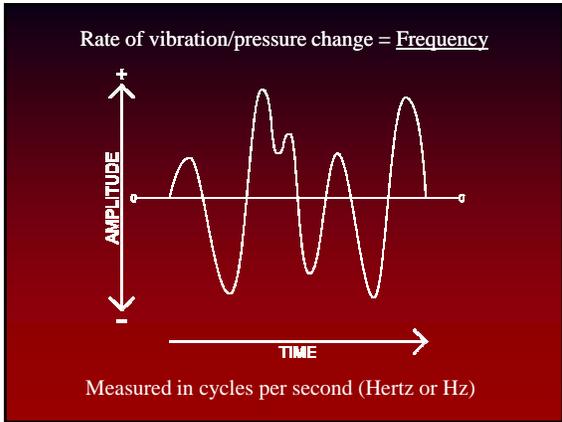
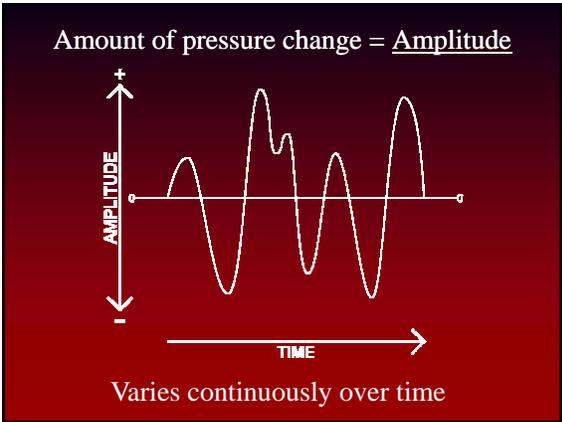
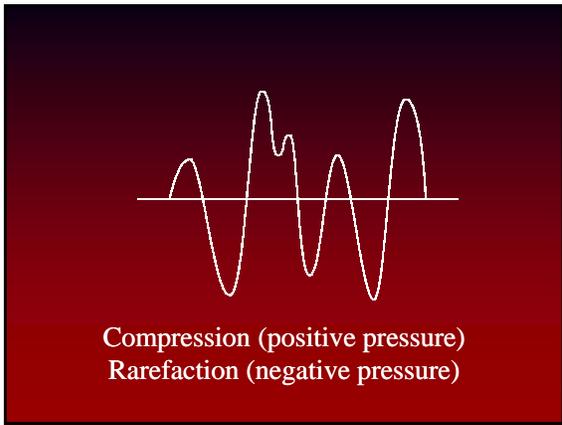
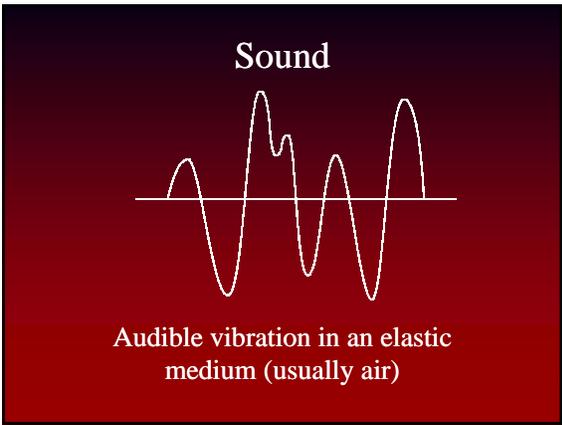
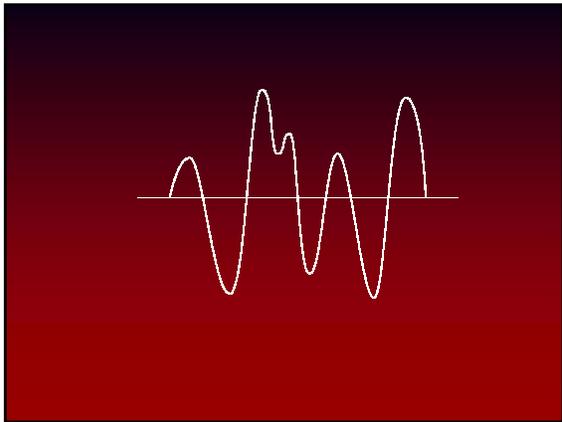
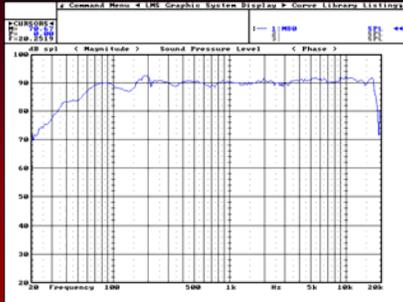


IMGD-1001  
The Game Development Process  
Game Audio  
(Content by professor Brian Moriarty)



### Frequency range of human hearing: Approximately 20 to 20,000 Hz



### Analog recording and playback



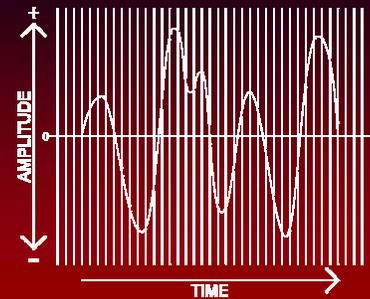
Transducers: Convert one type of energy to another  
All transducers introduce distortion

### Digital audio

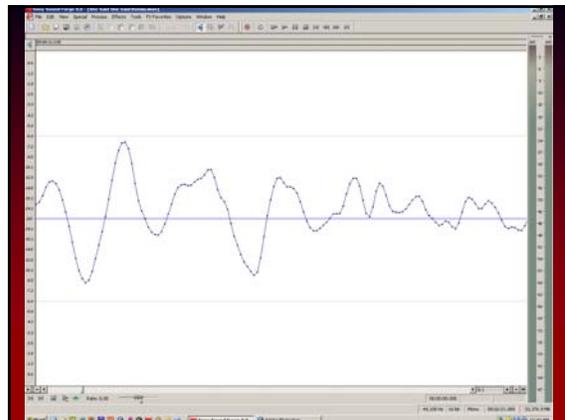
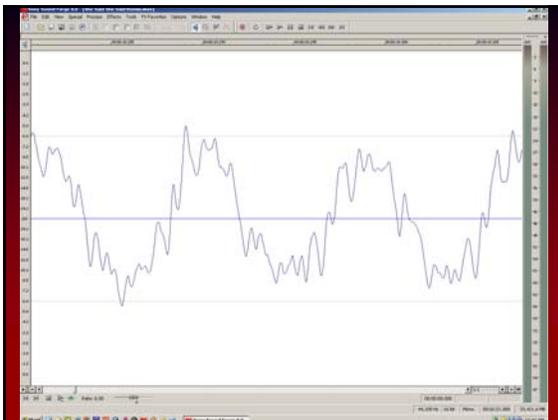


- Experimental recordings: Late '60s
- Jazz/classical: Early 70s
- First symphonic recording: 1976
- First major label recording: 1979
  - Ry Cooder's *Bop Till You Drop*
- Compact Disc
  - Jointly created by Sony/Phillips
  - Introduced October 1, 1982
    - Billy Joel's *52nd Street*
  - Biggest seller
    - Beatles *1* (30M+ copies)

### Digital audio based on sampling



Amplitude of signal is measured (and usually recorded) at precise time intervals, converted to stream of numbers



## Digital recording and playback



Extremely accurate, low noise and distortion  
 Almost immeasurable wow or flutter  
 Easily edited and manipulated  
 Essentially perfect replication

## Digital sampling (“digitizing”)

- Sample rate
  - Number of samples taken per second
  - Also measured in Hertz
- Sample resolution
  - Range of numbers used to describe each sample
  - Measured in binary bits
  - 8 bits = 256 values ( $\pm 127$ )
  - 16 bits = 65,536 values ( $\pm 32K$ )
  - 24 bits = 16,777,216 values

## How often to sample?

- Depends on desired frequency range
  - Nyquist frequency = Sample rate required to fully express a signal
  - 2X maximum required frequency
  - 2X 20 kHz = 40 kHz minimum sample rate to represent full human range

## How much to sample?

- Depends on desired dynamic range
- Dynamic range = Difference between softest and loudest sounds
  - Measured in decibels (dB); 1 dB = faintest perceptible sound
  - Real-world range: 10-20 dB (anechoic chamber) to 140 dB (beside jet engine)
  - Each bit of sampling resolution approximately doubles dynamic range

## Home audio formats

- Compact Disc
  - Sample rate: 44.1 kHz
  - Sample resolution: 16 bits
  - Dynamic range: >90 dB
  - Two channels for stereo
  - “CD quality”
- HD/BluRay DVD
  - Up to 8 channels 96 kHz 24-bit audio
  - Dynamic range: >120 dB



## “CD quality” data rate

- 44,100 samples per second
- 16 bits (2 bytes) per sample
- 2 channels
- $44,100 \times 2 \times 2 = 176,400$  bytes/sec or 10.584 MB per minute
- Typical pop song 30-40 MB if uncompressed

## Compressed digital audio

- Lossless compression
  - Preserves data perfectly
  - Compression ratio: 2:1 typical
- Lossy compression
  - Discards some data to increase compression ratio
  - The trick is: What to throw away?

## The game changer: MP3 (1994)

- Lossy compression algorithm based on auditory masking
  - Loud low-frequency sounds can make softer high-frequency sounds inaudible
  - Perceptual coding: Throw away high frequencies that “can’t be heard anyway”
  - Compression ratio: 10:1 or better
  - Pop song becomes a 3 MB file



## The MP3 Phenomenon

- First Web appearance: Late '94
- Winamp, mp3.com (Summer '97)
- First portable players (Spring '98)
  - 32 MB Eiger MPMan F10, Rio PMP300
- Napster (June '99)
  - Created by Shawn Fanning (19), Northeastern University

## Game audio: Early days

- Apple II and PC: Click the speaker
- Atari, C64, early consoles: FM synths
- Macintosh (January 1984)
- AdLib PC sound card (1976)
- Creative Labs Sound Blaster (1989)
  - AdLib with digital audio + game port
- CD-ROM (1985)
- CD-R (1990)
- MIDI/music synthesis

## Game audio: Today

- All game audio is digital
  - Music, SFX, VO delivered pre-rendered
- Typical assets
  - .wav (bigger, no decoding)
  - .mp3 (small, decoded, may require license because of patent)
  - .ogg (small, decoded, no license)
  - .flac (smaller, decoded)
- Real-time mixing, effects, spatialization