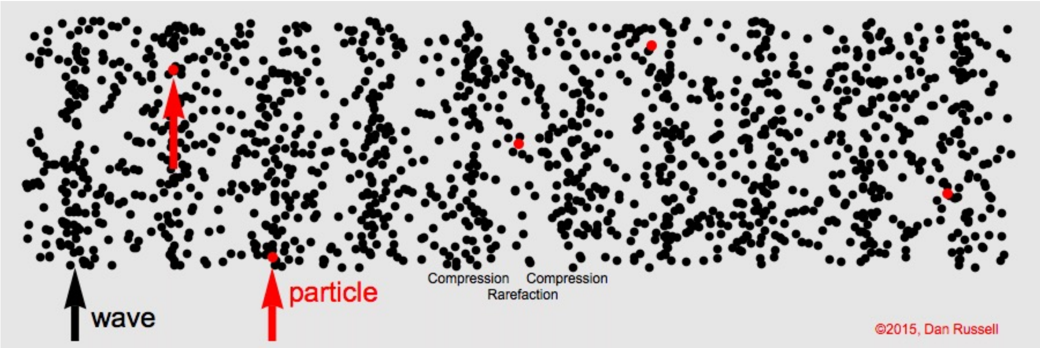
Sound

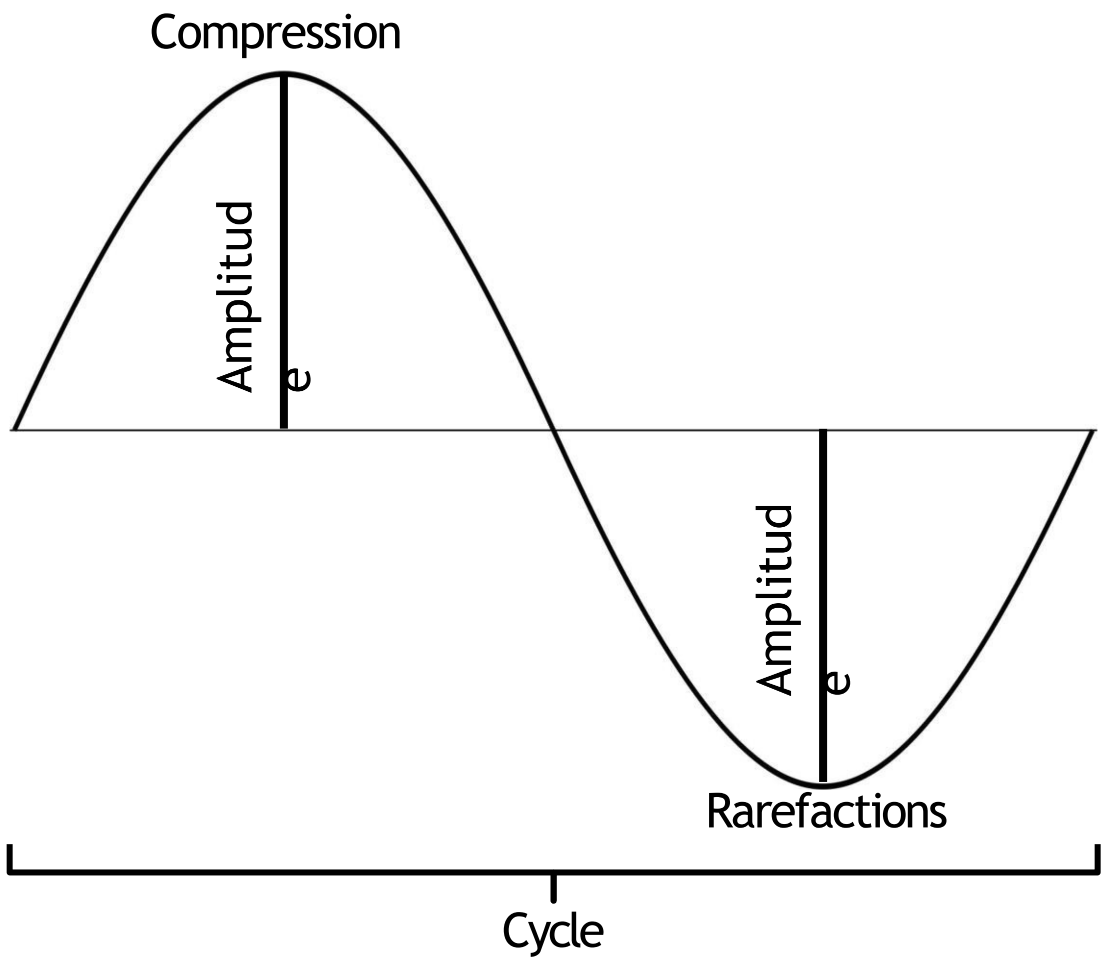
What is Sound?



- Travels as waves of energy
- As the energy travels through the air, it moves the particles causing themto collide with one another
- Each time the particles collide they transfer energy, but a little lesseach time

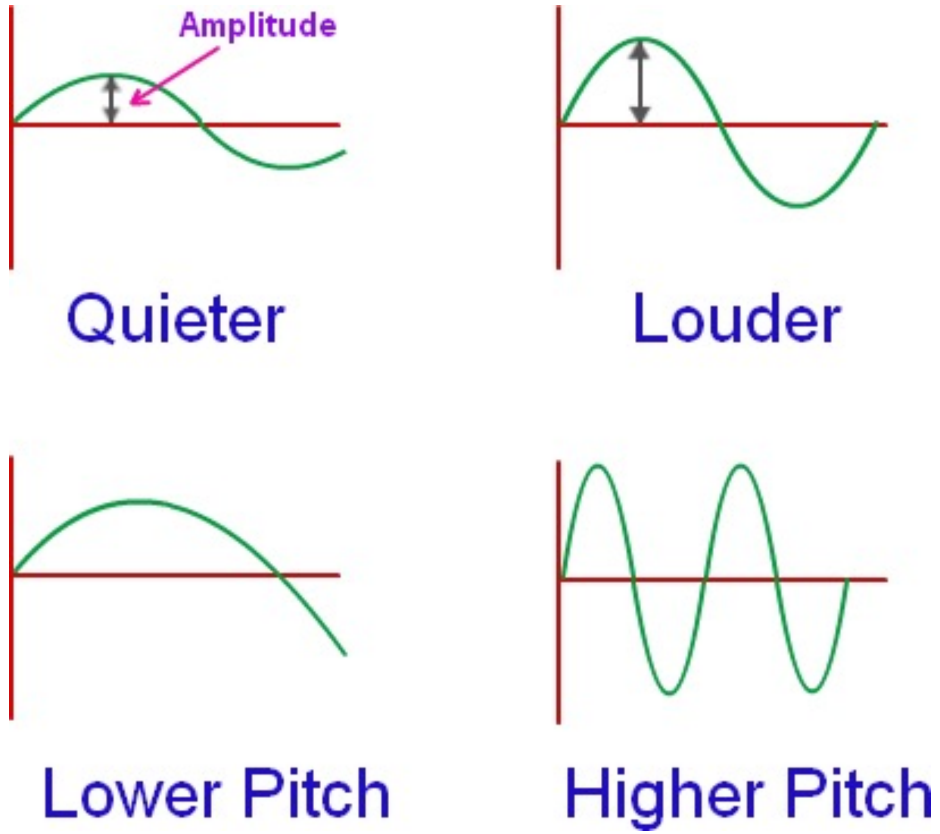
Compressions and Rarefactions

- Compressions are points of increased pressure
- Rarefactions are area of low pressure in the sound wave
- The distance between a compression and rarefaction is a cycle
- The distance between a point of no pressure and the highest or lowest pressure is called amplitude



Amplitude and Frequency

- Amplitude contributes to loudness (intensity) of a sound
- Higher the peaks, the louder the sound
- Frequency contributes to the pitch of the sound.
- Shorter cycles make a higher pitch than longer cycles

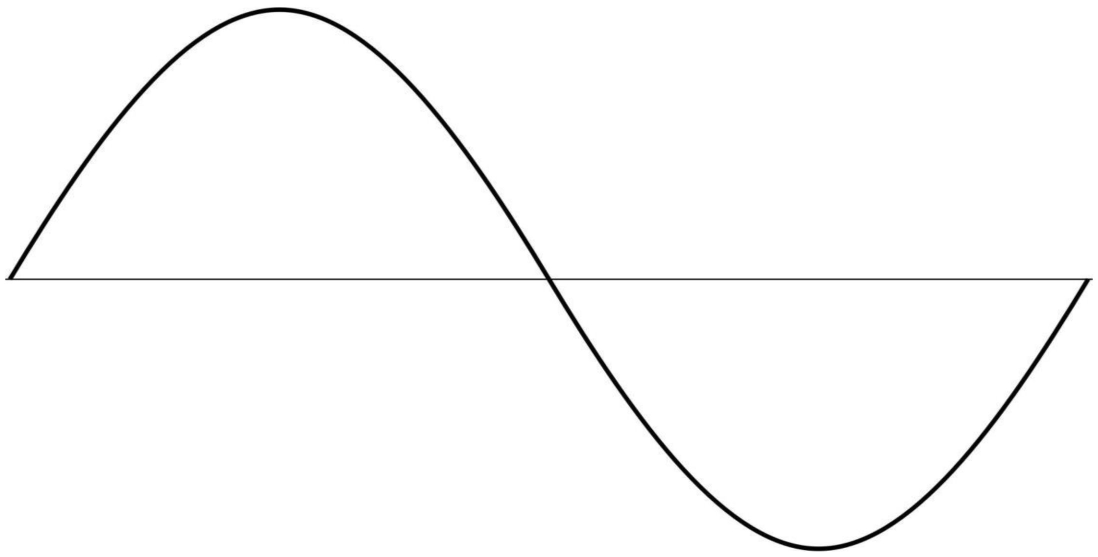


Units in Sound

- Frequency or pitch is measured in cycles per second (cps) or Hertz (Hz)
- Increases in pitch mean an increase in Hertz
- Changes in volume, or amplitude are measured in decibels (dB)
- Volume and pitch are both perceived logarithmically (as a ratio and not absolute changes)

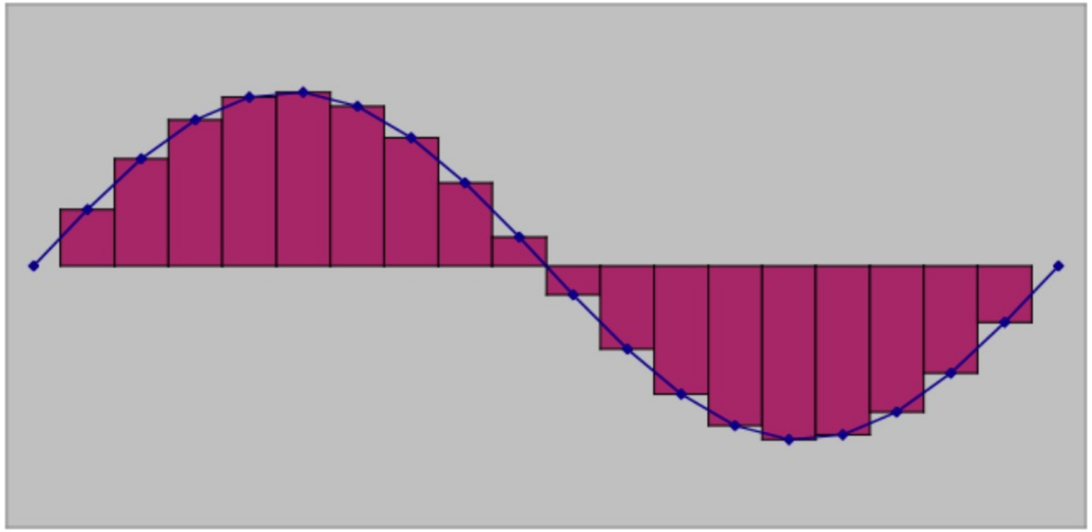
Encoding Sound

- Sound is analog (continuous)
- We need a way to digitize it into a discrete approximation
- Higher pressure == Compressions
- Negative numbers == Rarefactions



Analog to Digital Conversion

- We create and approximation by observing momentary values ofthe analog signal
- This method is calledsampling
- Nyquist theorem says tocapture a sound with a most *n* cycles per second, we need 2*n*samples per second
- The sample rate (how oftenwe record the sound values) is measured inHertz.



Encoding Sound

- The sampling technique is called pulse code modulation
- Once again, we use binary
- Sample tend to be 2 bytes or 16 bits
- Unlike images, we need to store positive AND negative numbers
- For that, we need a slightly different representation of our numbers
- We call this representation two's compliment notation

Two's Compliment Notation

- If we have 16 bits, the maximum value we could have is all 1's
  - 11111111 11111111 =65,535
- However, we need to use those bits for positive and negative numbers
- Simple solution would be to keep one bit to represent the *sign* of the number (0 for + or 1 for -)
- This leave15-bits
  - Possible combinations: $2^{15} = 32,768$
  - Since 0 takes a positive value the range is -32,768 to 32,767

Representing a Negative Number

- Let's say we have 20 in binary
  - 00010100
- To make -20, we first invert all the binary digits (1 -> 0 and 0 -> 1)
  - 11101011
- Then we add one to that result
  - ```
      11101011
    + 00000001
    --------------------
      11101100 = -20
    ```
    ```

Clipping

- What if a sound's value is outside the range of -32,768 and 32,767
- Since our binary representation cannot support those values, they are simply cut off or "clipped" at the maximum values