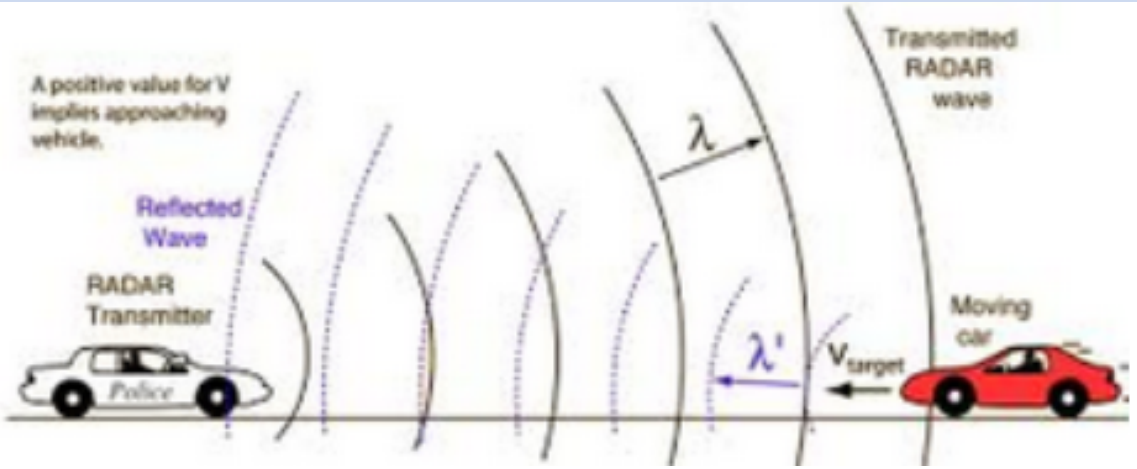


Doppler

Doppler/interference – shock waves, bow waves

- High frequency waves precede the source and low frequency waves trail the source
- Analyzing reflected waves can tell us if objects are moving and how fast
  - police radar guns
  - Baseball pitch speed
  - Tennis serve speed

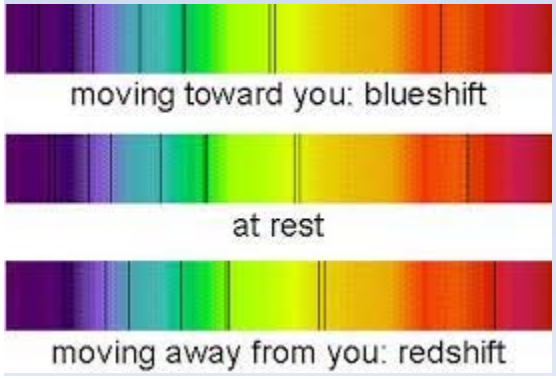




Doppler – Big Bang (Life Skill)

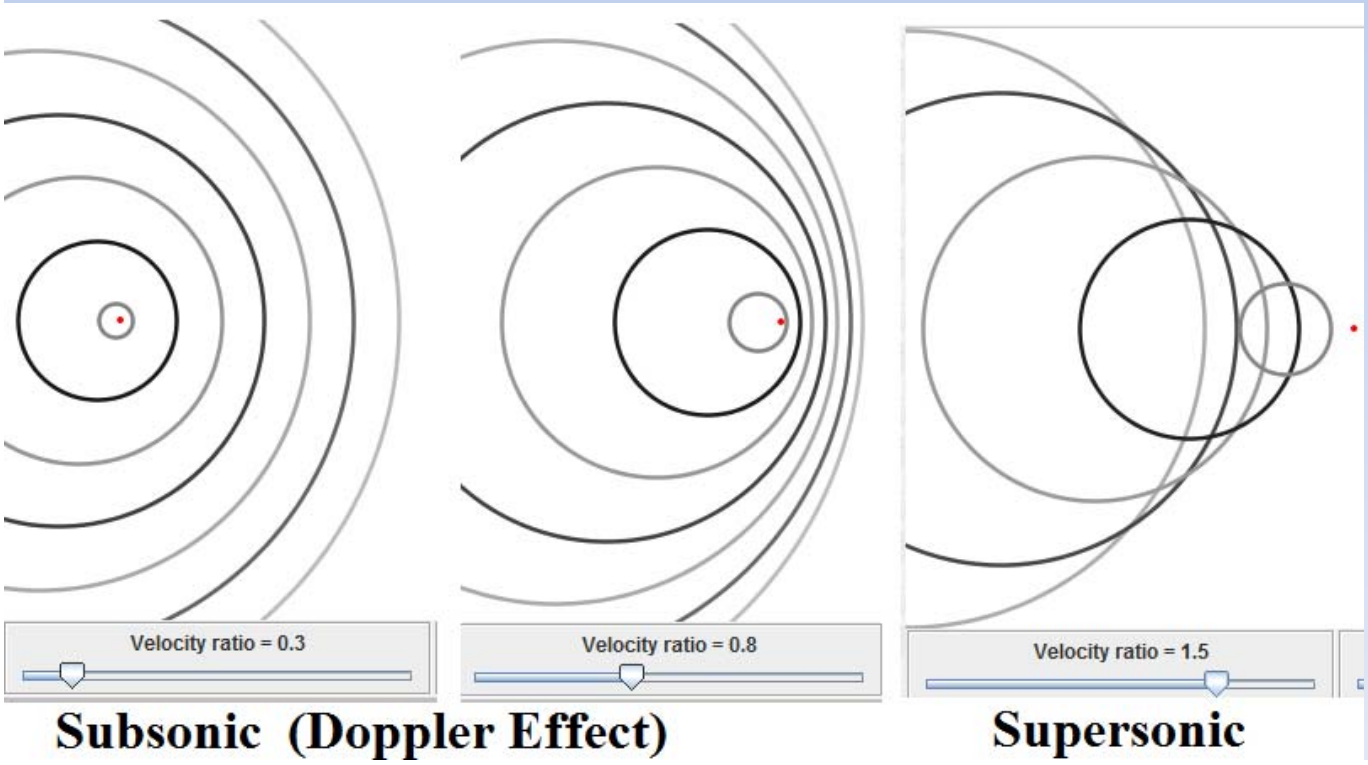
Doppler/interference – shock waves, bow waves

- Light is a wave, so Doppler works for light too
- High frequencies makes light “bluer”, low makes light “redder”
  - “Spectra” is light from stars/galaxies
  - Spectra are shifted depending on if stars move toward or away from us
  - Red shift means galaxy is moving away from us
  - Blue shift means galaxy is moving toward us
- Hubble found 99% of galaxies are moving away from us and from each other! Universe is expanding!
- Extrapolating results says universe started out as tiny and exploded for some reason (Big Bang!)



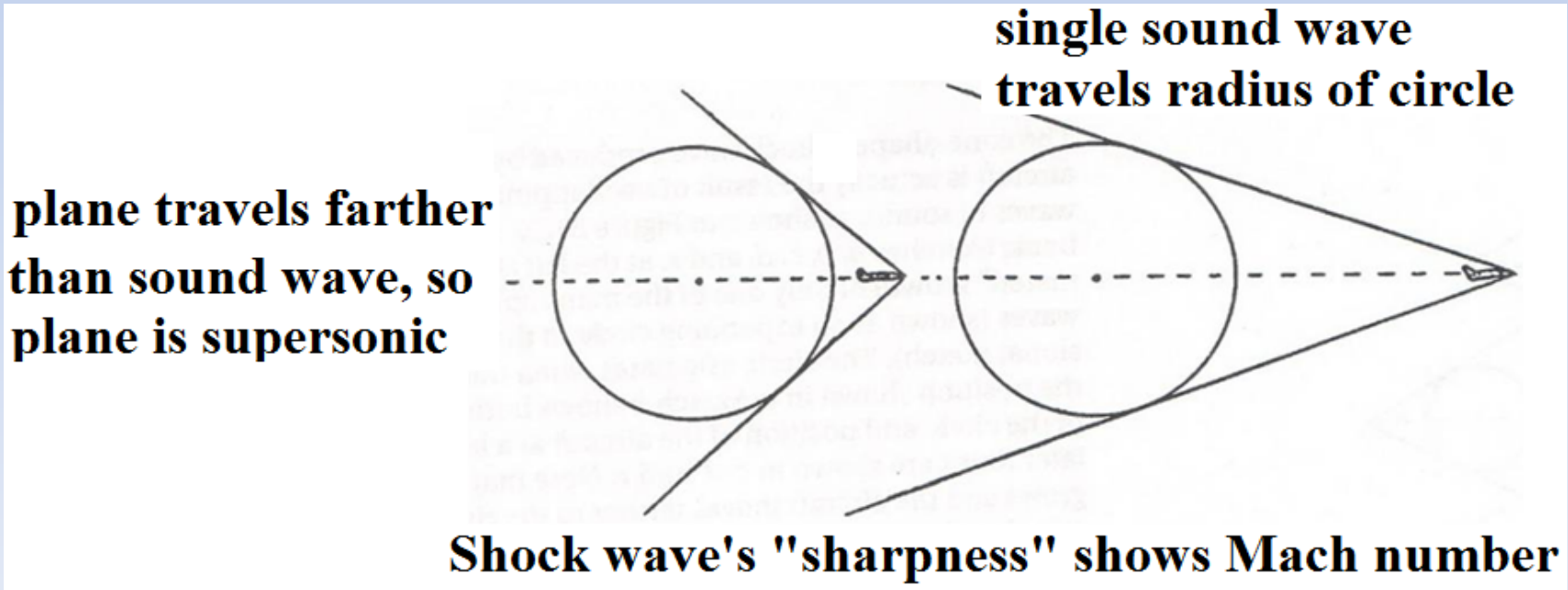
Shock waves – “Doppler on steroids”

- Sound source speeds up, Doppler noticeable
- Source exceeds speed of sound, wave crests pile up in cone shape
- Constructive interference along crest front makes big amplitude (loud “boom”)



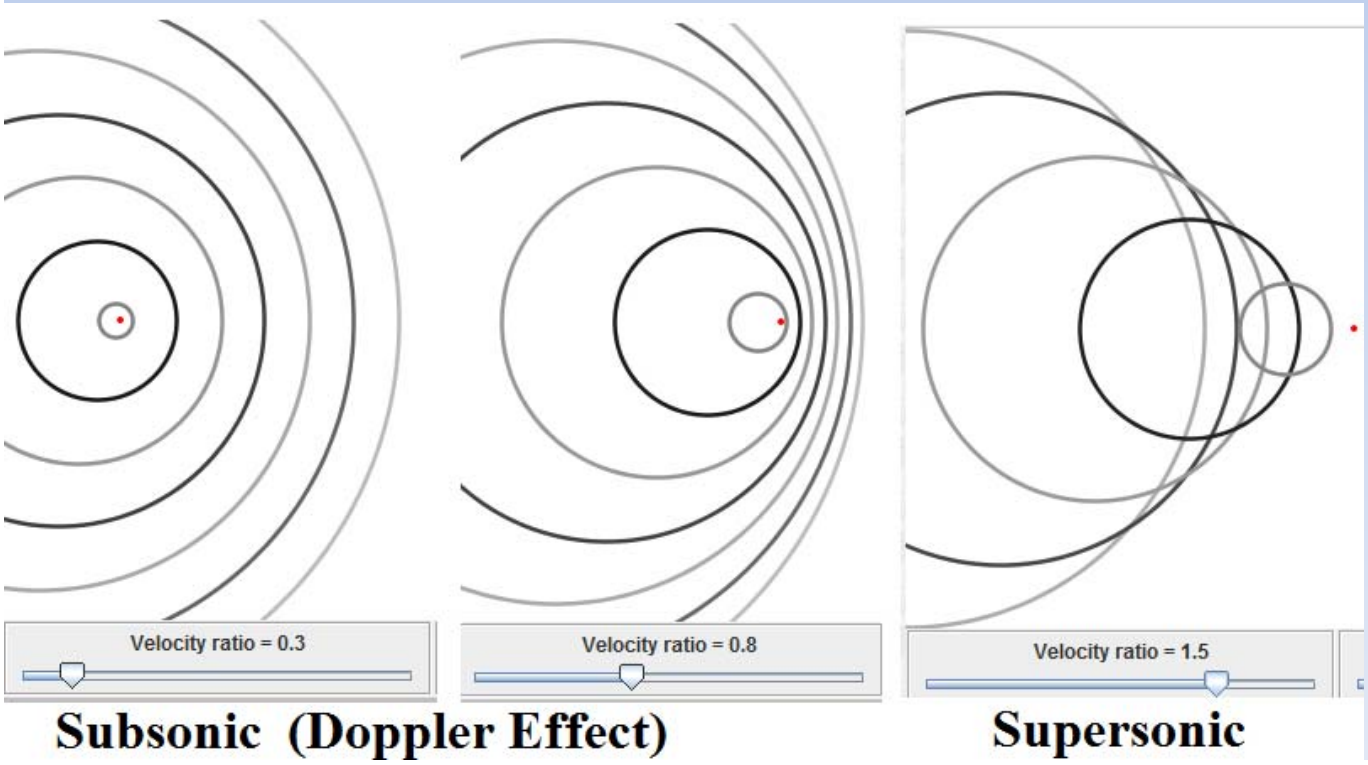
Shock waves – Identifying plane speed based on cone shape

- Sharp cones mean plane is going fast
- Blunt cones mean plane is still supersonic, but not by much
- No cone (shock wave) means plane is subsonic



Sonic Boom and Boat's Bow waves

- Shock wave in air is sonic boom
- Myth: Sonic boom happens when plane reaches mach 1
- Fact: Mach 1 or better produces continuous boom everywhere cone drapes along land
- Bow wave is 2-d version of shock wave
  - V-shaped instead of cone (water constrained to 2-d)



Doppler

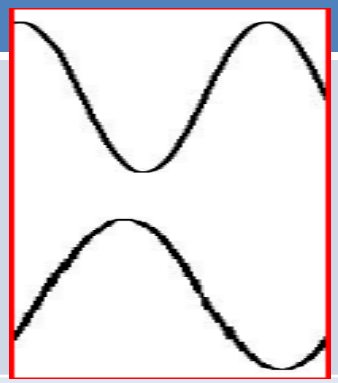
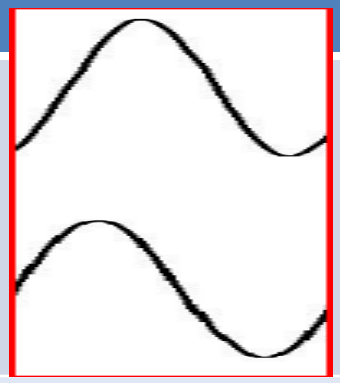
- Humans can hear sounds between 20 Hz and 20,000 Hz
  - Infrared means light with frequencies too low to see; infrasonic means sound with frequencies too low to hear (below 20 Hz)
  - Ultraviolet means light with frequencies too high to see; ultrasonic means sound with frequencies too high to hear (greater than 20,000 Hz)
- Radio waves are light. They are **NOT** sound!
- Supersonic: faster than sound
- Subsonic: slower than sound
- Sonic: at the speed of sound

Waves/Sound Notes Beats

- Remember interference sound examples:
  - Constructive: loud, piling waves **ADD** together for huge amplitude
  - Destructive: noise reducing headphone, dead spots, wave amplitudes **subtract** for smaller amplitude
- Sound waves in phase are LOUD, sound waves out of phase are QUIET

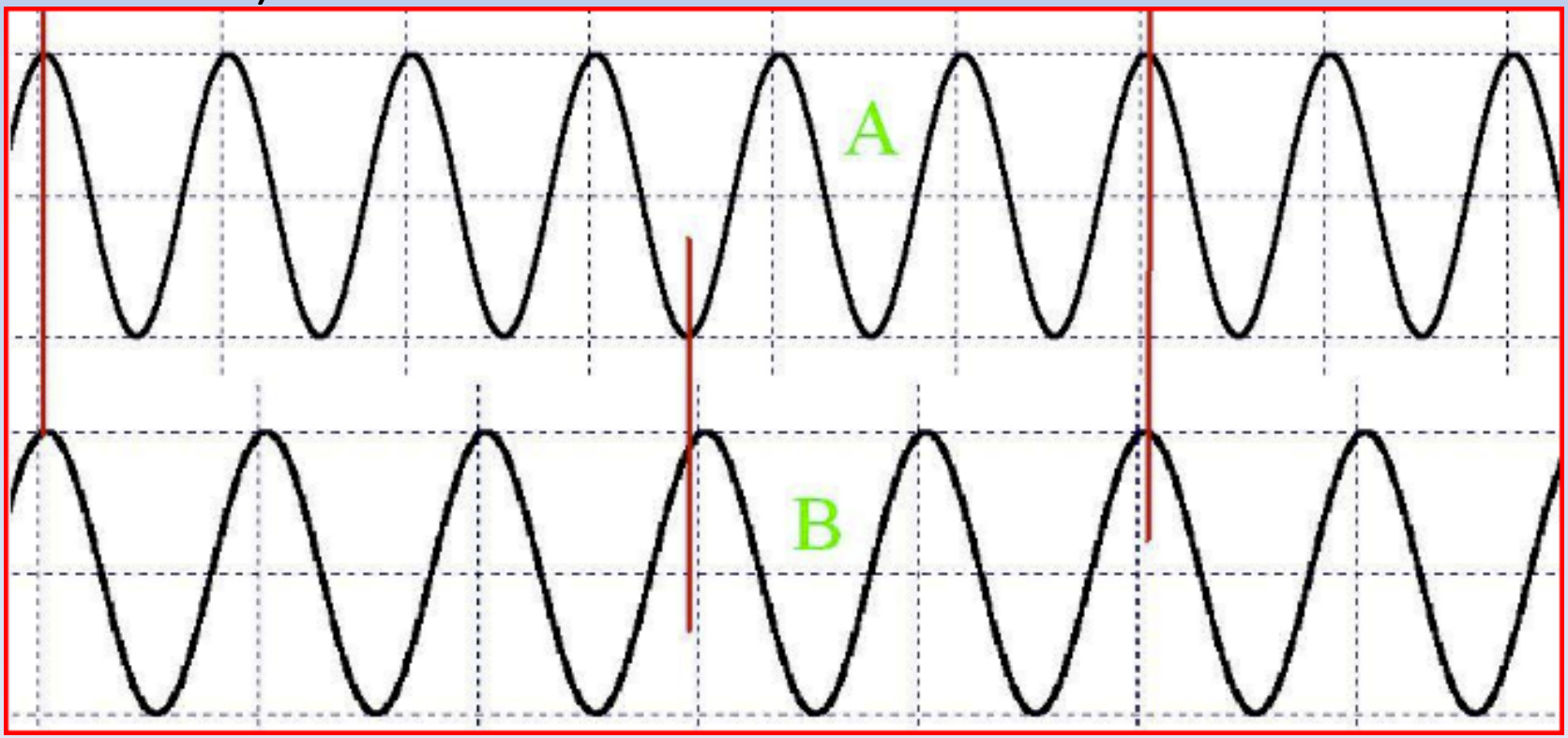
Waves/Sound Notes Beats

- Pretend A and B are Audacity waves (sinusoidal depiction) for two separate sounds
  - Which is in phase and which is out of phase?
  - Where do you see constructive interference? Destructive?
  - Which will sound quiet? Loud?

Situation A	Situation B
	

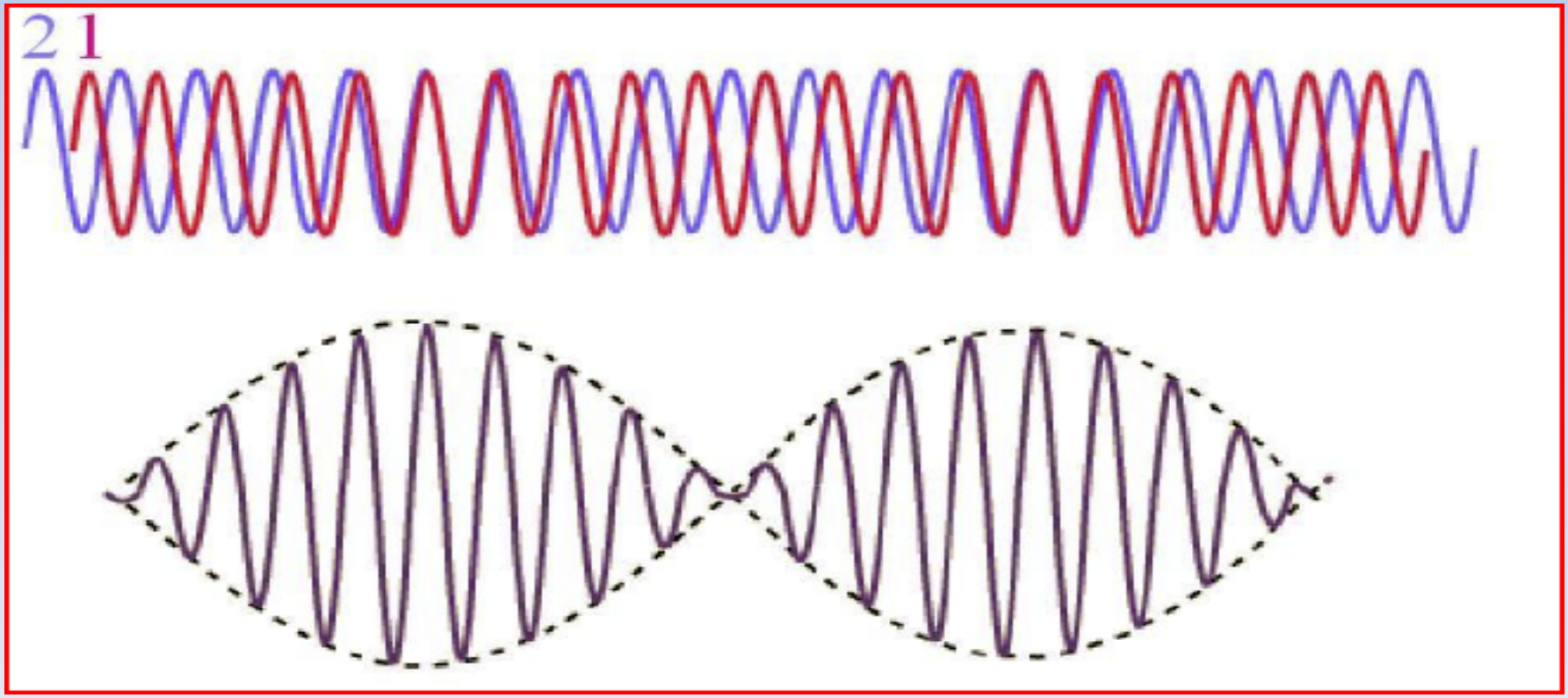
Waves/Sound Notes Beats

- Look at the waves below and recognize:
  - They are from two separate sound sources
  - The go from in-phase to out-of-phase
  - They go from LOUD to QUIET because of…… (begins with letter I)



Waves/Sound Notes
Beats

- Look at waves 1 and 2 below. Below that the waves amplitudes of the composite wave is shown by the SUPERPOSITION PRINCIPLE
- Can you imagine the QUIET/LOUD/QUIET/LOUD/QUIET pattern you would hear? Do you want to hear it for yourself?
- Listen to the sounds of two sound waves slightly out of phase and come up with the patter of “beats”
- How could this be used to tune a piano?



Interference

- Practical destructive interference examples you should know:
  - Sound canceling headphones
  - Dead spots in a room
  - Where to grip a vibrating tuning fork or metal rod (show)
  - Nodes on a slinky, or any standing wave
- Constructive interference examples you should know:
  - Musical instruments, Your voice
  - Breaking a wine glass with an opera singer's voice
  - Soldiers breaking step crossing an old bridge
  - Antinodes on a slinky, or any standing wave