Waves

A **wave** transfers energy from one place to another and is a traveling disturbance.

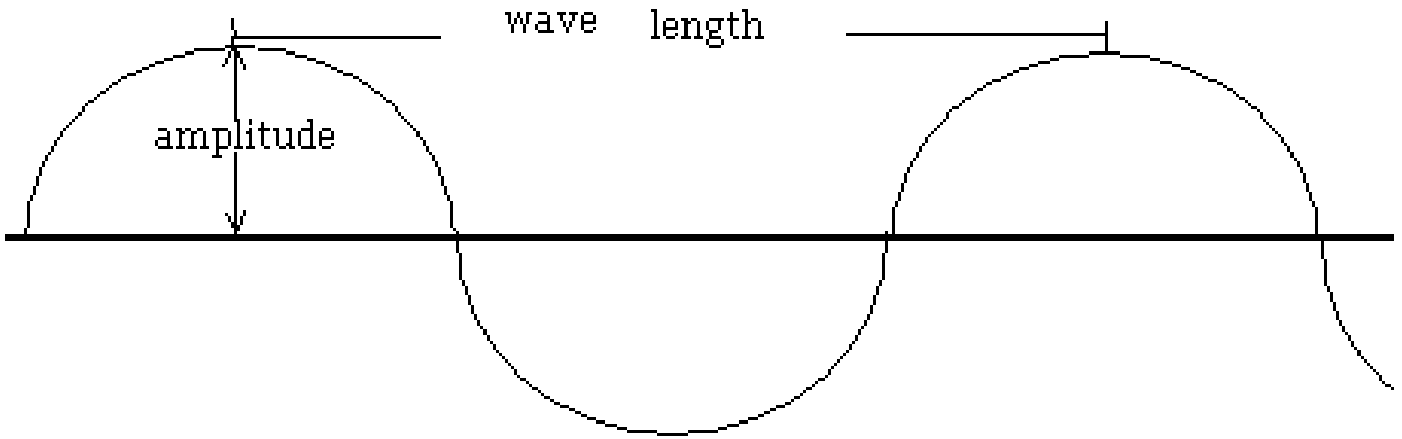
- **Forms of waves**
- 1. Mechanical: needs a medium
  - Ex: sound wave - air,
  - Water wave - water,
  - Spring wave – spring,
  - Earthquake - earth
- 2. Electromagnetic: does not need a medium
  - Ex: light, x-rays, radio waves, infrared
- 3. matter waves – electrons become waves under quantum mechanical conditions.

Types of wave propagation (movement)

- 1. Transverse Wave – the wave vibrates perpendicularly to the direction of propagation.
- 2. Longitudinal Wave – the wave vibrates in the direction it propagates.

Attributes of the wave

- Period (T) – The amount of time (in seconds) for one complete wavelength.
- Frequency (f) – The amount of cycles per second. In Hertz (Hz)= s^{-1}
- Wavelength (λ) – The distance in meters of a wave.
- Amplitude (A) - The height of the wave from the equilibrium point in meters.


wave length
amplitude

Formulas

- $f=1/T$ $v=\lambda f$ $v=\lambda/T$

- What is your favorite radio station?
- f=
- $v \approx c=3x10^8$ m/s
- λ=?
- T=?

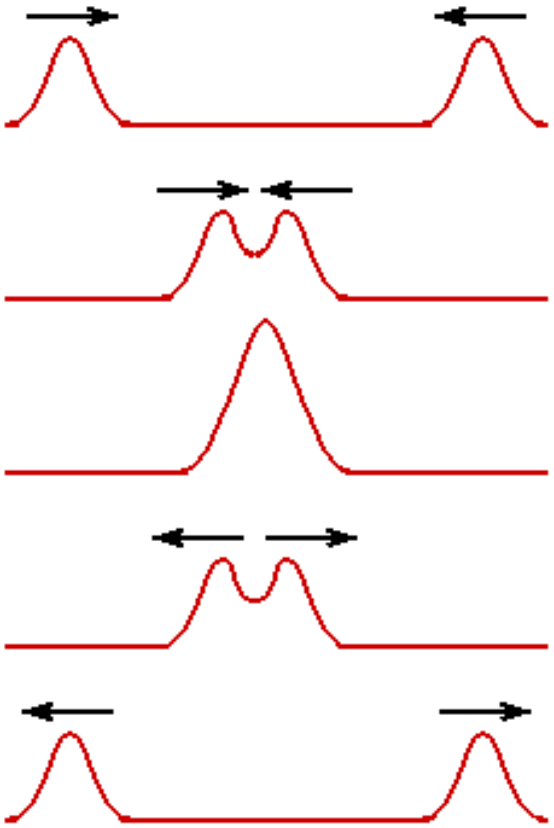
Diffraction

- Diffraction is the bending of a wave around a corner. This is why you can hear a noise around a corner.
- Low frequencies (longer wavelengths) diffract better.
- Why then does AM not come in clearer? (as the Federal Broadcast commission thought it would when this was set up)
  - Range!
    - 1020 KHz can broadcast from 1,019.5kHz -1,020.5 kHz= **1kHz range for AM**
    - 99.1 MHz can broadcast from 99,050kHz -99,150kHz = **100KHz range for FM**

Adding waves

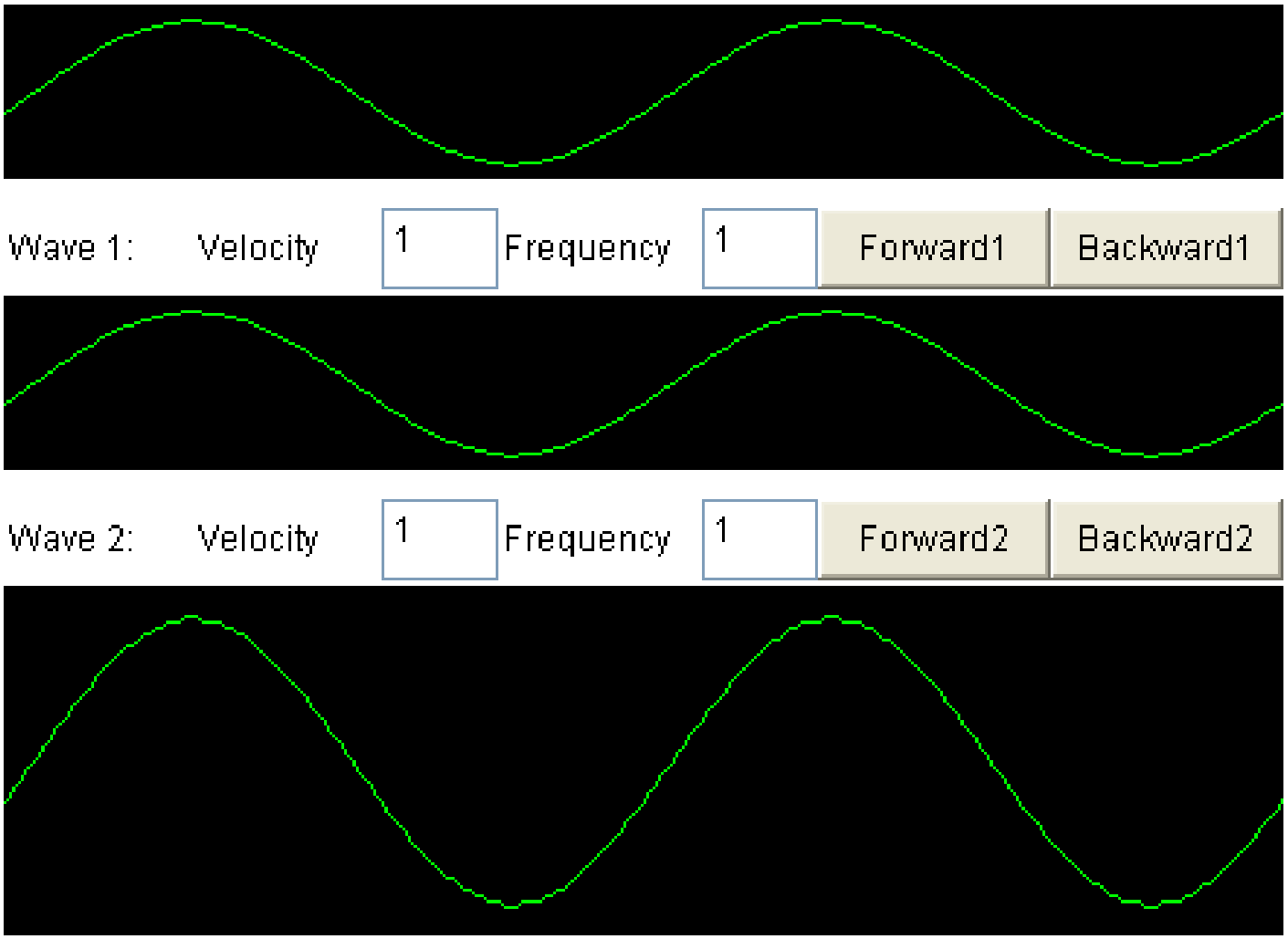
- use the **principle of superposition** put the two waves on top of each other and see how they add. (either constructive or destructive)

Waves that are in phase (have peaks at the same time) add constructively.



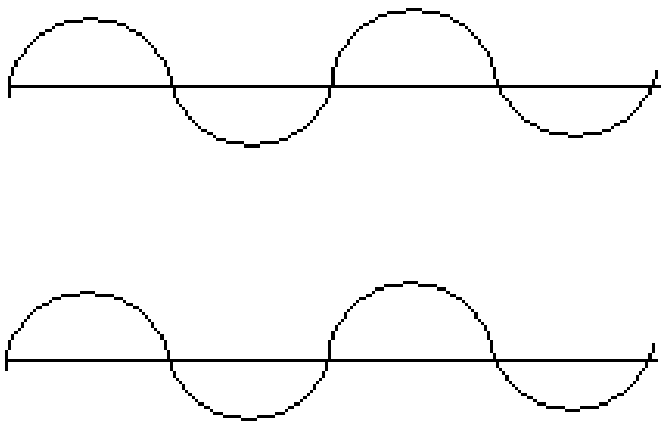
Superposition of Two Waves

by Zilun Gong , York U.

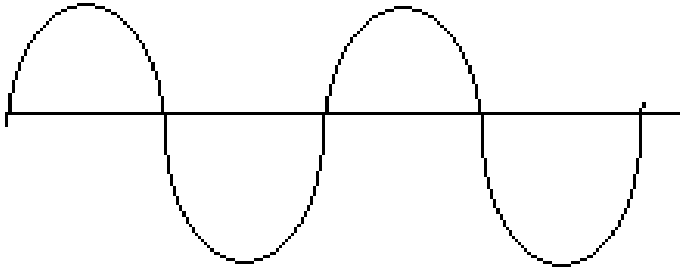


Waves that are in phase (have crests at the same time) add constructively.

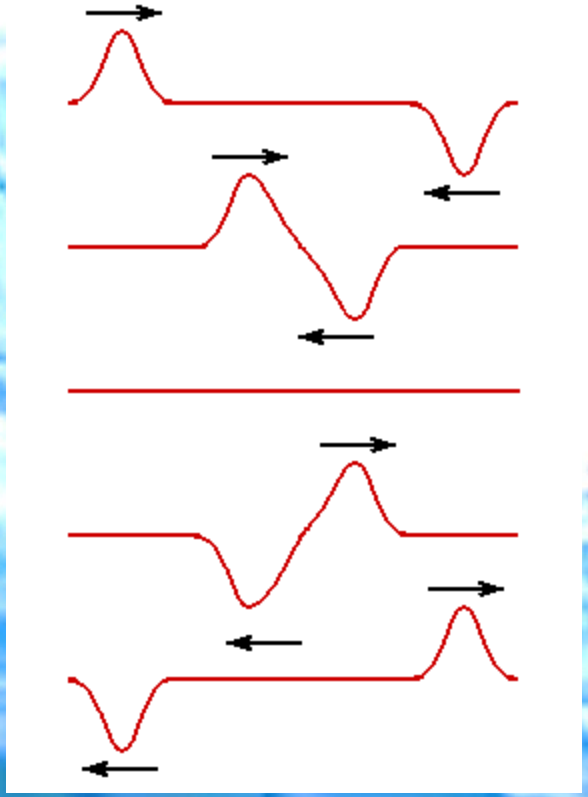
Add these two waves



get this wave



Waves that are out of phase (have peaks at opposite times) add destructively



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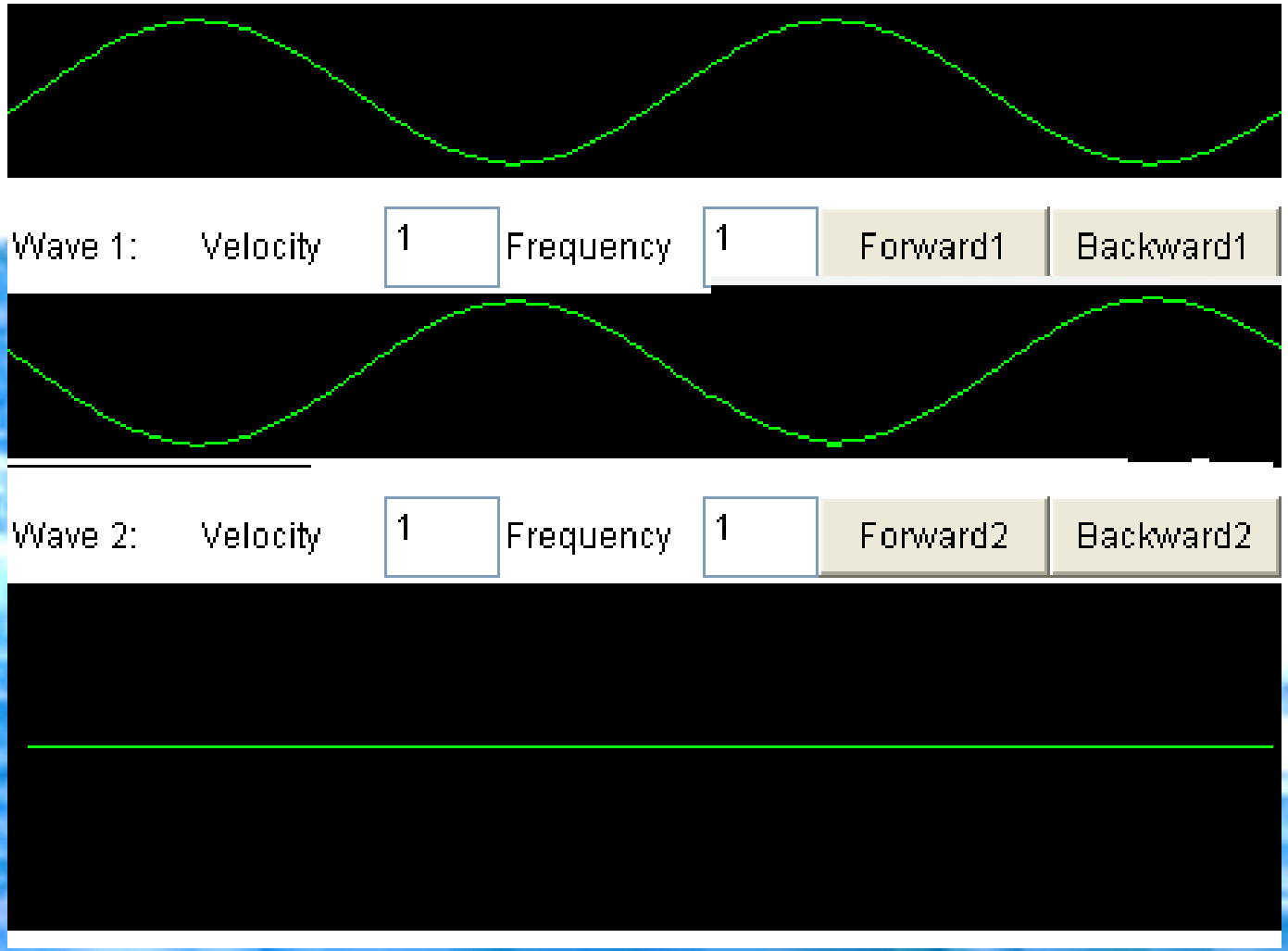

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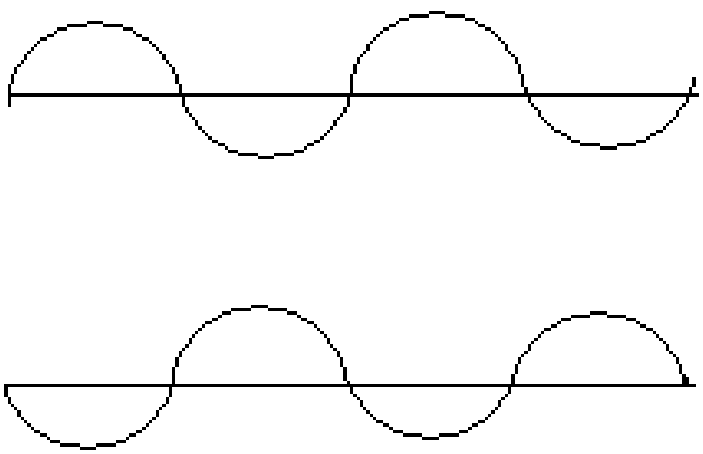
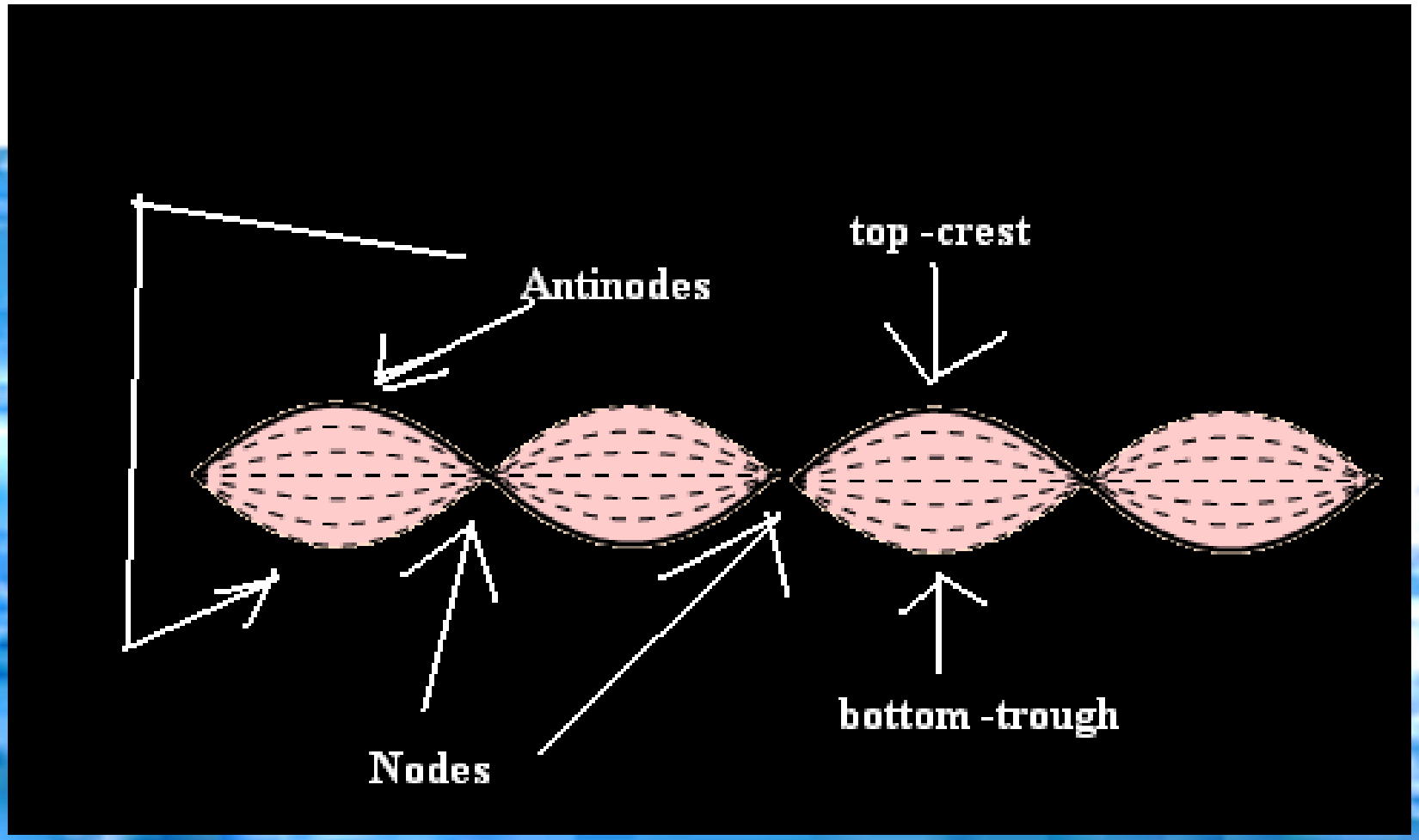


get this wave

Show water wave generator

http://www.phy.ntnu.edu.tw/ntnujava/viewtopic.php?t=35

A standing wave is one that has alternating destructive and constructive interference. Usually from the reflected source.



- Sound is a longitudinal wave that travels through matter.
- Air is compressed (higher density) and then rarefacted (lower density)

- The speed of sound (mach) depends on the medium and temp.
- Air at 0° C = 331 m/s
- Air at 20° C = 343 m/s
- Water at 20° C = 1482 m/s
- Glass = 5010 m/s
- Compared to speed of light 300,000,000m/s it is very slow.
- ≈5s between lightning flash and sound/ mile

The pitch we hear depends on frequency.

- Infrasonic < 20 Hz < Audible range < 20,000 Hz < Ultrasonic
- Dogs can hear up to 30,000 Hz- Hence dog whistles
- Ultrasonic waves are used to take pics of a fetus.
- **show dog whistle*

Resonance

- Resonance is when an external force is put on a material that makes the material vibrate at its natural frequency.
- Tuning forks have their natural frequency marked on them.

Harmonic series

- Harmonic series of a Pipe open at both ends or a string. Ex. Clarinet, guitar
- fn=n (v/2L) n= 1,2,3,…
- Harmonic series of a Pipe closed at one end.
- fn=n (v/4L) n= 1,3,5,…
- *_demo with tube open and closed and cpvc_
- *Over tones are other frequencies that are not amplified as much, but give the instrument its unique sound.*

- The intensity of a wave is $I=P/A = P/4\pi r^2$
- SI unit: watts/m^2
- follows the inverse square
- Also the intensity scale is logarithmic.

Decibels

- Decibels are used to measure relative intensities. 1.0 $x10^{-12}$ w/m^2 is zero on the decibel scale. Every time you mult by 10 on the intensity there is an increase of 10 in the decibels.
- 120 dB or 1 W/m^2 is the thresh of pain.
- Twice as loud is an increase of 10dB.
- Decibels are unitless.

Decibel Ratings and Hazardous Time Exposures of Common Noises

Decibels (dB) are measured logarithmically. An increase of 10 dB is ten times as loud. Thus, 80 dB is 10 times louder than 70 dB and 90 dB is 100 times louder than 70 dB.

Typical level(Decibels)	Example	Dangerous Time Exposure
0	Lowest sound audible	All exposure is safe
30	Quiet Library, soft whisper	All exposure is safe
40	Quiet office, or living room	All exposure is safe
50	Light traffic at a distance, refrigerator, gentle breeze	All exposure is safe
60	Air conditioner at 20 feet, conversation, sewing machine	All exposure is safe
70	Busy traffic, noisy restaurant. At this level, noise may begin to affect hearing if you are constantly exposed.	Risk begins
80	Subway, heavy city traffic, alarm clock at two feet	Over 8 hours
90	Truck traffic, noisy home appliances, shop tools, lawnmower. As loudness increases, the safe time exposure decreases.	Under 8 hours
	Chainsaw, boiler shop, pneumatic drill. Exposure may be dangerous at 100 dB.	Under 2 hours

70	noise may begin to affect hearing if you are constantly exposed.	
80	Subway, heavy city traffic, alarm clock at two feet	Over 8 hours
90	Truck traffic, noisy home appliances, shop tools, lawnmower. As loudness increases, the safe time exposure decreases.	Under 8 hours
100	Chainsaw, boiler shop, pneumatic drill. Exposure may be dangerous at 100 dB. Safe exposure time is cut in half with every 5 dB increase.	Under 2 hours
120	Rock concert in front of speakers, sandblasting, thunderclap. At 120 dB, exposure can injure the ear.	Serious danger
140	Gunshot, jet plane at 50 feet. Noise at 140 dB may cause actual pain in the ear.	Any exposure can cause damage
180	Rocket laynching pad. Without ear protection, noise at this level causes irreversible damage.	Hearing loss inevitable

Source: The Canadian Society of Otolaryngology

Doppler Shift

- The frequency shifts as an object that is giving off noise moves.
- Toward you higher frequency.
- Away from you lower frequency.
- * *demo with speaker swing*

Octave

- 2 notes w/ a ratio of 2:1 differ by an octave.
- Small ratio's of frequencies make notes such as an "A", or "B"