# Topic 1

## Recording & Sampling

# The Edison Cylinder Recorder

# Recording sound

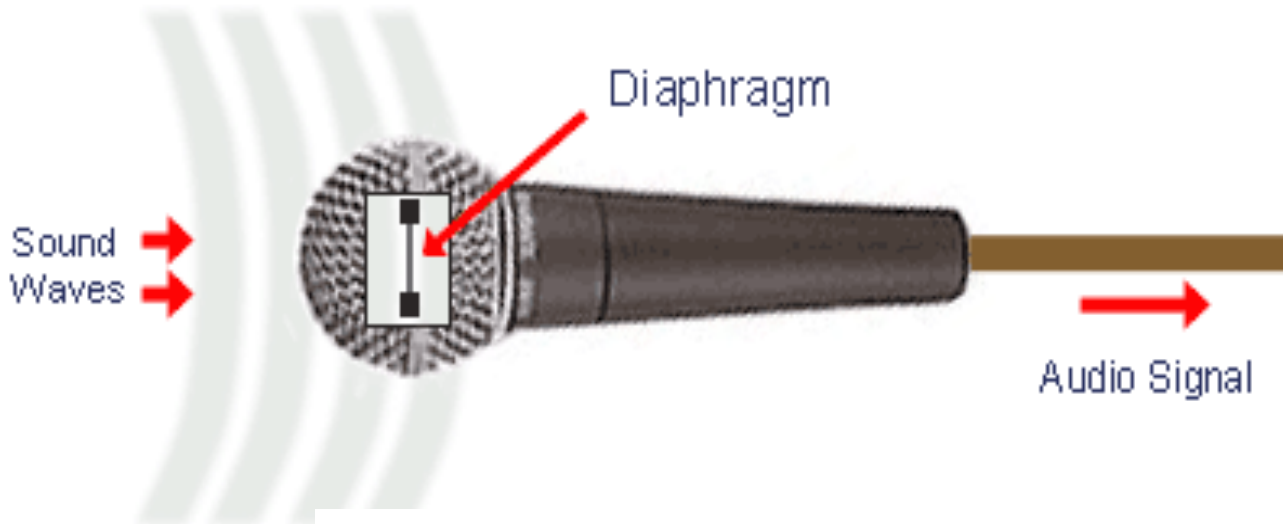
Mechanical Vibration

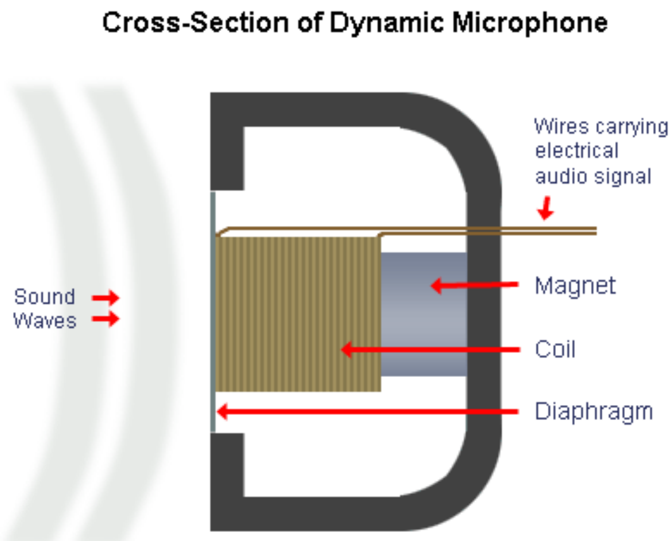
Pressure Waves

Motion->Voltage Transducer

Voltage over time

# Microphones



# Magnetic tape

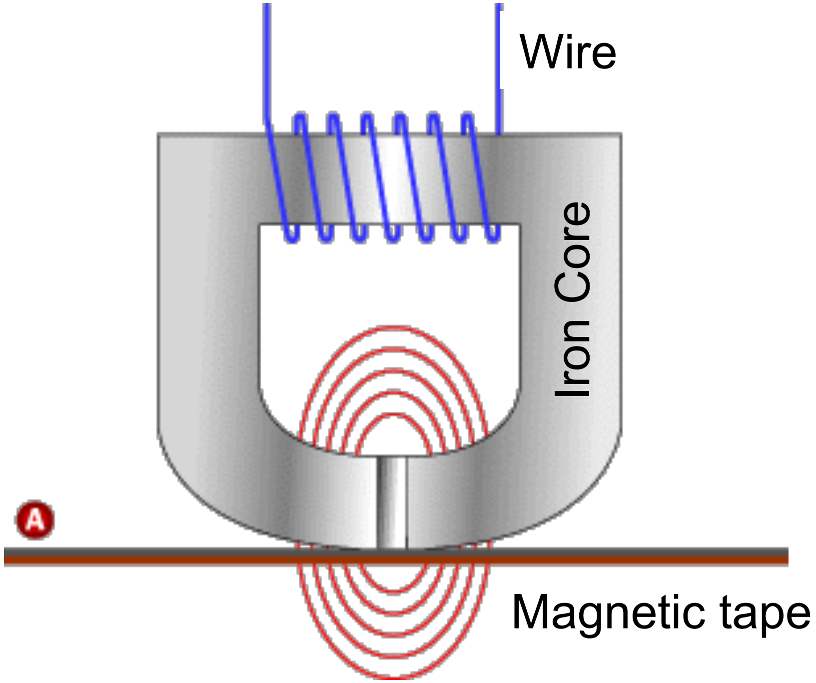
**Recording**
audio signal is sent through the coil of wire to create a **magnetic field** in the core.

At the gap, magnetic flux forms a **fringe pattern** that magnetizes the oxide on the tape.

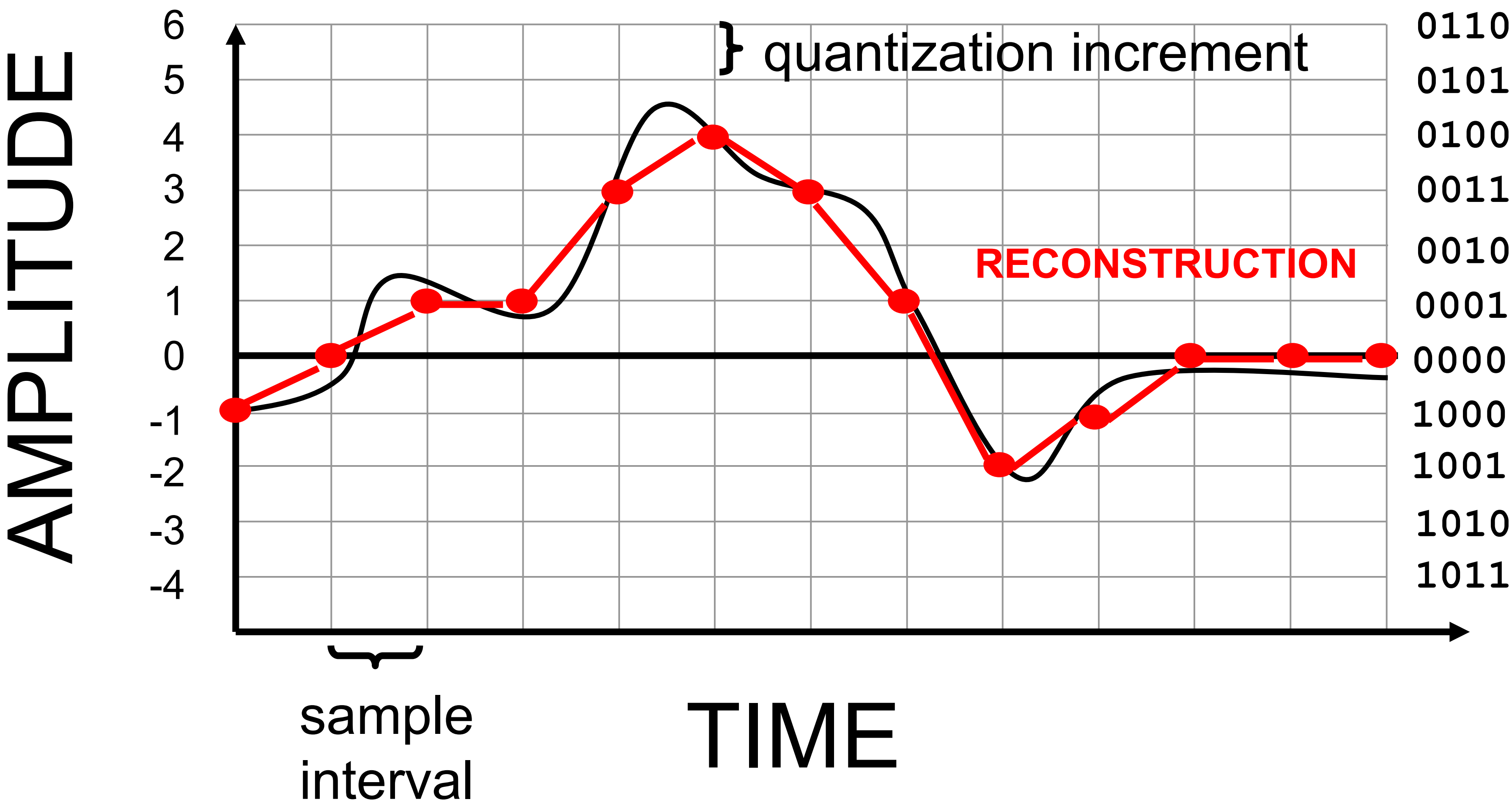
**Playback**
The motion of the tape pulls a varying magnetic field across the gap.

This creates a varying magnetic field in the core and therefore a signal in the coil.

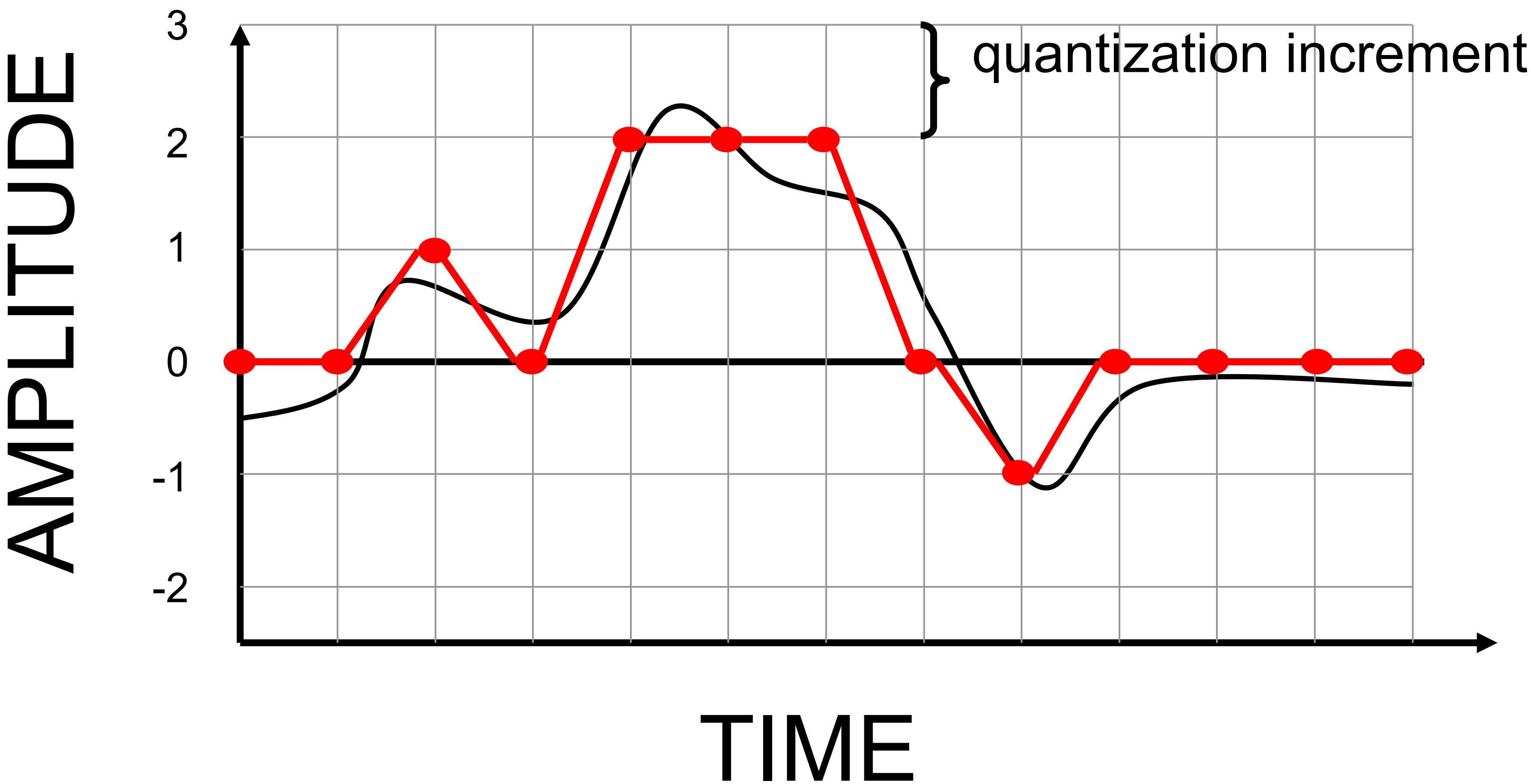
This signal is amplified to drive the speakers.




# Digital Sampling



# More quantization levels mean more dynamic range

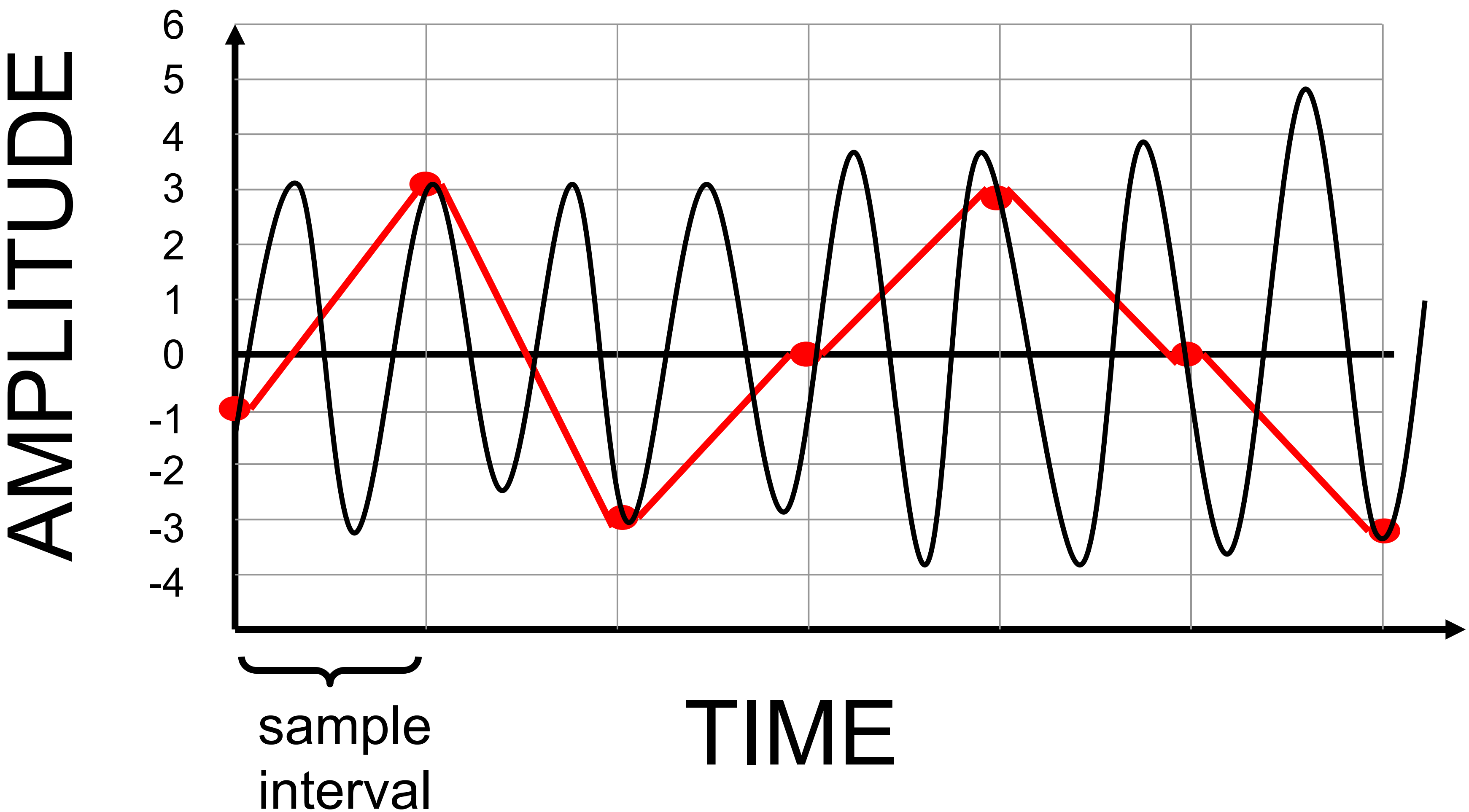


# Bit depth and dynamics

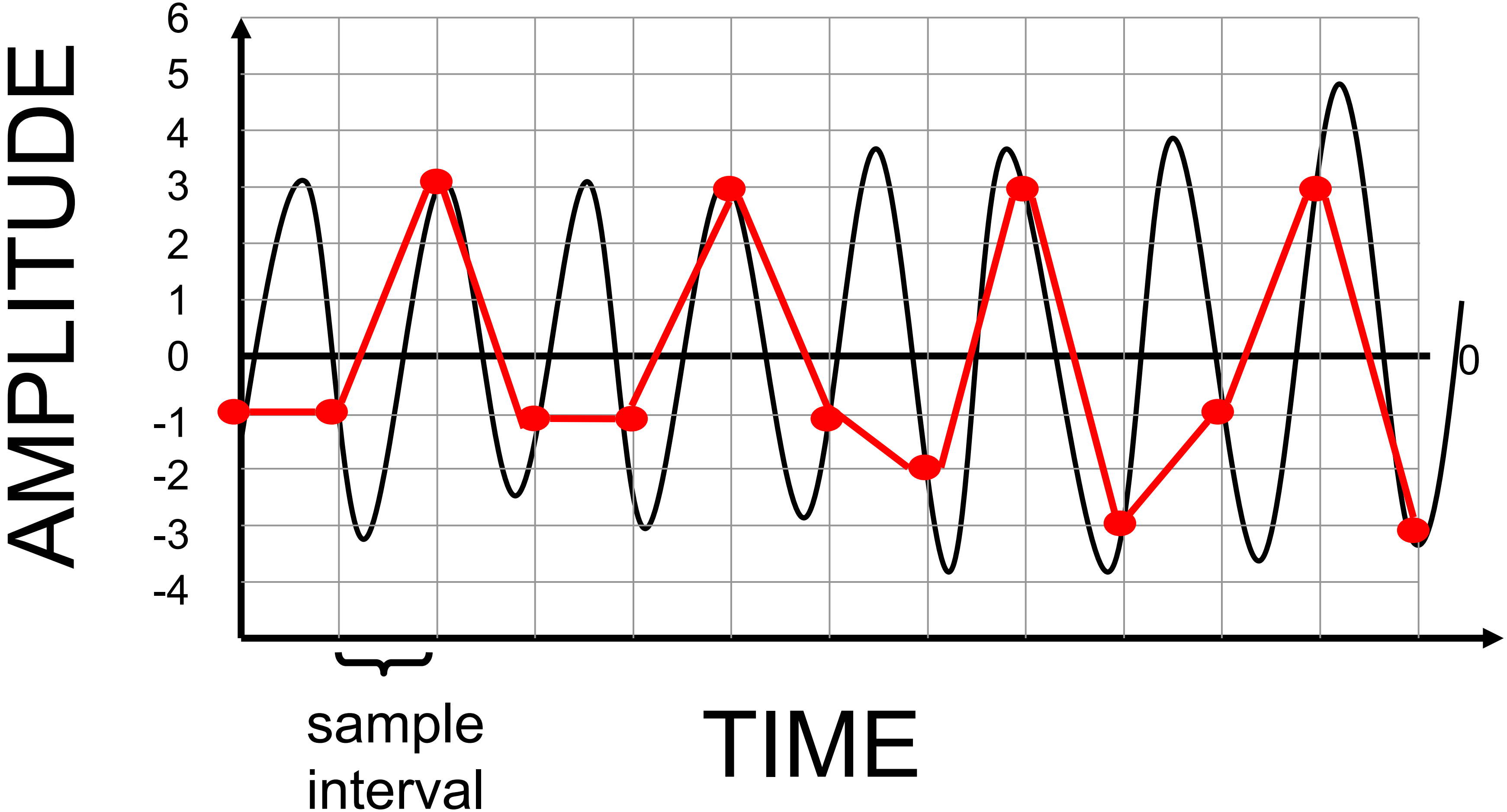
- More bits = more quantization levels
- More quant. levels = more dynamic range
- More dynamic range = better sound

- Compact disc = 16 bits = 65,536 levels
- POTS = 8 bits = 256 levels

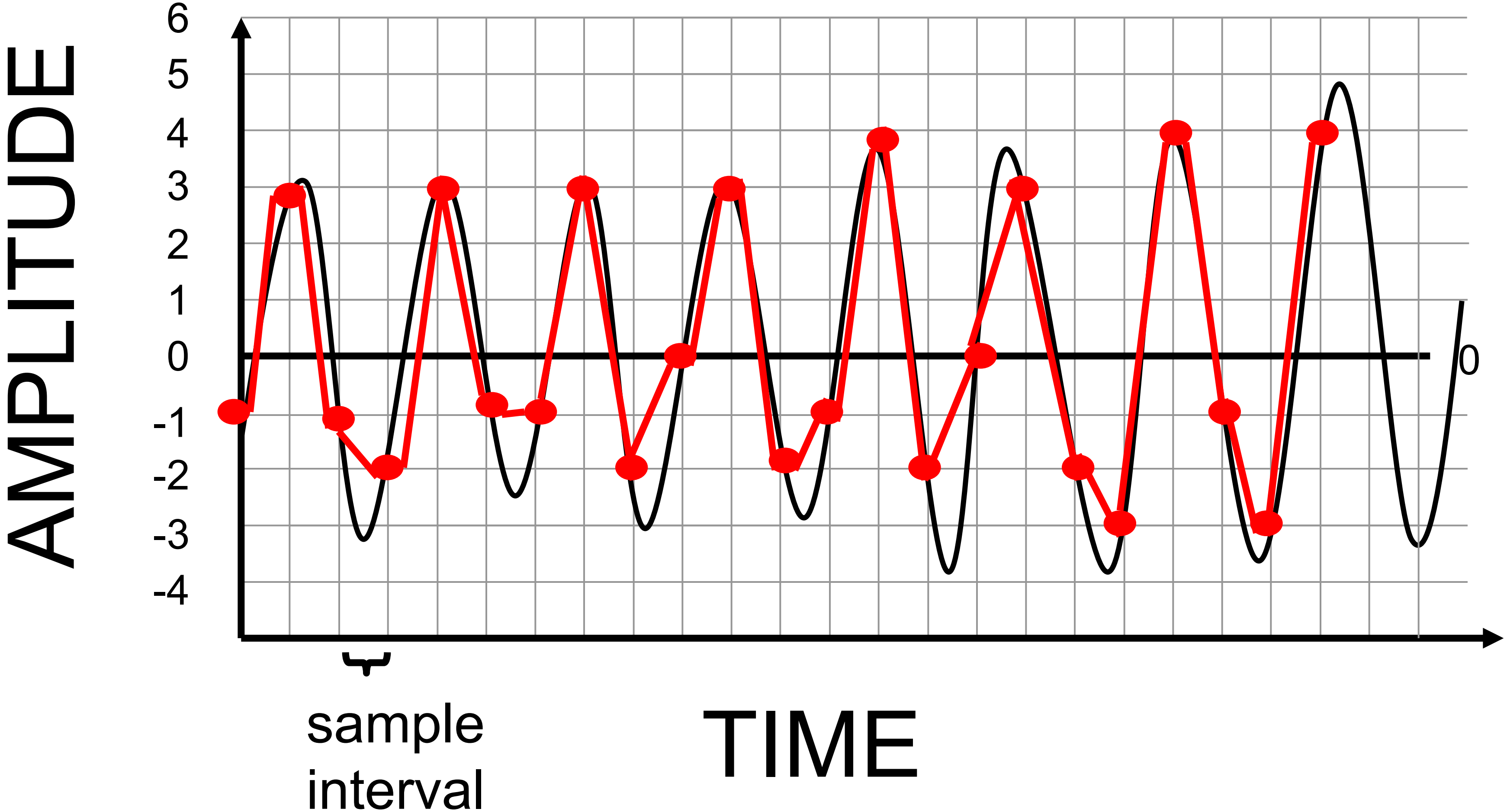
# Faster sample rates = better reconstruction



# Aliasing and Nyquist



# Aliasing and Nyquist



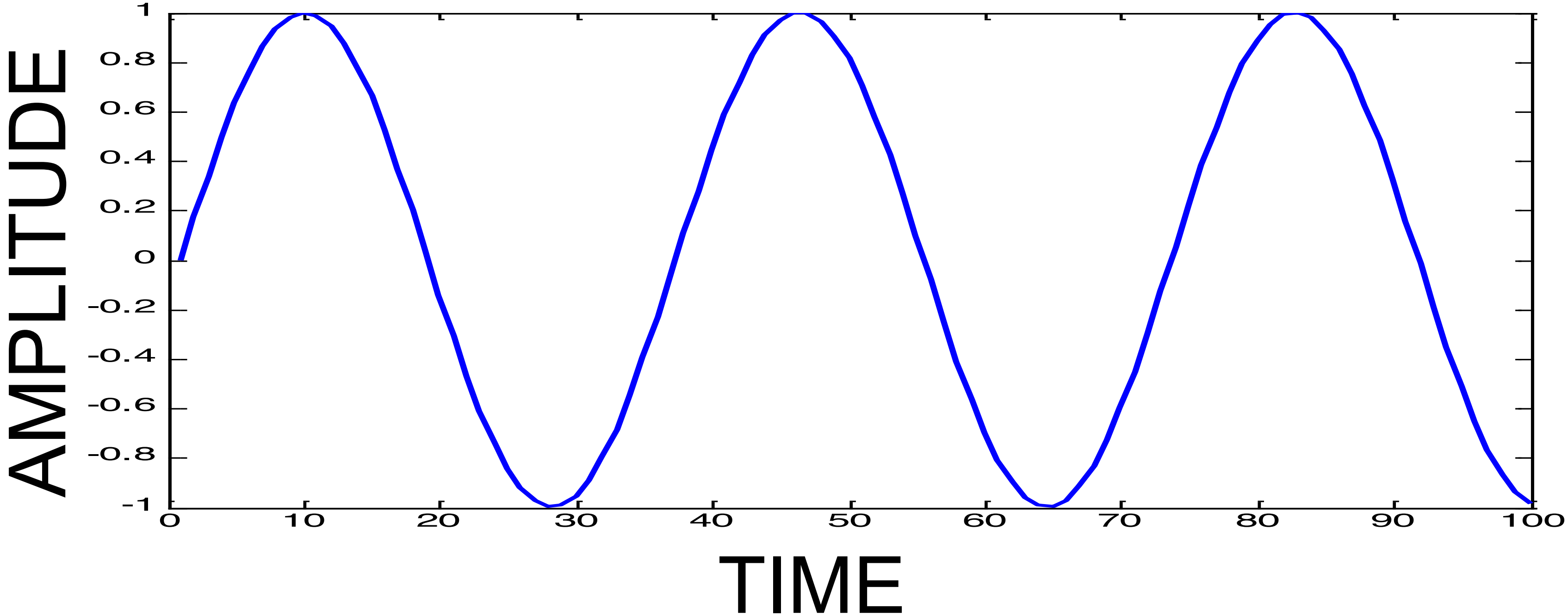
# Sample rates

- You can't reproduce things if your sample rate isn't fast enough to catch them
- Nyquist frequency (def 1)
  - Over twice the frequency of the highest frequency you want to represent
- Nyquist frequency (def 2)
  - ½ the sample frequency…

# Common Encodings

- Compact Disc
  - 16 bits
  - 44,100 Hz
- POTS (Plain old telephone service)
  - 8 bits
  - 8,000 Hz
- MP3
  - It’s complicated. Tell you later.

# Pure Tone = Sine Wave




$$x(t) = A\sin(2\pi f + \phi)$$

time

amplitude

frequency

phase

# Reminders

- Frequency, $f = 1/T$ is measured in cycles per second , AKA *Hertz* (*Hz*).

- One cycle contains $2\pi$ *radians.*

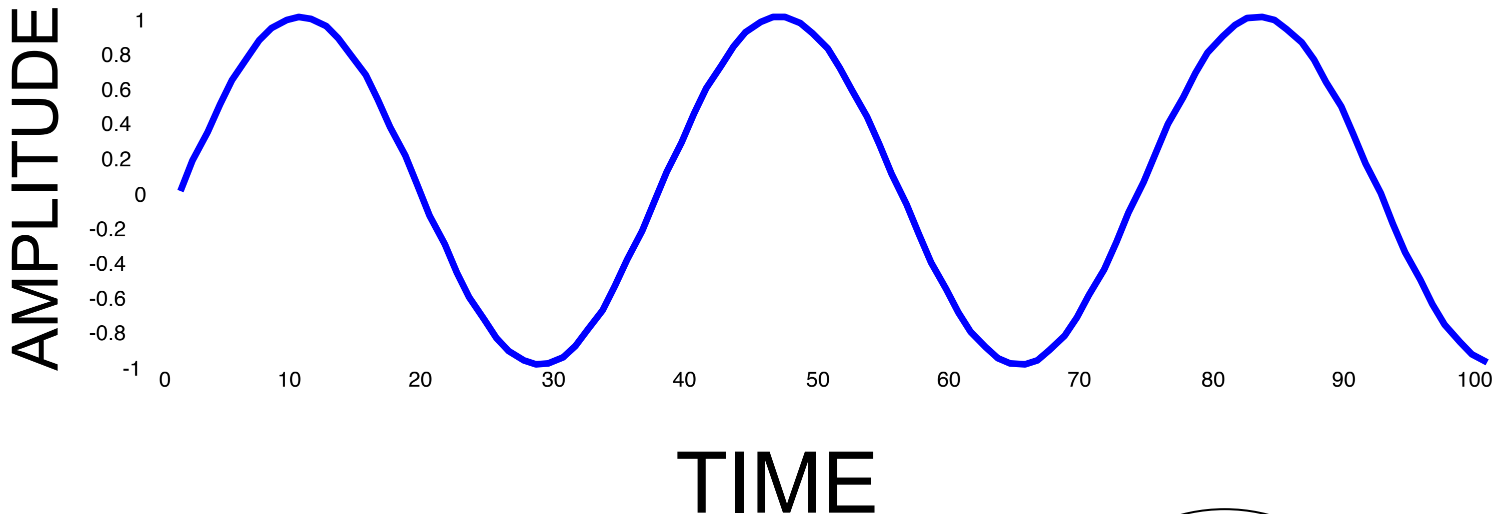
  »

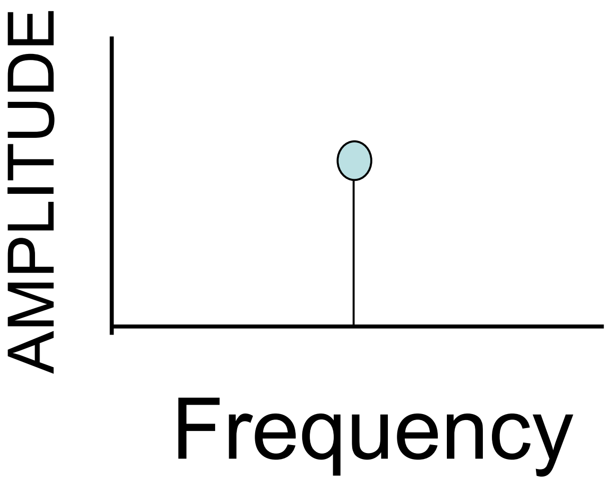
- Angular frequency, $\omega$, is measured in radians per second and is related to frequency by $\omega = 2\pi f$

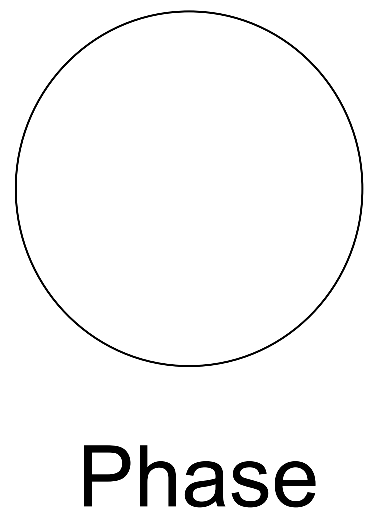
- So we can rewrite the sine wave as

$$x(t) = A\sin(\omega t + \phi)$$

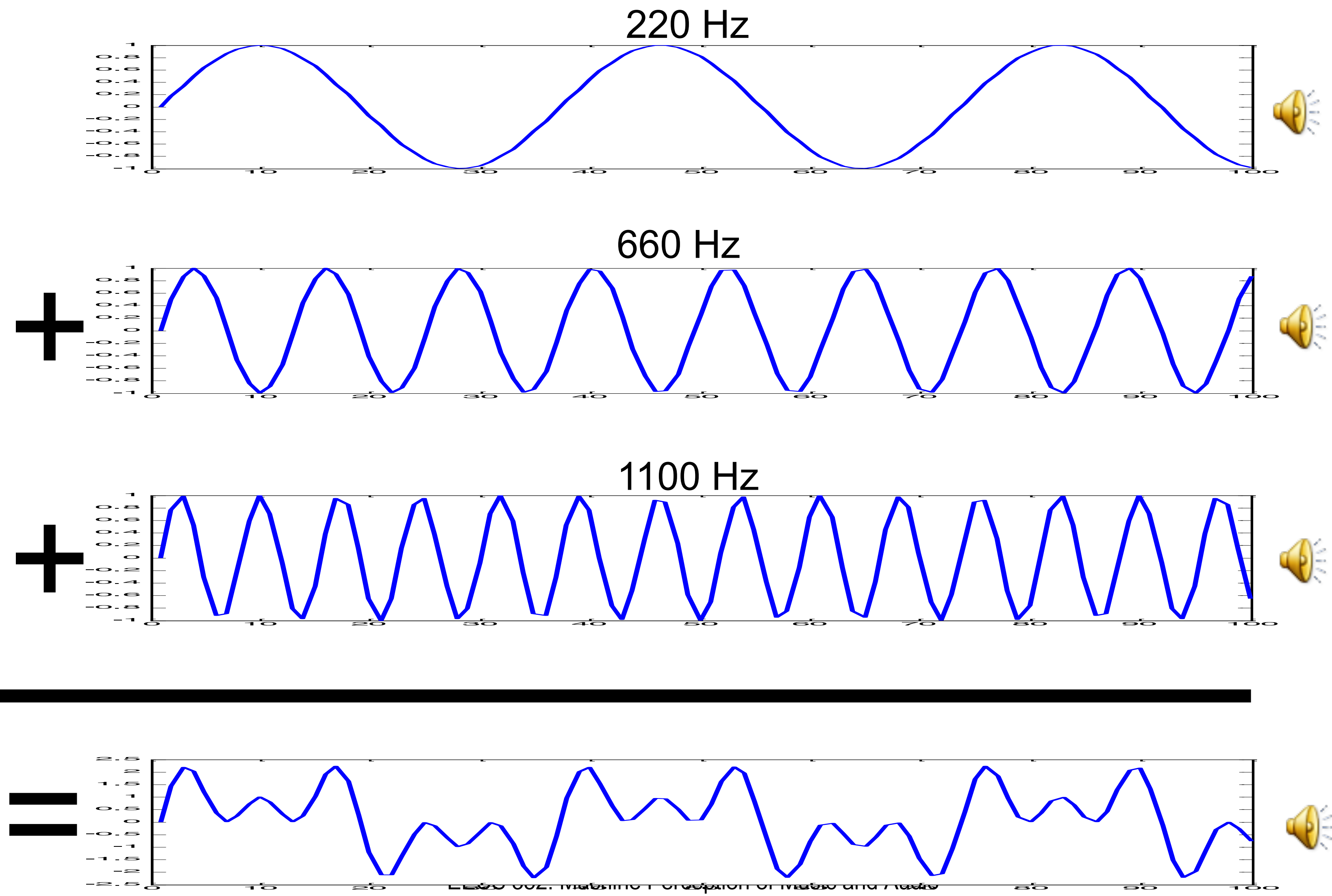
# Alternate Representation



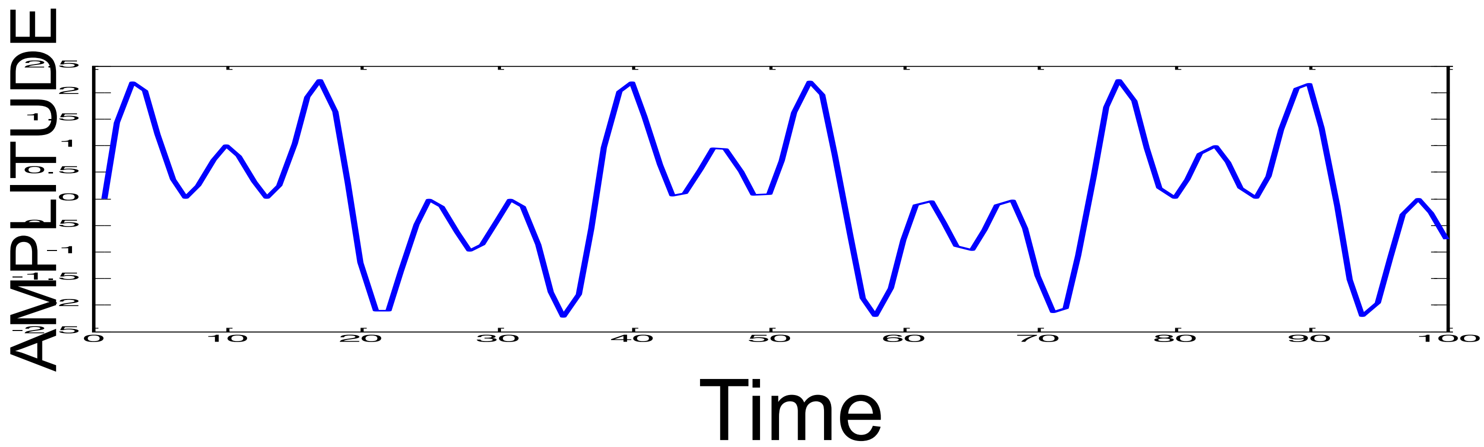



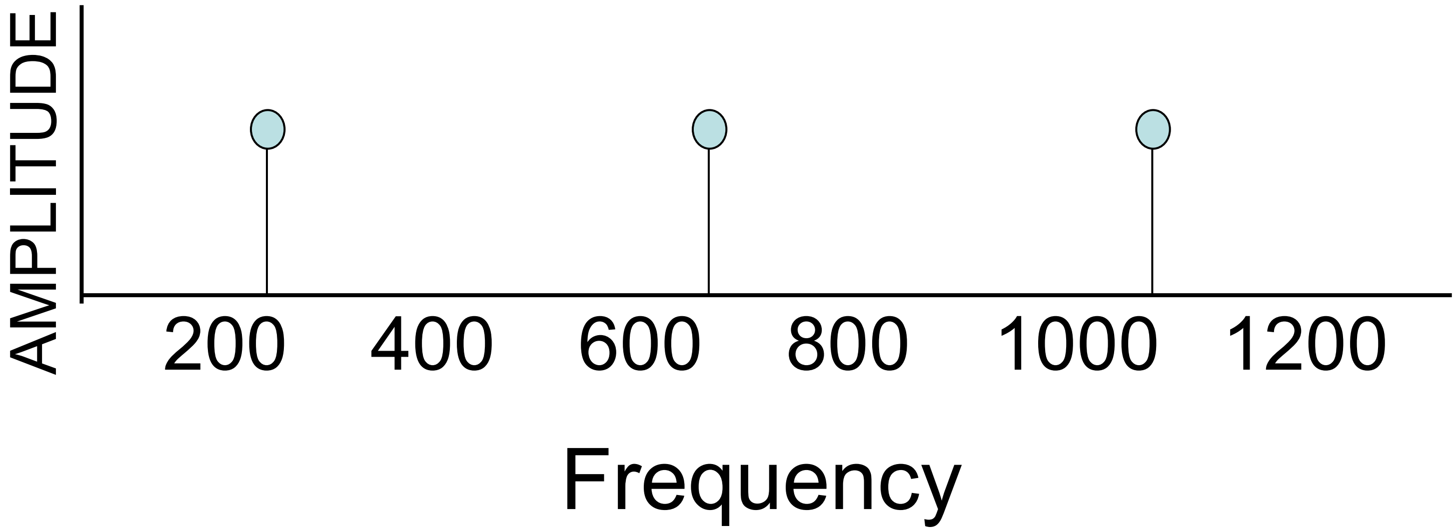



# Complex Tone = Sine Waves



# Alternately



# Harmonic Sound

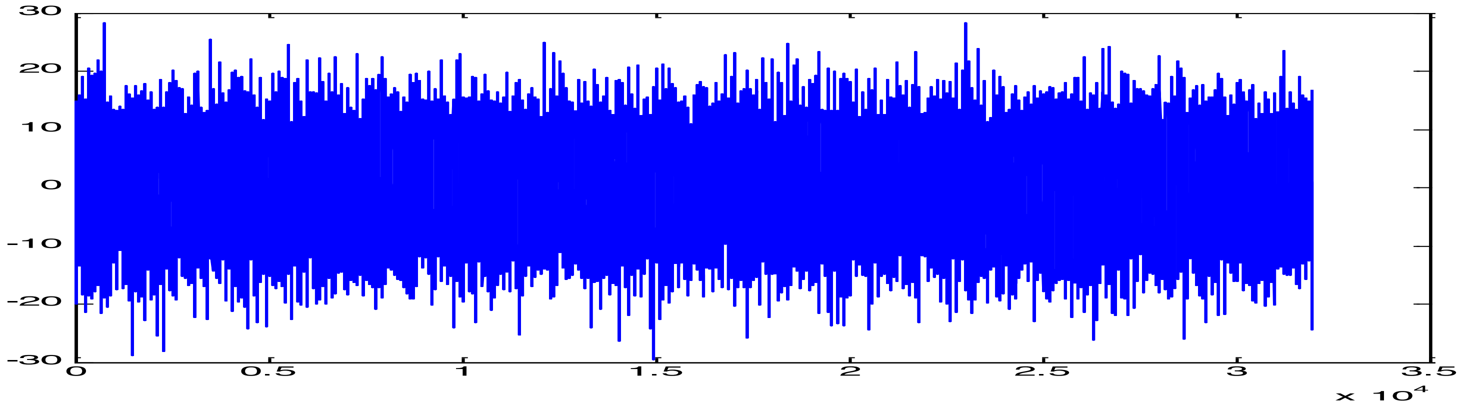
- 1 or more sine waves
- Strong *components* at INTEGER MULTIPLES of a *FUNDAMENTAL FREQUENCY in the range of human hearing (20 Hz to 20,000 Hz)*

- *Examples*

  *220 + 660 + 1100 is HARMONIC*

  *100 + 220 + 263 is NOT HARMONIC*

# Noise




- Lots of sines at random freqs. = NOISE
- Example: 100 sines with random frequencies, such that $100 < f < 10000$

# A Fun Example (Thanks to Robert Remez)