# Digital Audio, Part 1

CST 205

Representing sounds

- Sounds are rapidly-changing vibrations in air

- Human auditory system (HAS) can hear between 20 and 20,000 vibrations per second

- The rate of vibrations per second is called the *frequency* and is measured in **Hertz** (Hz)

   - 1 Hz is a rate of vibration of 1 oscillation per second

Frequency and music

- The musical note A above middle C, known as concert A, is a sine wave with 440 vibrations per second

  - 440 Hz
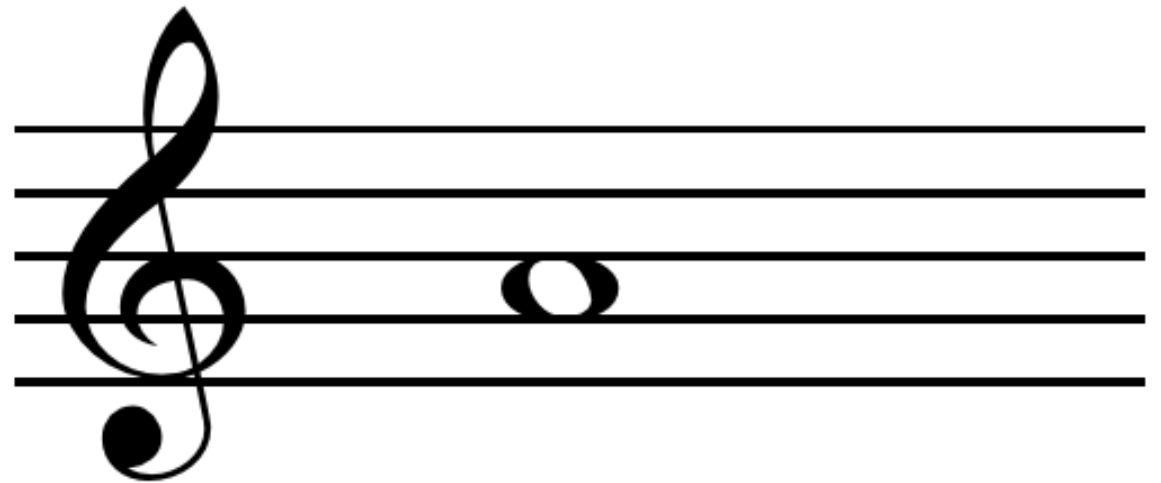
Sound wave properties

- Wavelength: distance between waves

  - the greater the distance, the lower pitch

- Amplitude: strength of power of waves

  - the higher the amplitude, the louder the volume

- Frequency: number of times per second
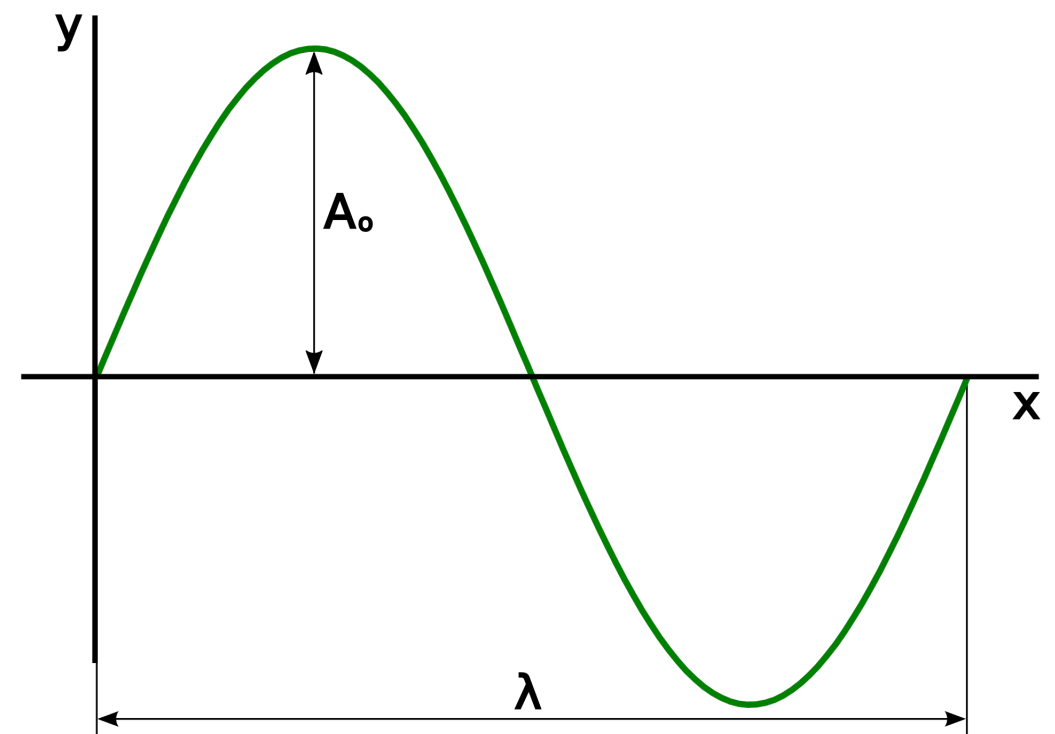
A Problem

- Waves in nature, including sound waves, are *continuous*.

  - between any two points on the curve, there are an infinite number of points

- Computers cannot represent continuity

  - can only deal with *discrete* values

- Need to convert continuous values to discrete values

Sampling

- Sampling rate describes how many sample rates per unit of time — dividing horizontal axis into discrete pieces

  - Each sample has a timestamp and a value

  - The value describes the amplitude of the sound wave at one point in time

  - `44,100 Hz` is the sampling rate of audio CDs.

    - `20 kHz` is the highest frequency of HAS, CDs use roughly double that (see Nyquist-Shannon sampling theorem)

Quantization

- Quantization provides the precision of the amplitude measurement — dividing the vertical axis (signal strength) into pieces

- The lower the quantization, the lower the quality of the sound.

- CD quality sound uses 16 bits (65,536 levels)

Pulse-Code Modulation (PCM)

- **Modulation** — a way of **encoding** information (audio signals) for purposes of transmission

- In PCM, the audio signal undergoes sampling, quantization, and coding. (More info <u>here</u>.)

- PCM devised by Alec Reeves in 1937.

  - Not used commercially until the 1950s

- PCM is the format for uncompressed audio in media files and the standard for CD audio

Data on Compact Disc (CD)

- Tiny grooves in the polycarbonate surface, known as **pits**

  - Minimum pit size is 0.83 μm

- Space between pits known as **land**

- Change from pit to land or land to pit represents a **1**

- No change (pit to pit or land to land) represents a **0**
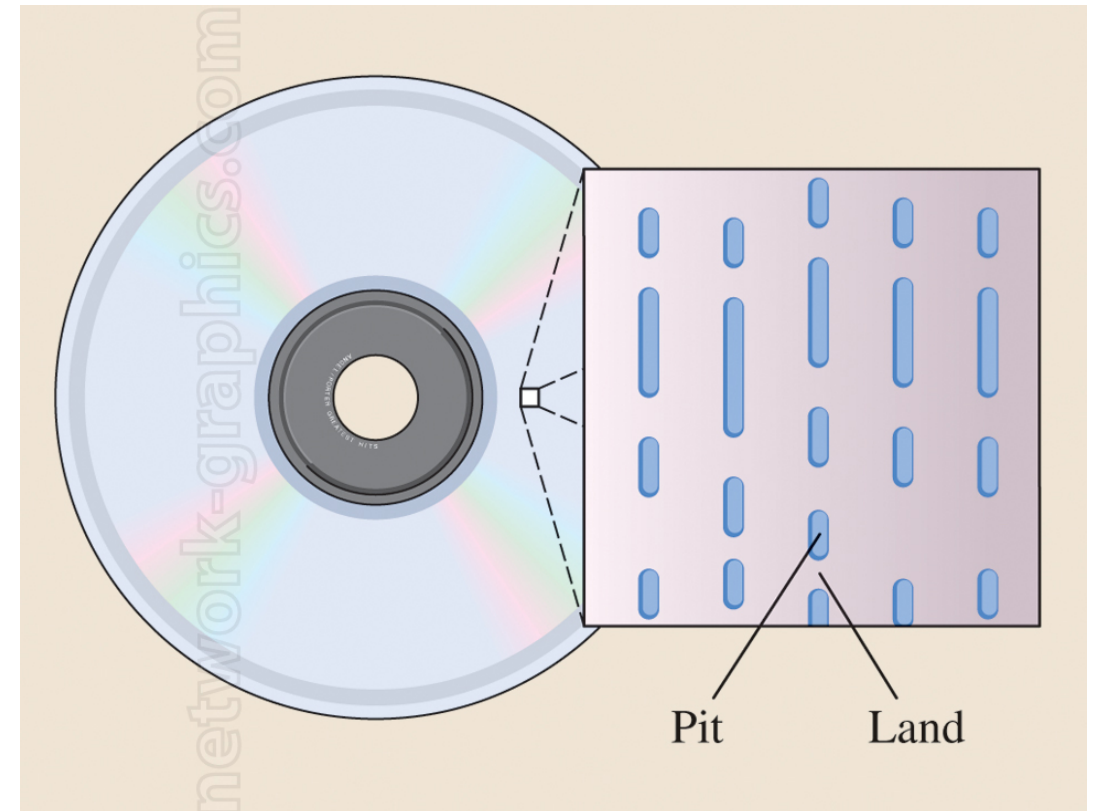
Size of audio files

44,100 samples per second

x

2 bytes per sample (16 bits)

x

2 channels (for stereo)

x

60 seconds

≈

10 MB / minute

Waveform Audio File Format (.wav)

- Introduced in Windows 3.1 (1992)

- Most common type of file adhering to the Resource Interchange File Format (RIFF)

- Widely used for uncompressed 8-, 12-, and 16-bit audio files, both mono and multi-channel, at a variety of sampling frequencies.

- More on WAVE file format <u>here</u>

Container vs. Codec

- Codec is a device or program for encoding and decoding a digital stream of audio.

- Container is what holds the grouping of data as defined by the codec

  - container takes care of packaging, transport, and presentation

  - for audio CDs, `.wav` is a wrapper for PCM encoding