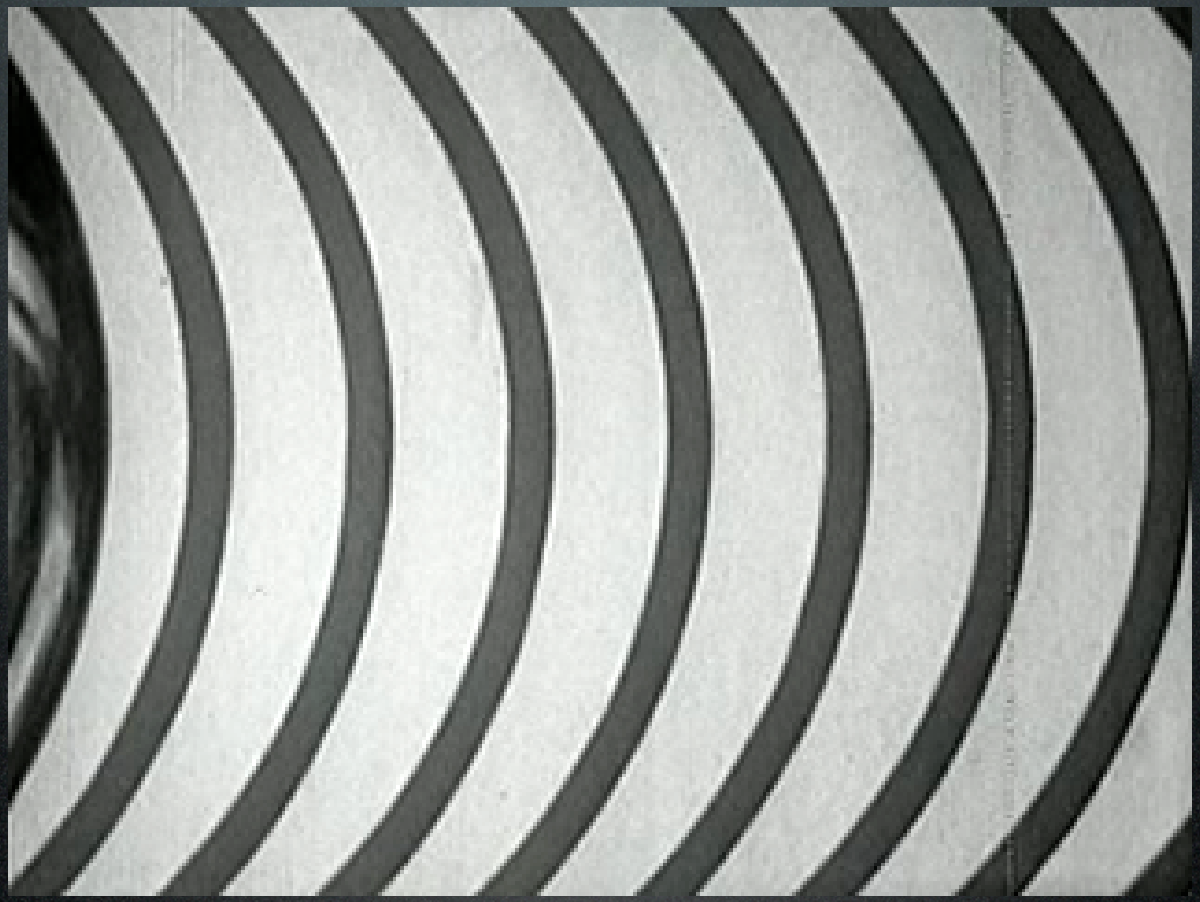
# Soundgarden

...an introduction to sound.

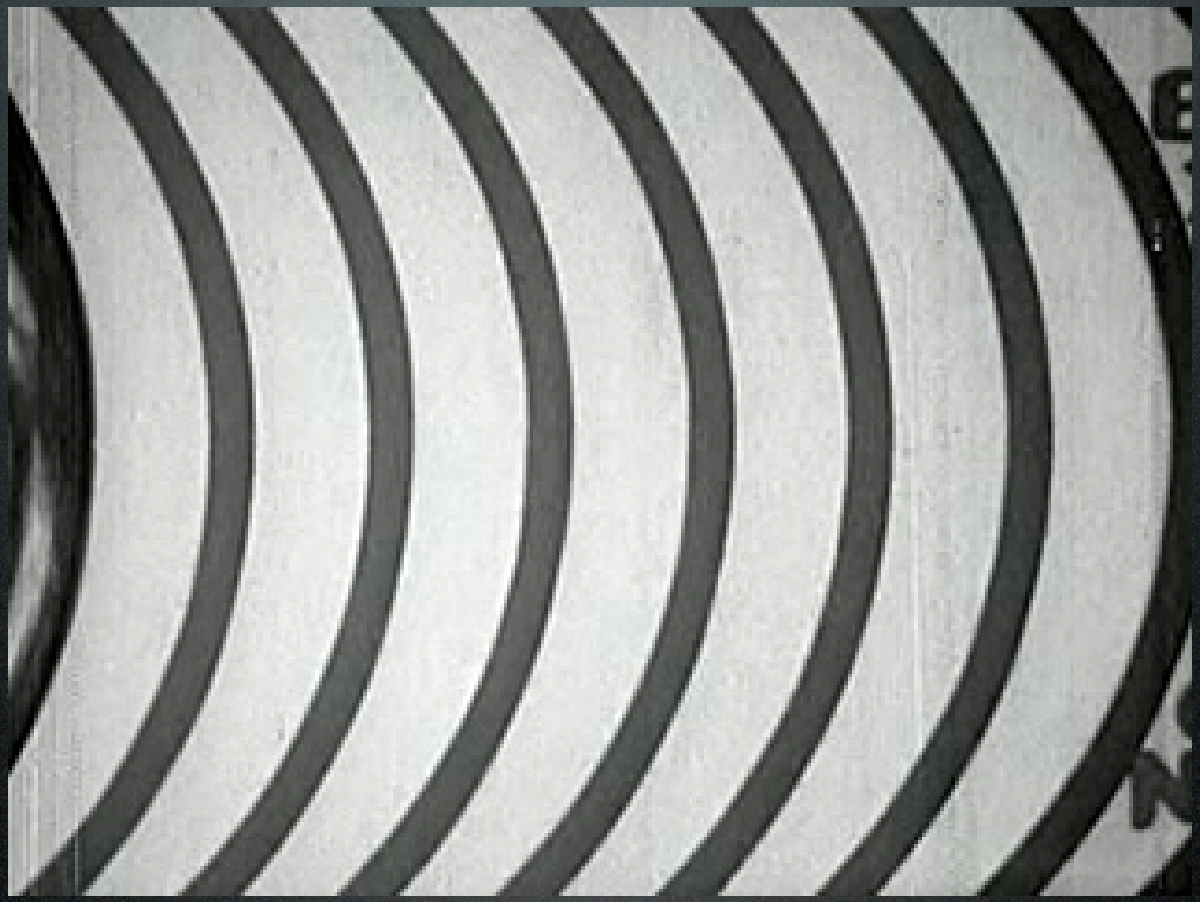
# What is sound?

- **Sound** is the result of alternating waves of pressure (areas of high and low density) propagating outward from a resonating source.
- **Sound travels** as particles within a compressible matter (solid, liquid, or gas) are alternately displaced by a sound wave.



# How is it measured?

- **Frequency** is determined by the number of oscillations/compressions ("waves") occurring per second.
- **Wavelength** is determined by frequency in relationship to speed of sound.



- **Frequency** is measured in Hertz (Hz).
- **Sound travels** in average air temperature at speed of 330 meters per second.
- **So….** what about wavelength?

# Let's talk about light...

## Electromagnetic Radiation (EM)

EM is everywhere!

electrical energy (50-60Hz)
am radio waves
fm radio waves
microwaves/radar
infrared light
visible light (405-790 billion Hz)
ultraviolet light
x-rays
gamma radiation (30-300 quintillion Hz)

Light is...

Electromagnetic Radiation (EM)

Sound is **not.**

# Why do I care?

...because you don't live in a vacuum.

# Sound

* Alternating pressure waves.
* Needs matter in order to travel.
* Frequency determines perception.

# Light

* Alternating EM waves.
* Can travel in a vacuum.
* Frequency determines perception.

# How is sound measured?

- Frequency
- Wavelength
- Amplitude

# Sound Amplitude...

- is determined by the intensity of the expansion and contraction of matter by sound waves.
- is also referred to as “sound pressure level,” or “spl” for short.
- is measured in decibels (db).

# Jimmy Foster

# Phil Hansen


# The Nature of Sound

**(1947)**

Back to amplitude...

# Amplitude Ranges

| Source | Intensity | Intensity Level | # of Times Greater Than TOH |
|---|---|---|---|
| Threshold of Hearing (TOH) | $1*10^{-12}$ W/m$^2$ | 0 dB | $10^0$ |
| Rustling Leaves | $1*10^{-11}$ W/m$^2$ | 10 dB | $10^1$ |
| Whisper | $1*10^{-10}$ W/m$^2$ | 20 dB | $10^2$ |
| Normal Conversation | $1*10^{-6}$ W/m$^2$ | 60 dB | $10^6$ |
| Busy Street Traffic | $1*10^{-5}$ W/m$^2$ | 70 dB | $10^7$ |
| Vacuum Cleaner | $1*10^{-4}$ W/m$^2$ | 80 dB | $10^8$ |
| Large Orchestra | $6.3*10^{-3}$ W/m$^2$ | 98 dB | $10^{9.8}$ |
| Walkman at Maximum Level | $1*10^{-2}$ W/m$^2$ | 100 dB | $10^{10}$ |
| Front Rows of Rock Concert | $1*10^{-1}$ W/m$^2$ | 110 dB | $10^{11}$ |
| Threshold of Pain | $1*10^{1}$ W/m$^2$ | 130 dB | $10^{13}$ |
| Military Jet Takeoff | $1*10^{2}$ W/m$^2$ | 140 dB | $10^{14}$ |
| Instant Perforation of Eardrum | $1*10^{4}$ W/m$^2$ | 160 dB | $10^{16}$ |

Damage to human hearing starts occurring at 90db and above.

# SPL Meter

- measures sound pressure level in decibels (db)

# “Noise Floor”

- average level (amplitude) of ambient room sound
- evaluation and quantification of sonic environments
- important consideration when recording and mixing (40db and below is desirable)

# “Equal Loudness Curve”

...more on this later.

# Linear systems...

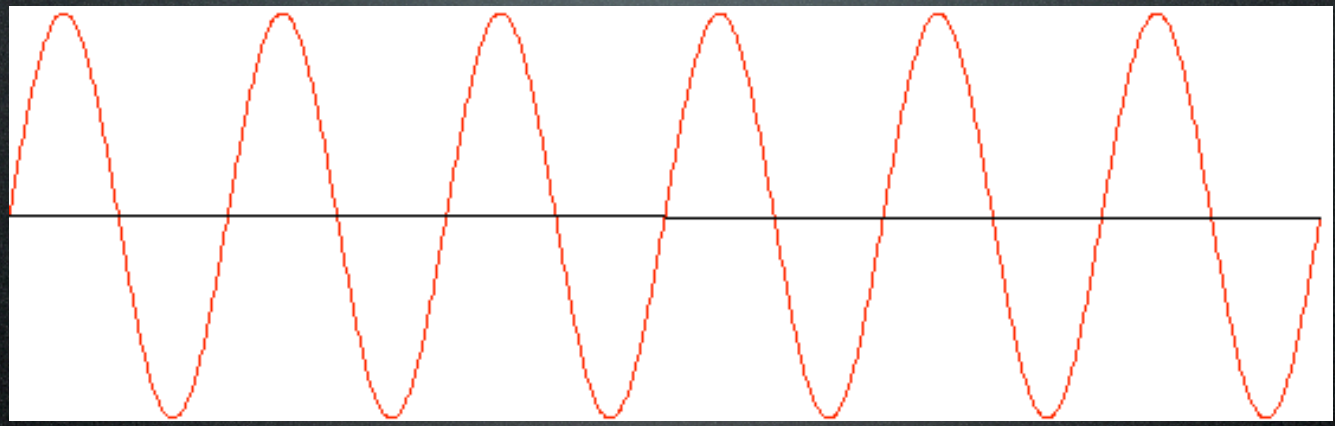
# Fourier Analysis

- Waveform Oscilloscope
- Sonogram

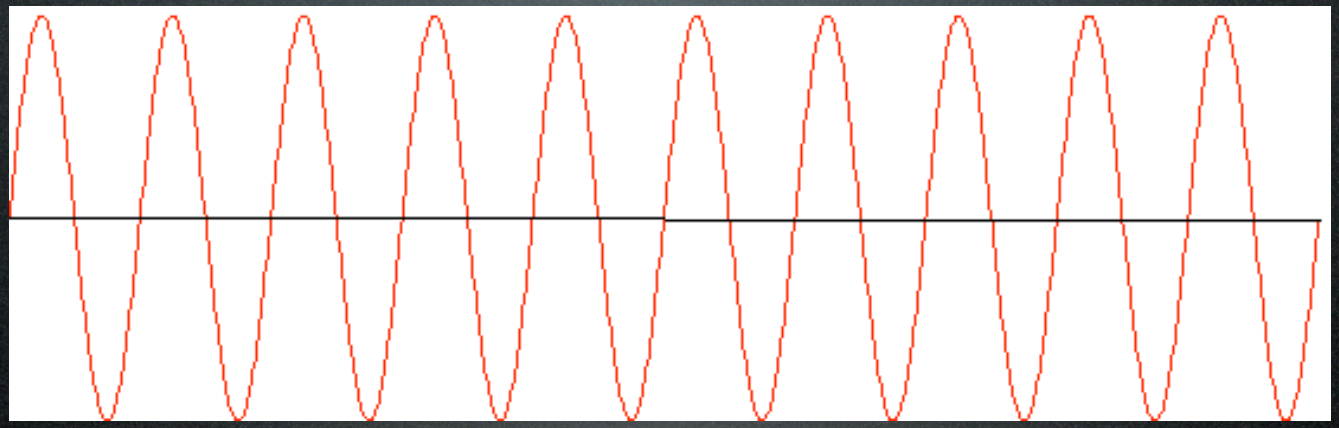
# Sine Waves

- Linear
- Core component for modeling more complex waves.
- Frequency defines pitch.

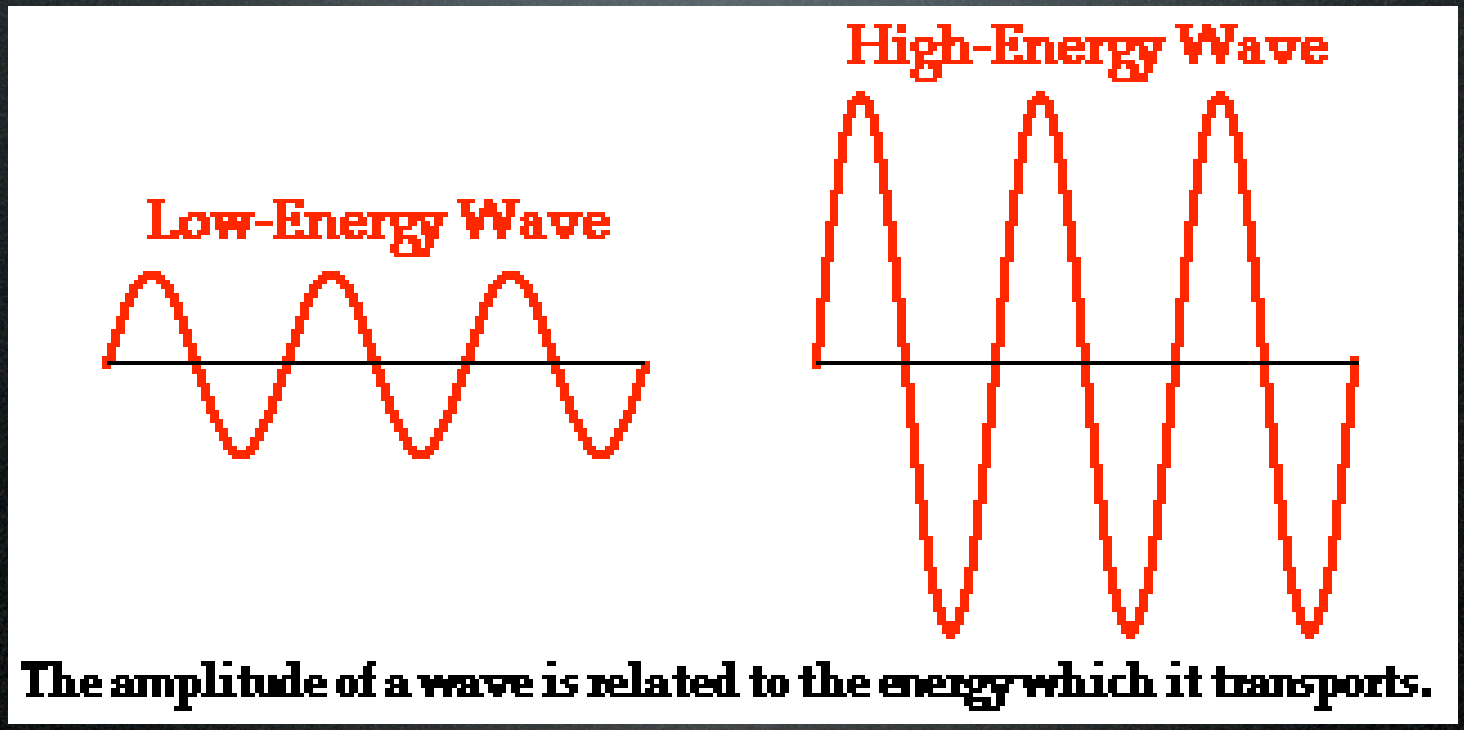
# 300 Hz



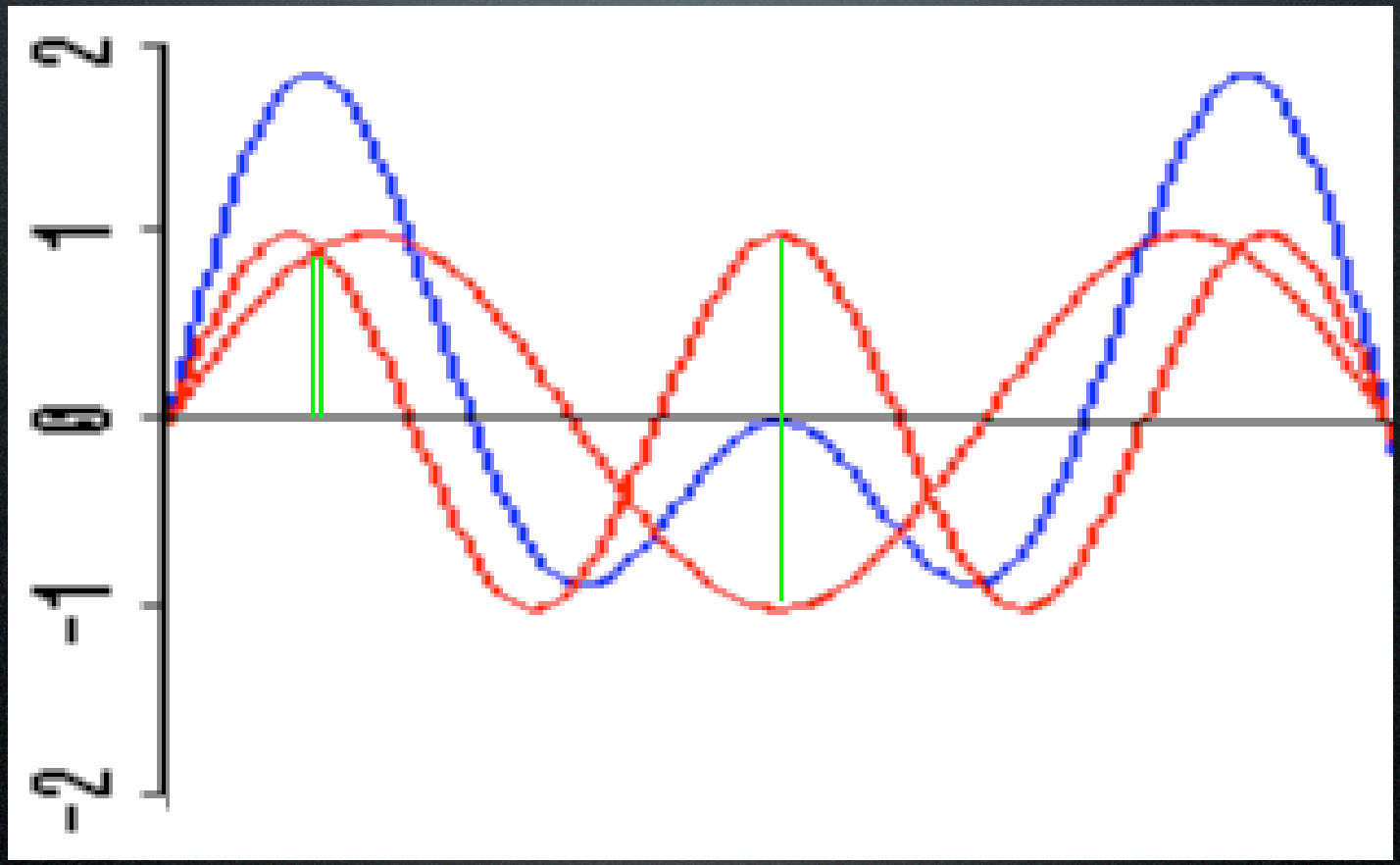
# 500 Hz



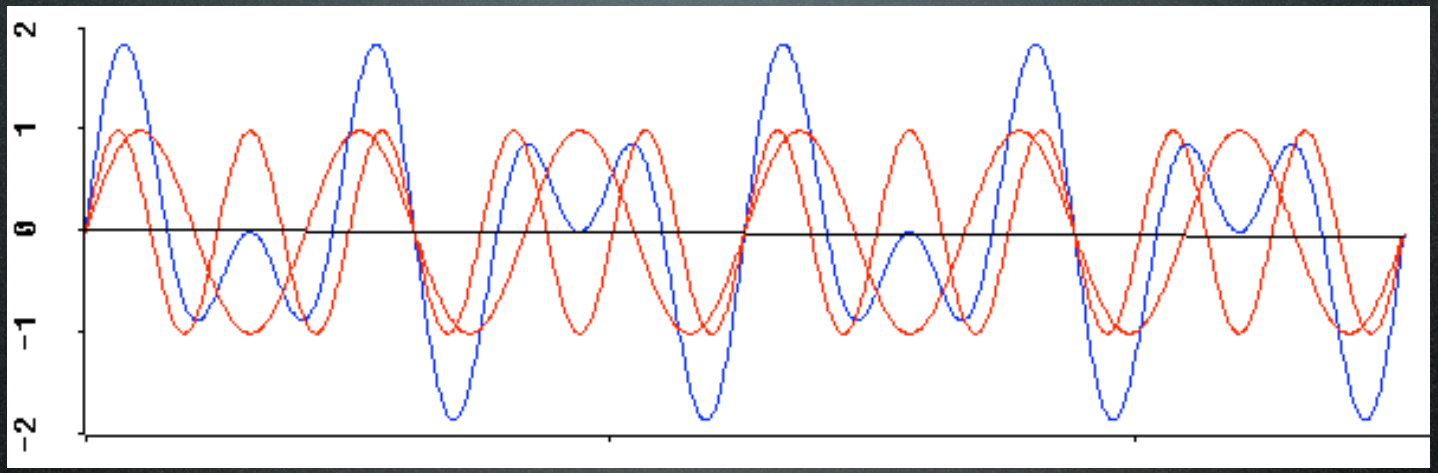
# Sine Waves and Amplitude

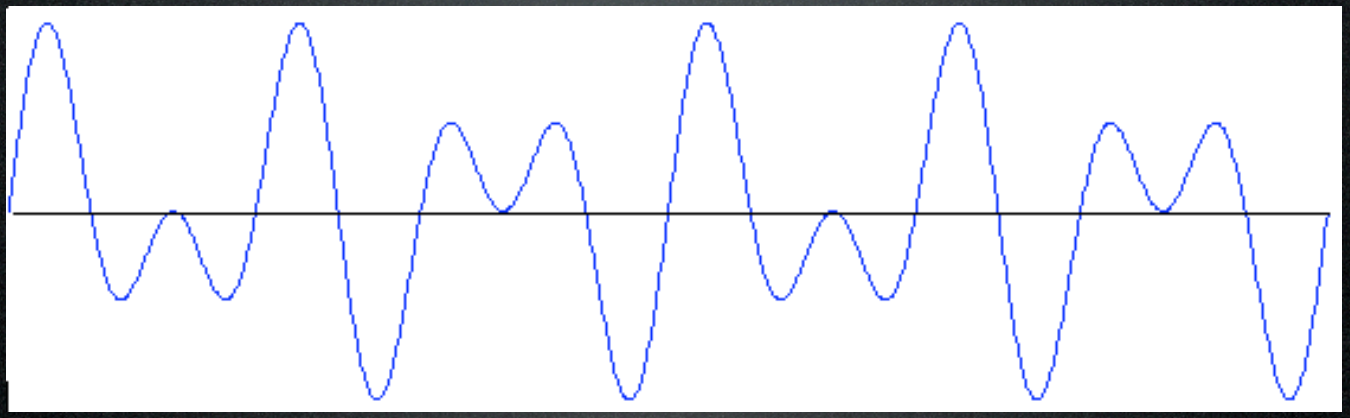


# Combination of Sine Saves



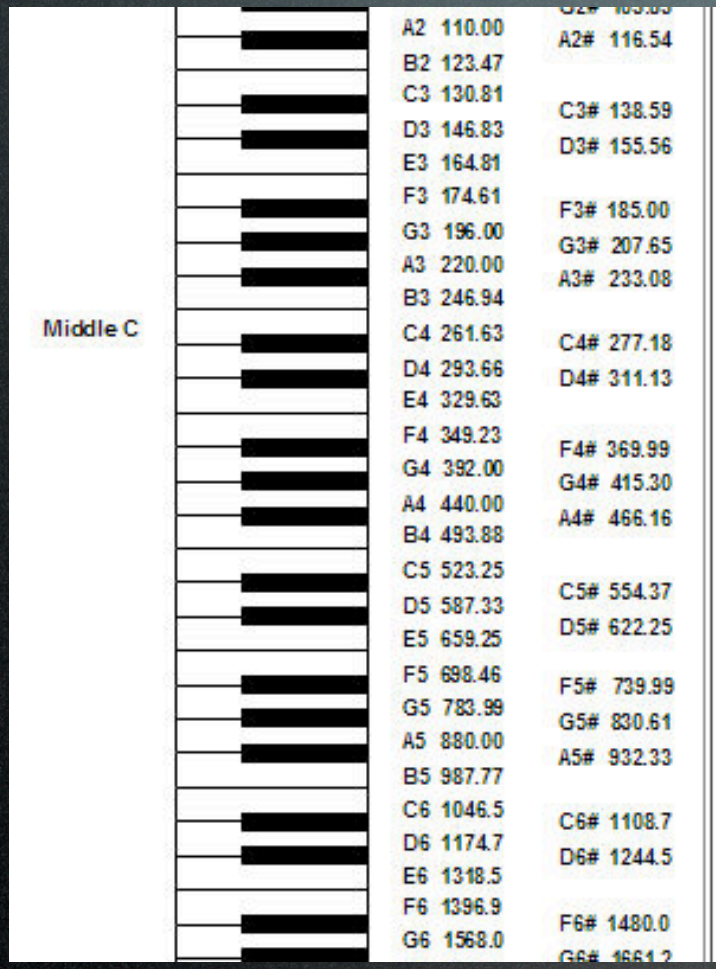
# 300 + 500 Hz



Back to light and sound...

| | |
|---|---|
| Red | 480-405 THz |
| Orange | 510-480 THz |
| Yellow | 530-510 THz |
| Green | 600-530 Thz |
| Cyan | 620-600 Thz |
| Blue | 680-620 Thz |
| Violet | 790-680 Thz |




## PIANO KEYBOARD

The number beside each key is the fundamental frequency in units of cycles per seconds, or Hertz.

## OCTAVES

For example, the A4 key has a frequency of 440 Hz.

Note that A5 has a frequency of 880 Hz. The A5 key is thus one octave higher than A4 since it has twice the frequency.

## OVERTONES

An overtone is a higher natural frequency for a given string. The overtones are "harmonic" if each occurs at an integer multiple of the fundamental frequency.

# The “quality” of sound…

- Upper harmonics of a sound give the sound it’s distinctive character.
- Can be analyzed and viewed by fourier analysis
- Demonstration…

# What have we covered?

- What is sound?
- How does it travel?
- Frequency?
- Hertz?
- Amplitude?
- Decibels?
- Sound Pressure Level?
- Electro Magnetic Radiation?
- How light compares to sound?
- db?

# What have we covered?

- spl?
- Hearing loss begins at what db level?
- spl meter?
- Noise floor?
- Linear system?
- Fourier Analysis?
- Sonogram?
- Waveform Oscilloscope?
- Sine Waves?
- What defines sound quality?

Bye, Bye.