Audio signal

- Representation of sound

- Encodes all info we need to reproduce sound

Houston we have a problem!

Houston we have a problem!

Analog

Digital

VS
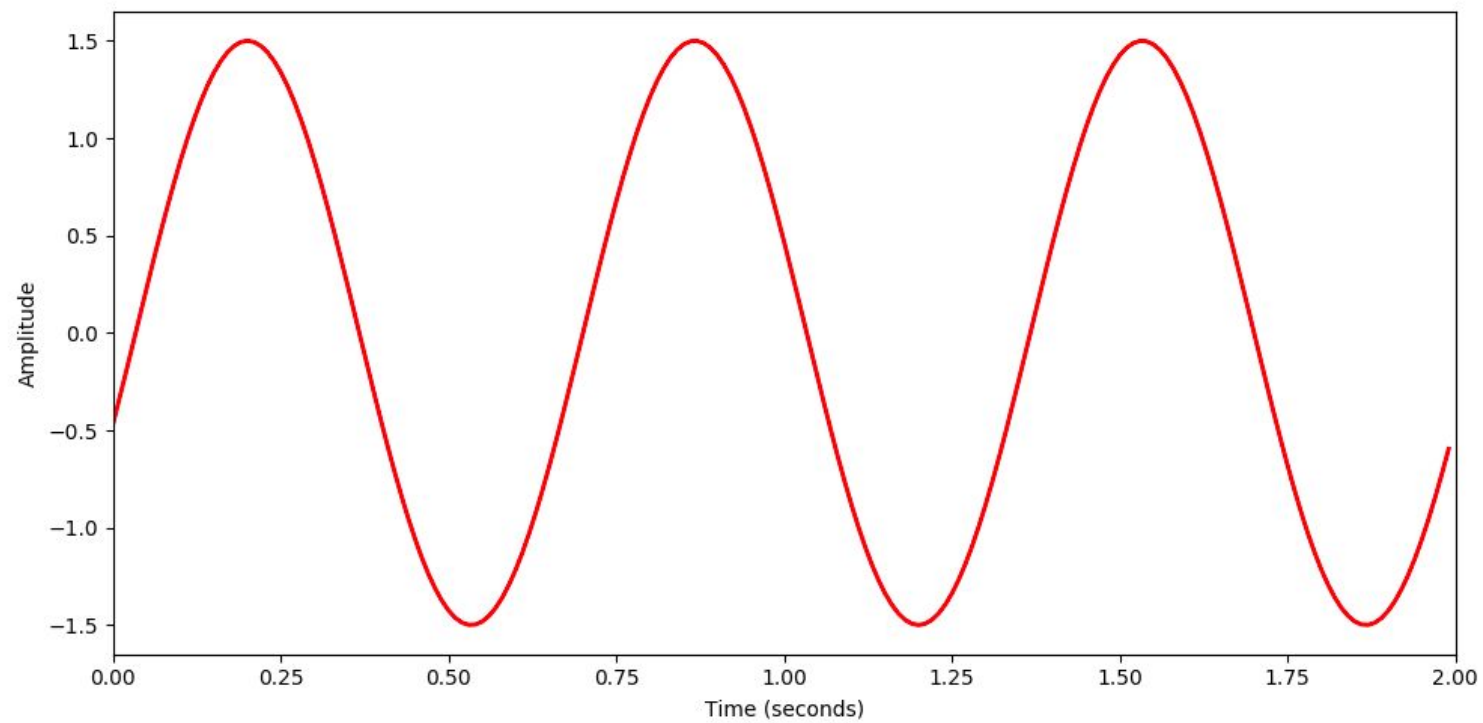
Analog signal

- Continuous values for time

- Continuous values for amplitude

Analog signal

Digital signal

- Sequence of discrete values

- Data points can only take on a finite number of values

Analog to digital conversion

- Sampling
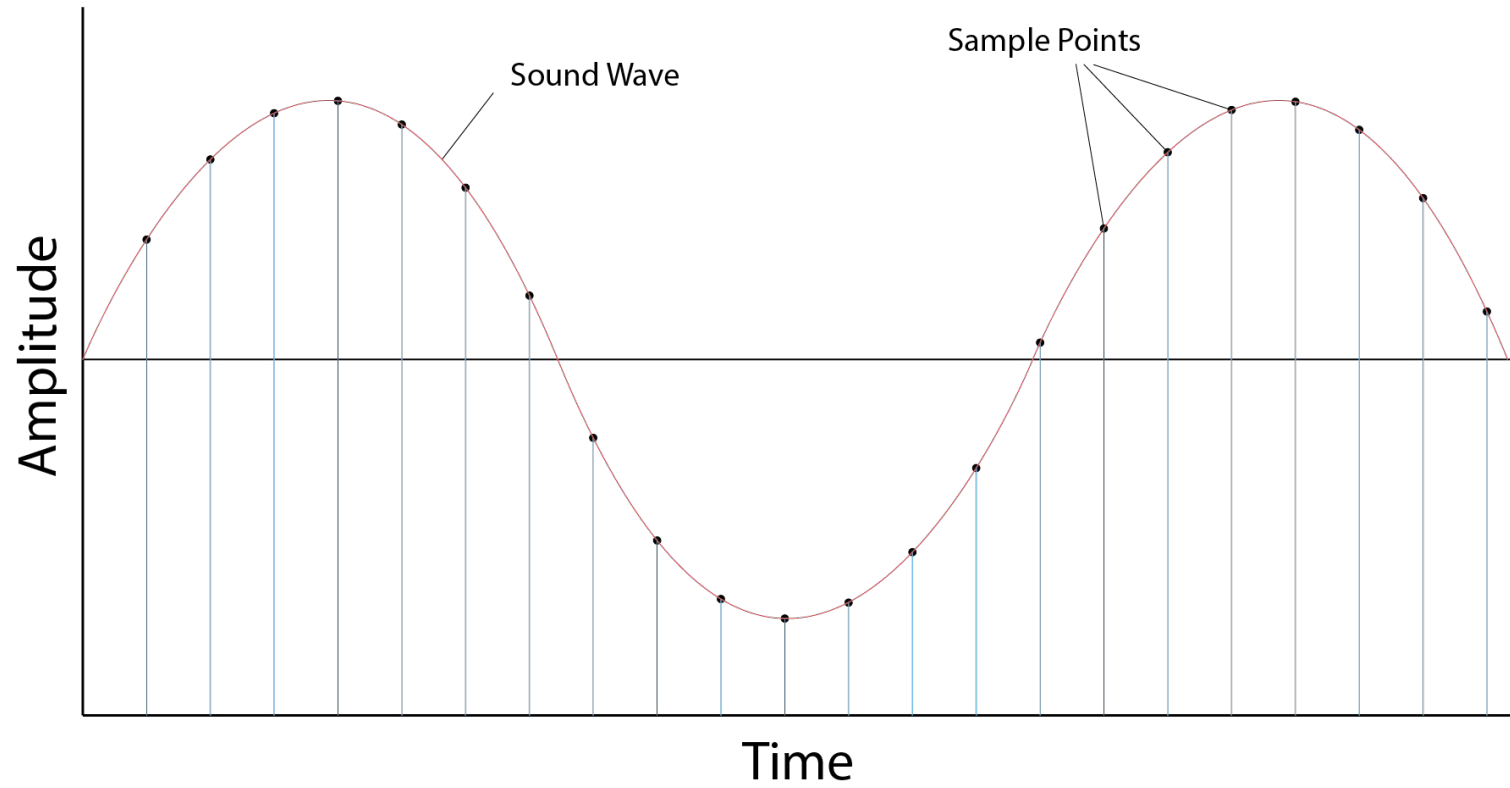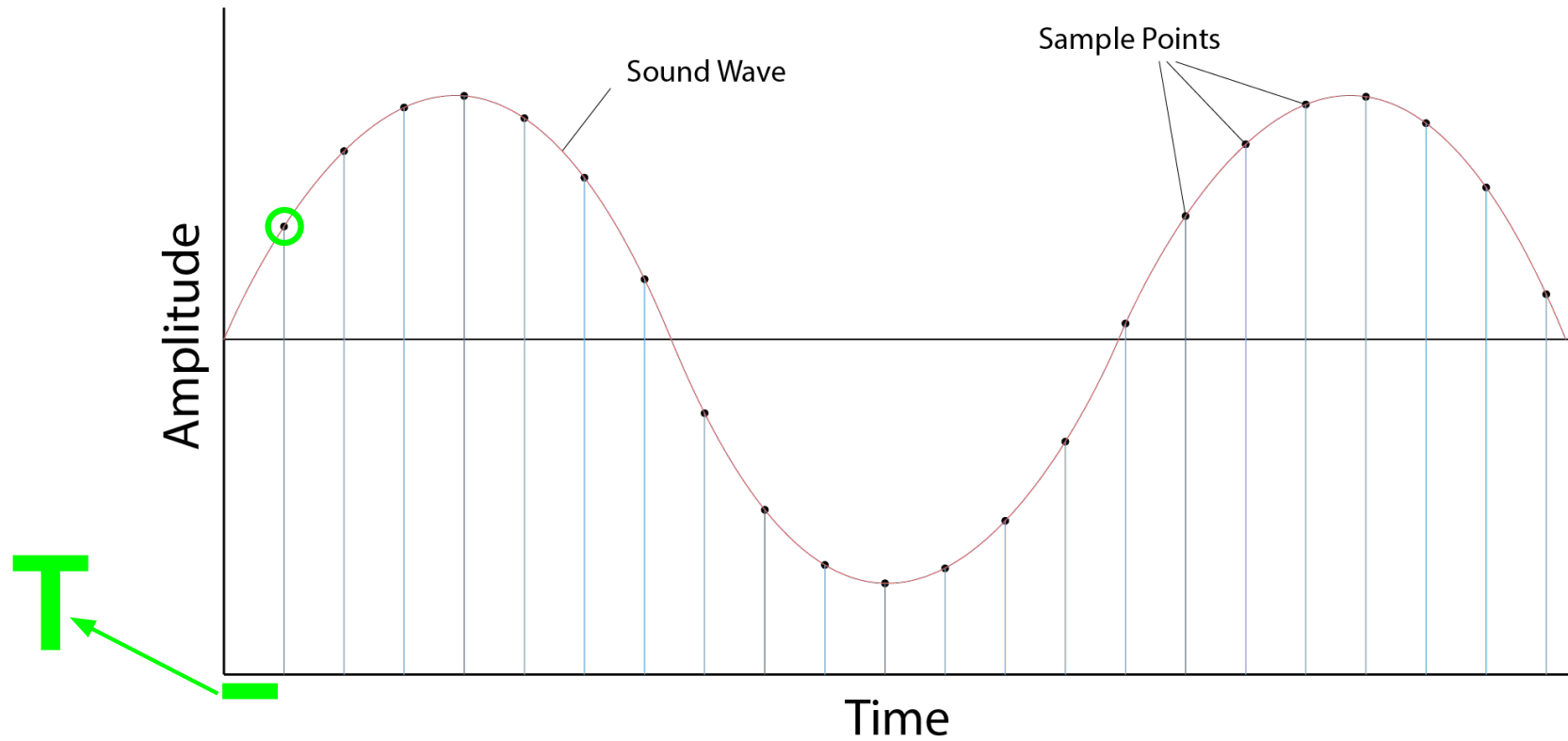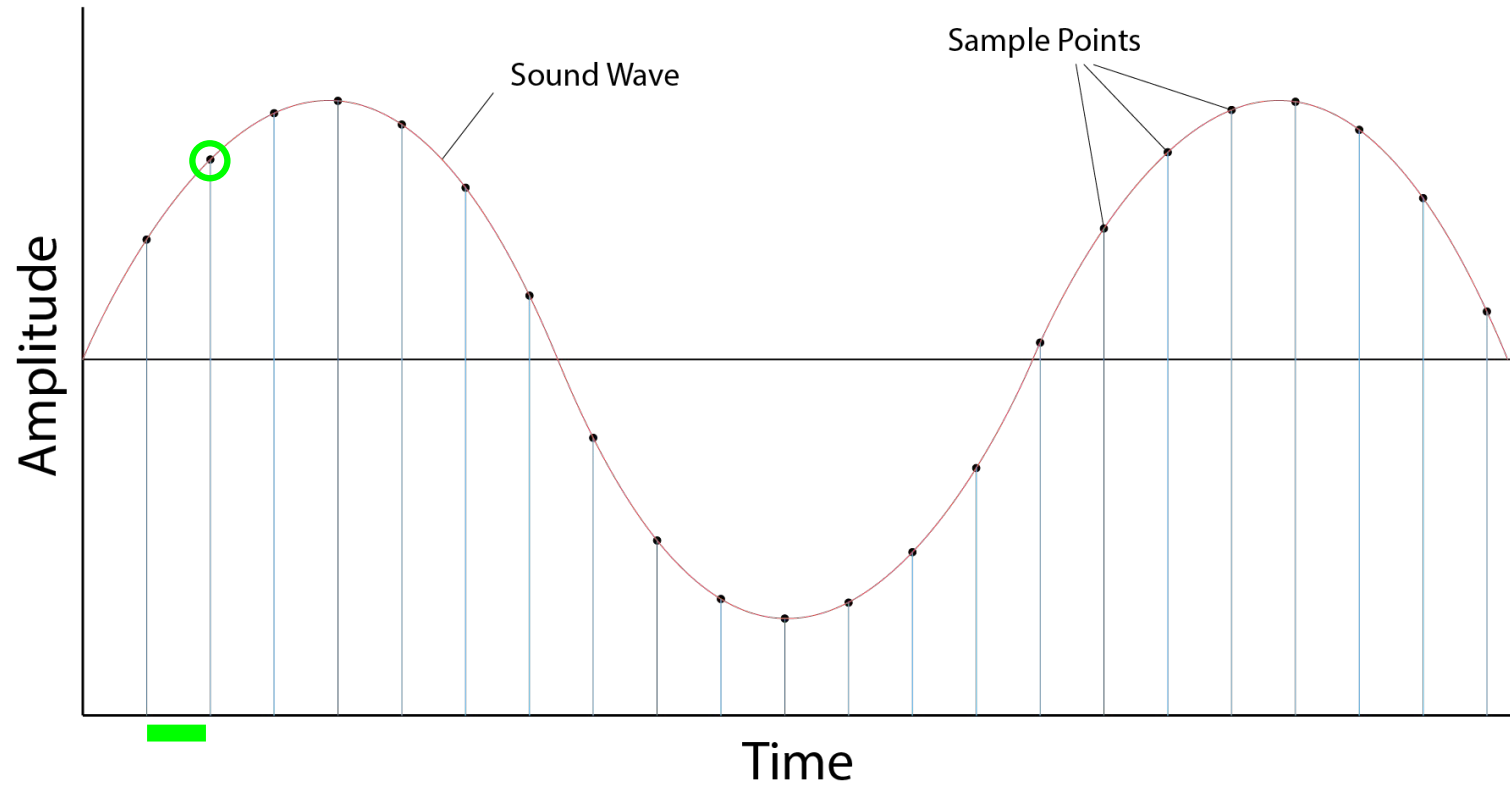
- Quantization
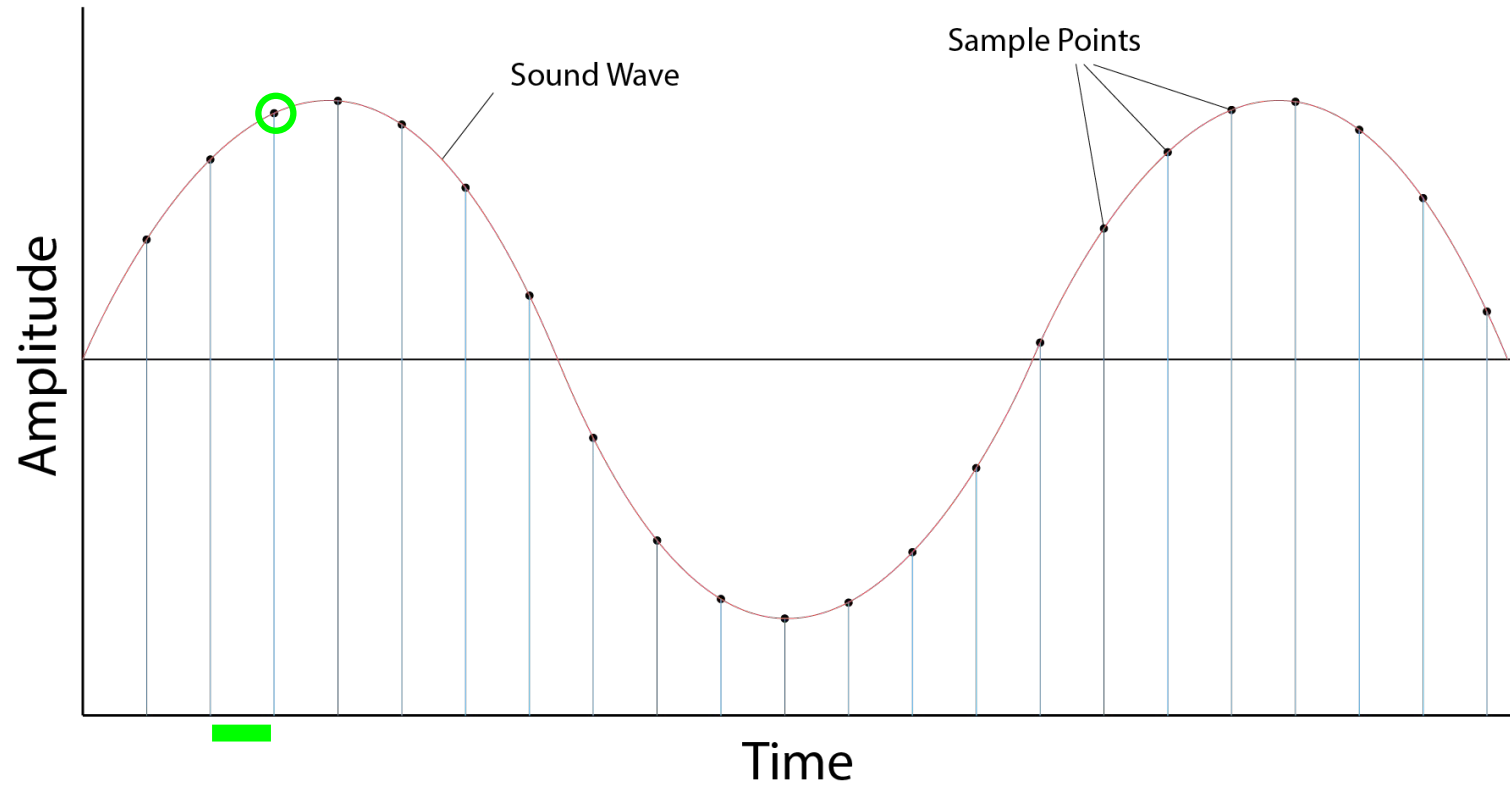
Pulse-code modulation

Sampling

Sampling period

Sampling period

Sampling period

Locating samples

$$t_n = n \cdot T$$

Sampling rate

$$s_r = \frac{1}{T}$$

Sampling rate

Low Sample Rate

Higher Sample Rate
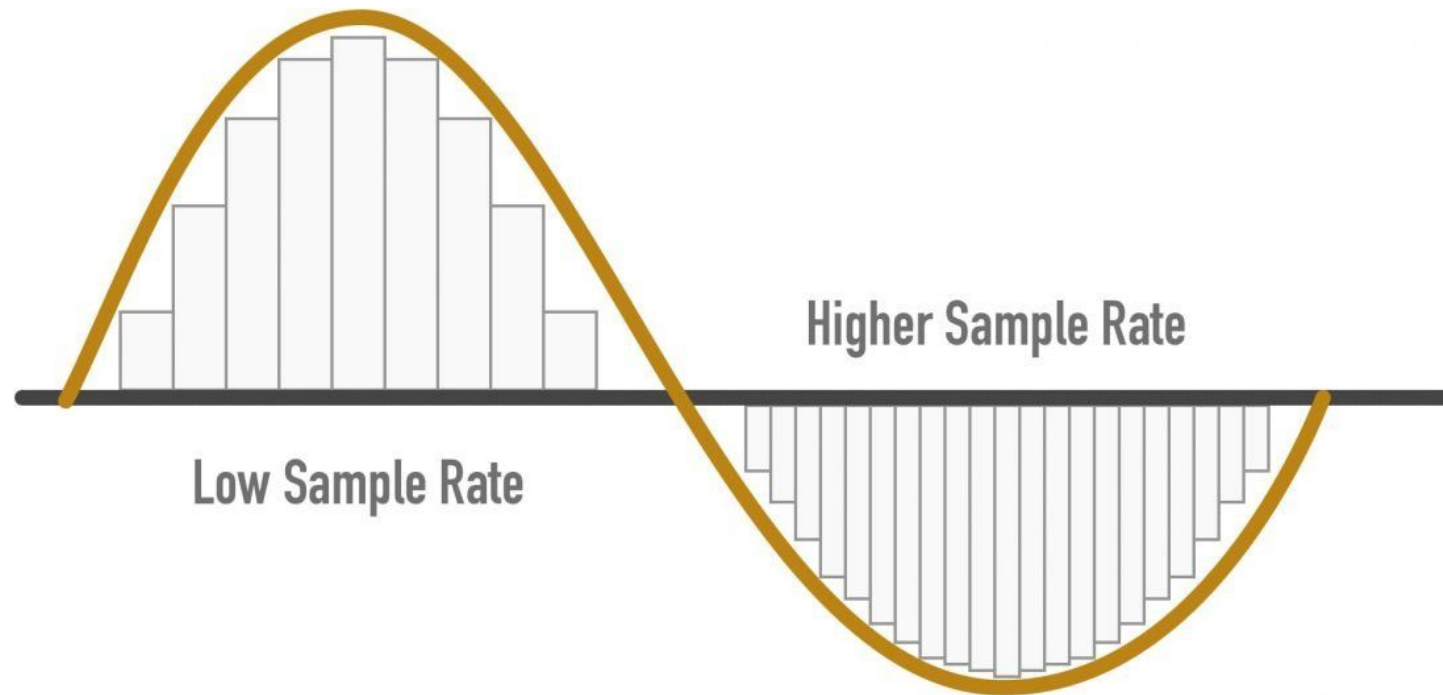
Why sampling rate = 44100hz?

Nyquist frequency

$$f_N = \frac{s_r}{2}$$

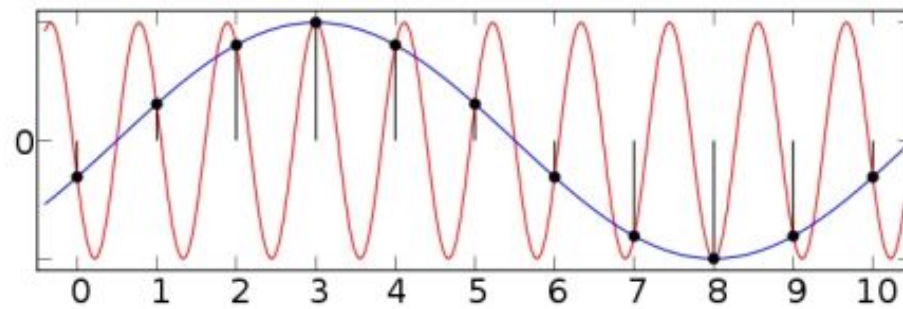# Nyquist frequency for CD

$$f_N = \frac{44100}{2} = 22050$$
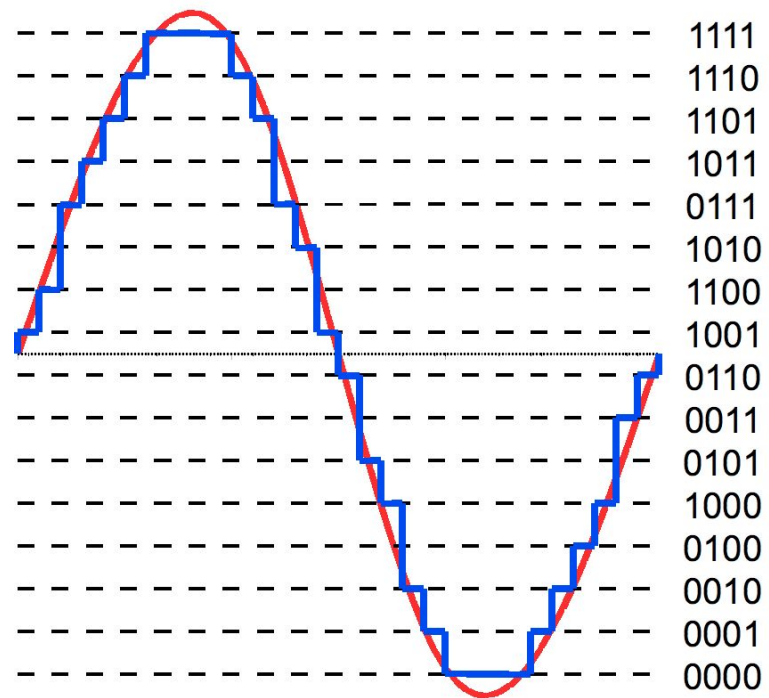
Aliasing

Quantization

Quantization

- Resolution = num. of bits

Quantization

- Resolution = num. of bits

- Bit depth

Quantization

- Resolution = num. of bits

- Bit depth

- CD resolution = 16 bits

Quantization

- Resolution = num. of bits

- Bit depth

- CD resolution = 16 bits

$$2^{16} = 65536$$

Memory for 1' of sound

- Sampling rate = 44100 Hz

- Bit depth = 16 bits

Memory for 1' of sound

- Sampling rate = 44100 Hz

- Bit depth = 16 bits

$$(((16 \cdot 44,100)/1,048,576)/8) \cdot 60$$

Memory for 1' of sound

- Sampling rate = 44100 Hz

- Bit depth = 16 bits

$$(((16 \cdot 44,100)/1,048,576)/8) \cdot 60$$

Memory for 1' of sound

- Sampling rate = 44100 Hz

- Bit depth = 16 bits

$$(((16 \cdot 44,100)/1,048,576)/8) \cdot 60$$

Memory for 1' of sound

- Sampling rate = 44100 Hz

- Bit depth = 16 bits

$$(((16 \cdot 44,100)/1,048,576)/8) \cdot 60$$

Memory for 1' of sound

- Sampling rate = 44100 Hz

- Bit depth = 16 bits

$$\boxed{(((16 \cdot 44,100)/1,048,576)/8)} \cdot 60$$

Memory for 1' of sound

- Sampling rate = 44100 Hz

- Bit depth = 16 bits

$$(((16 \cdot 44,100)/1,048,576)/8) \cdot \boxed{60}$$

Memory for 1' of sound

- Sampling rate = 44100 Hz

- Bit depth = 16 bits

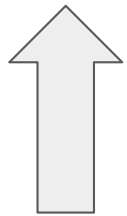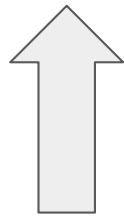$$(((16 \cdot 44,100)/1,048,576)/8) \cdot 60 = \boxed{5.49MB}$$

Dynamic range

- Difference between largest/smallest signal a system can record

Dynamic range

↑ resolution   ↑ dynamic range

Signal-to-quantization-noise ratio

- Relationship between max signal strength and quantization error

- Correlates with dynamic range

Signal-to-quantization-noise ratio

- Relationship between max signal strength and quantization error

- Correlates with dynamic range

$$SQNR \approx 6.02 \cdot Q$$

Signal-to-quantization-noise ratio

- Relationship between max signal strength and quantization error
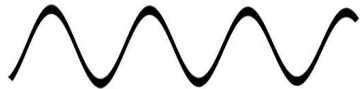
- Correlates with dynamic range

$$SQNR(16) \approx 96dB$$

How do we record sound?

How do we record sound?

How do we record sound?

How do we record sound?

How do we reproduce sound?

How do we reproduce sound?

How do we reproduce sound?

DAC

How do we reproduce sound?

DAC

What's up next?

- Overview of audio features