°Computer Science 1033 – Week 10

AUDIO

Watch how the music and animation meld

"Adding sound to movies would be like putting lipstick on the Venus de Milo." Mary Pickford (Movie Actress from the 1920s)

Overview of This Week's Topics

Why use sound?

Where can you get sound?

What is sound?

Sample Rate

Sample Size

Sound Editing

Why compress?

How to compress?

File Format

What are MIDI files?

Posting sound on the Web

Remember to What You Did NOT Like u DID Like About This C

Feedback
- I wont know v
  - Video: https:// www.youtube.co amIWQ
  - Feedback: Fee

Make sure you get a copy of all your work!

Your assignment 2 and 3 websites will only be posted for the next month (till about ONE month after our final exam) so make sure you take a copy of everything you want to save and put it on a memory stick or in the cloud.

ONE MONTH AFTER THE COURSE ENDS YOU WILL **NOT** BE ABLE TO GET ANYTHING YOU POSTED ON

cs1033.gaul.csd.uwo.ca BACK. KEEP COPIES!

Introduction to Sound

Sound can:

- Set a mood ☐ http://pictoplasma.sound-creatures.com/#/gallery/sound-19/19-10

- Sell, Sell, Sell ☐ http://www.csd.uwo.ca/~lreid/cs033/sound/award winningpoo.wav

- Educate/Present Information ☐ http://www.cbc.ca/radio/

- Allow communication over the web via Internet Audio Conferencing

Where can you get Sound?

Pre-Packaged:

○ Download sound from companies ▯ e.g.
  http://soundbible.com/215-Cow-Mooing.html
○ http://soundbible.com/free-sound-effects-1.html

Where can you get Sound?

Create your own sound:

- Recording program with a computer's operating system (such as Sound Recorder) and speak into a microphone attached to the computer – quality will not be the best

- Recording studio with equipment such as DAT (Digital Audio Tape) devices that record sounds digitally. Produces a high quality commercial product

- Electronic instruments such as synthesizers can be used to create music sound files. Connecting the instrument to a computer allows the sounds to be captured in a MIDI (Musical Instrument Digital Interface) format.

What is Sound?

Sounds are pressure waves of air

Visualize the sounds as a series of recurring waves called a waveform.

Question: Which part of the wave indicates the volume of the sound?

Question: Which part of the wave indicates the pitch or frequency? ⍰

Volume - the higher the wave the louder the sound

Pitch or frequency - the closer
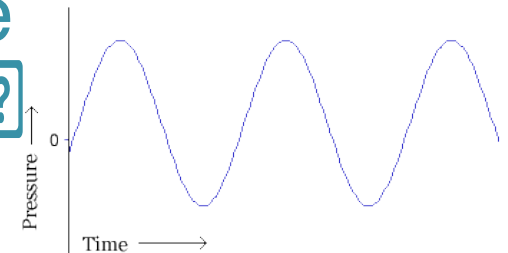
What is Sound?

Voice muscle vibrate and cause the air to move and thus cause sound (a series of waves)

Two people (or one person talking and music) talking causes two sets of overlapping waves. The overlapping waves actually form a new wave

Play audio clip
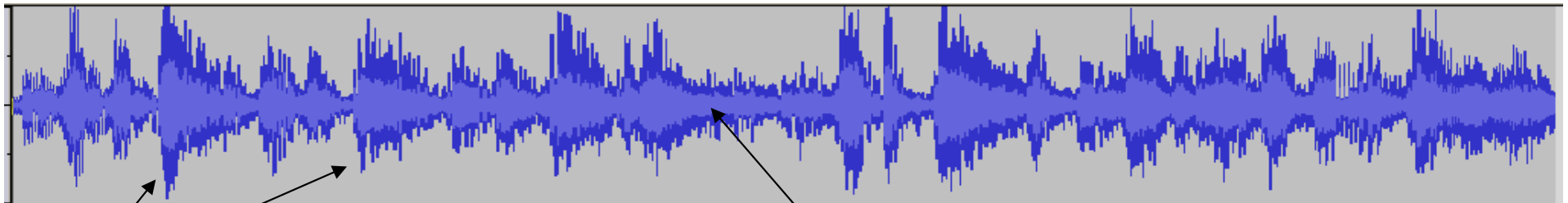
Bells

Oh

How do computers represent sound?

Computer must somehow represent the wave.

Question: What two things does a computer always do when it needs to represent something?

○

How do computers represent sound

Question: In the following sound wave image what is wrong if we take a sample of the wave every 5 units?
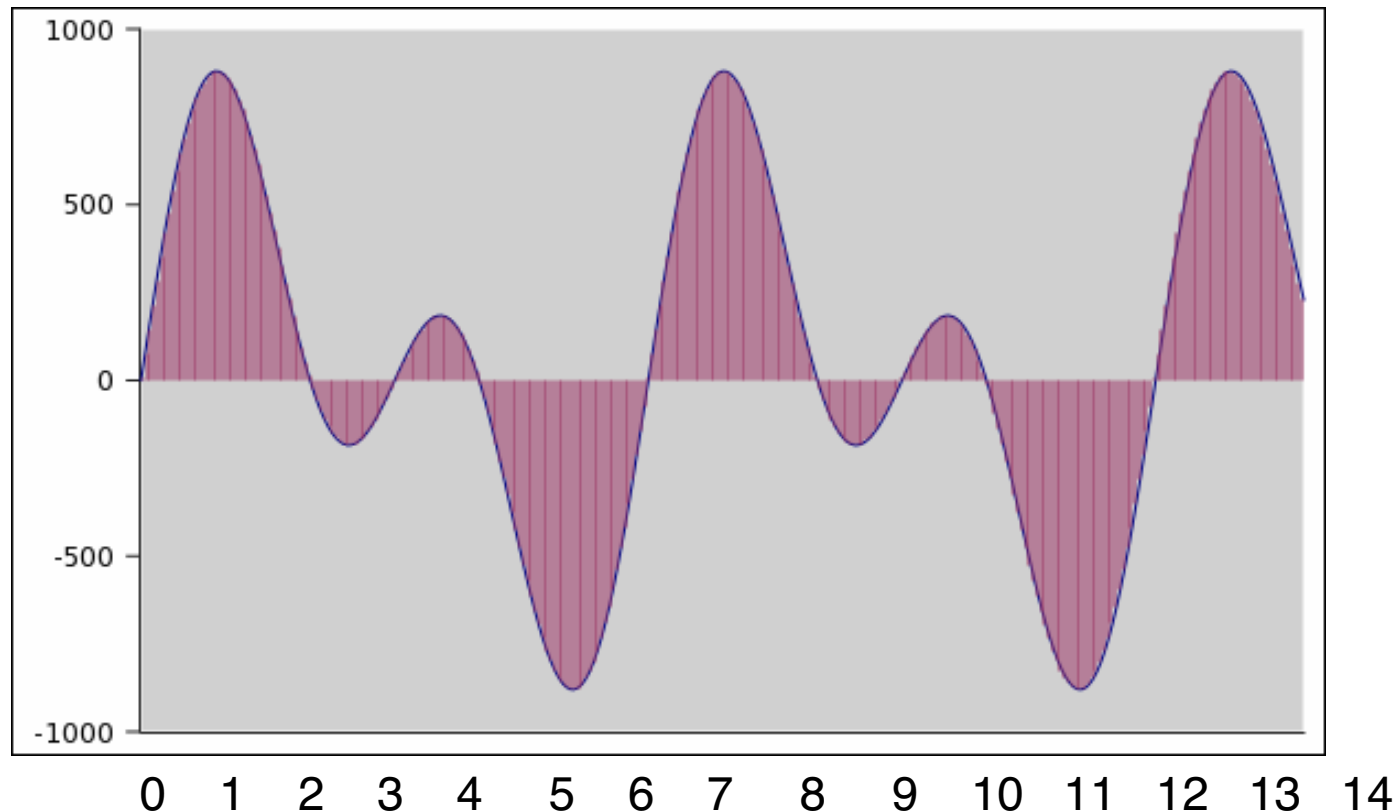
The Nyquist Limit

This rule says you <u>MUST take at least 2 samples</u> for every cycle of the wave. If you take less than two sample, you will get a completely different sound wave:

Question: Which of these sound waves has a higher pitch?
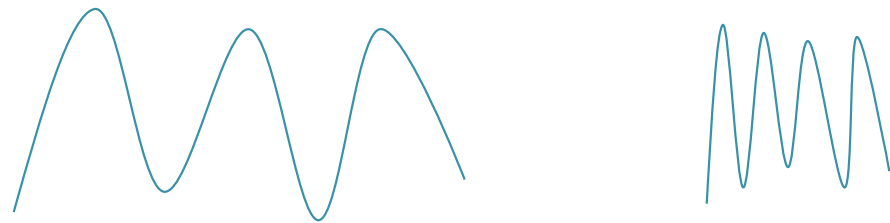
Question: What does the Nyquist Limit rule imply about taking samples for higher pitched sounds than lower pitched sounds?

Sampling

We MUST take 2 or more samples per wave

Question: what is the advantage of taking lots of samples per wave?

Question: What is the disadvantage of taking lots of samples per wave?

Number of samples per second is represented in Hertz (Hz)

Number of 1000 samples per second is represented in KiloHertz (KHz)

For CD quality we need 44,100 samples per second or 44,100Hz or 44.1KHz

Sample Rate

Sample Rate ⬚ number of samples we take per second of audio or number of times per second the waveform is measured.

An analog sound wave is a smooth curve of continuous values.
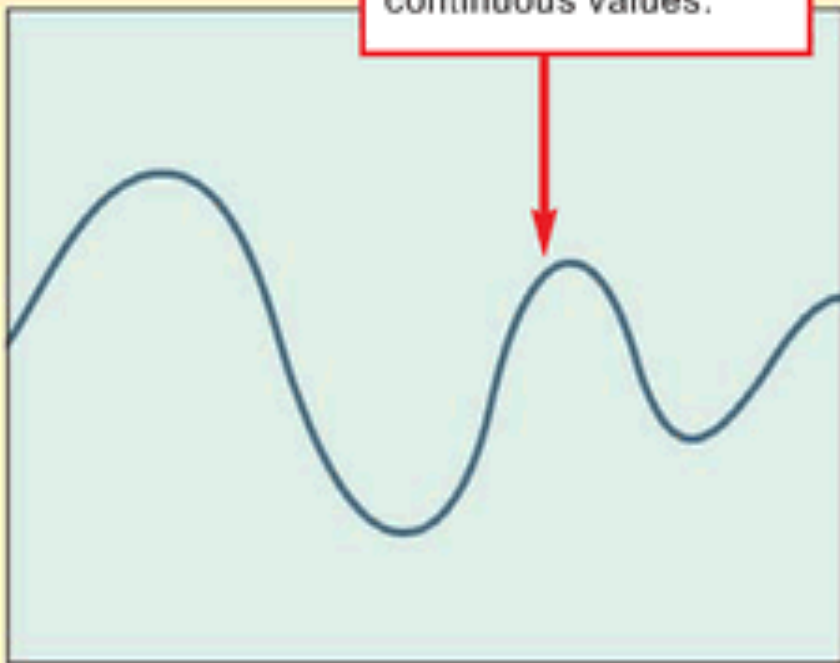
To digitize a wave, it is sliced into vertical segments, called samples. For purposes of illustration, this one-second sound wave was sliced into 30 samples.
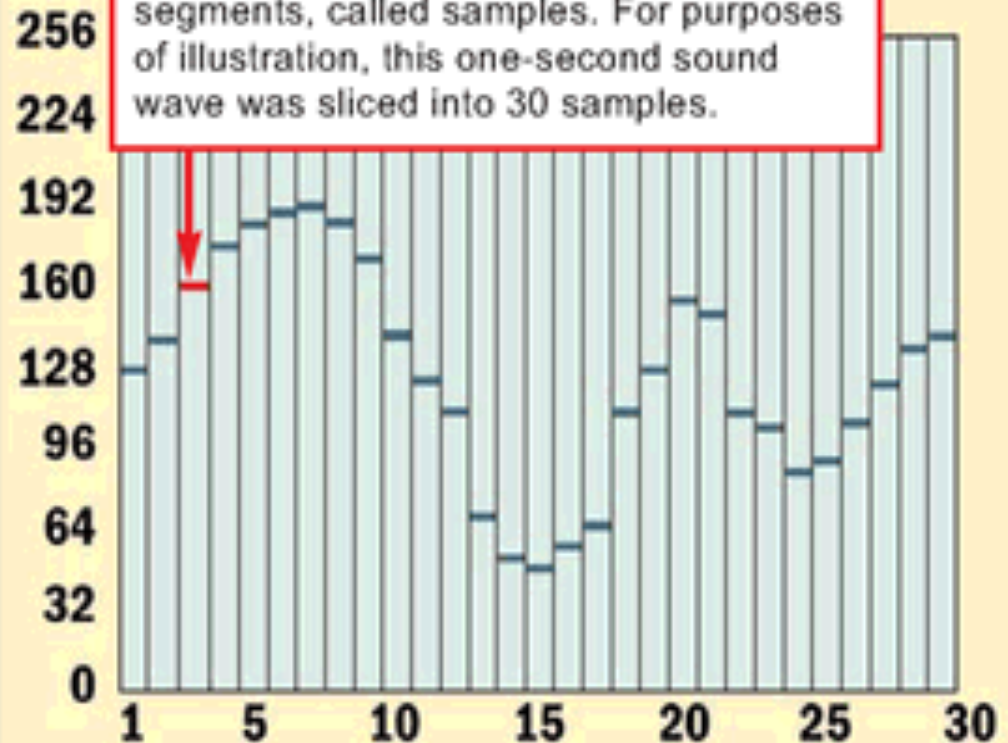
Sample Rate

Each dot represents a sample:
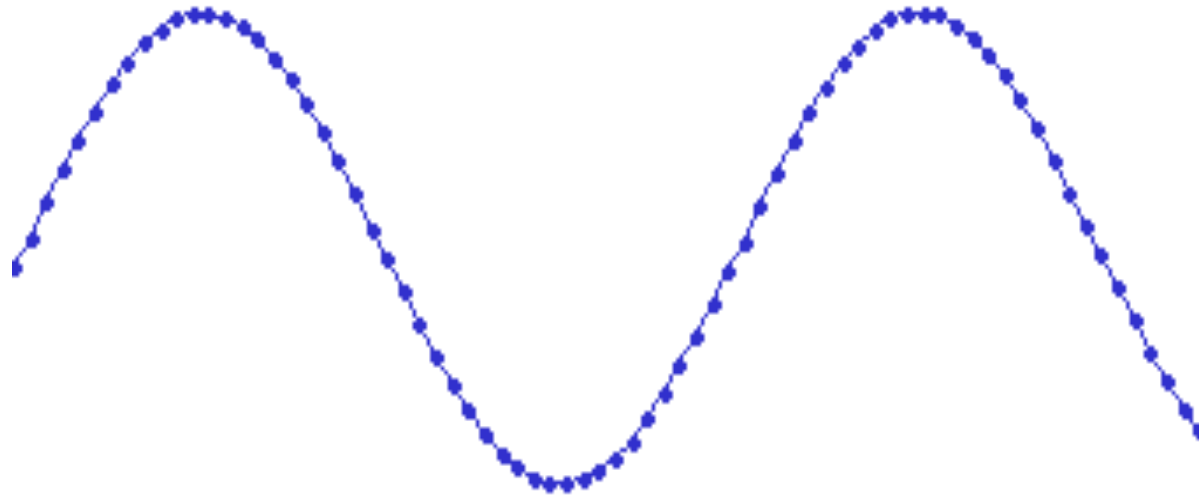
Typical Sample Rates

Voice Only (Telephone Quality)⬚ 8KHz

AM Radio Quality ⬚11.025 KHz

FM Radio Quality⬚ 22 KHz

CD Quality Music ⬚ 44.1KHz

Low sampling rate: File size = 66 KB

Medium sampling rate: File size = 124 KB

High sampling rate: File size = 235 KB

Sample Rate Example

One of these was sampled at 8000Hz (8KHz) and one at 16000Hz (16KHz).

Question: Which one should sound better?

Question: Which one does sound better?

- One
- Two

Quantizing – (aka ⍰ *Sample Size)*

Now that we know how many samples we will have (likely one of 22KHz or 44.1KHz), how do we represent either sample?

Question: What would 1-bit sound look like? (remember 1-bit or 8-bit or 24-bit colour)

0

1

0 0 0 0 1 0 1 0 1 0
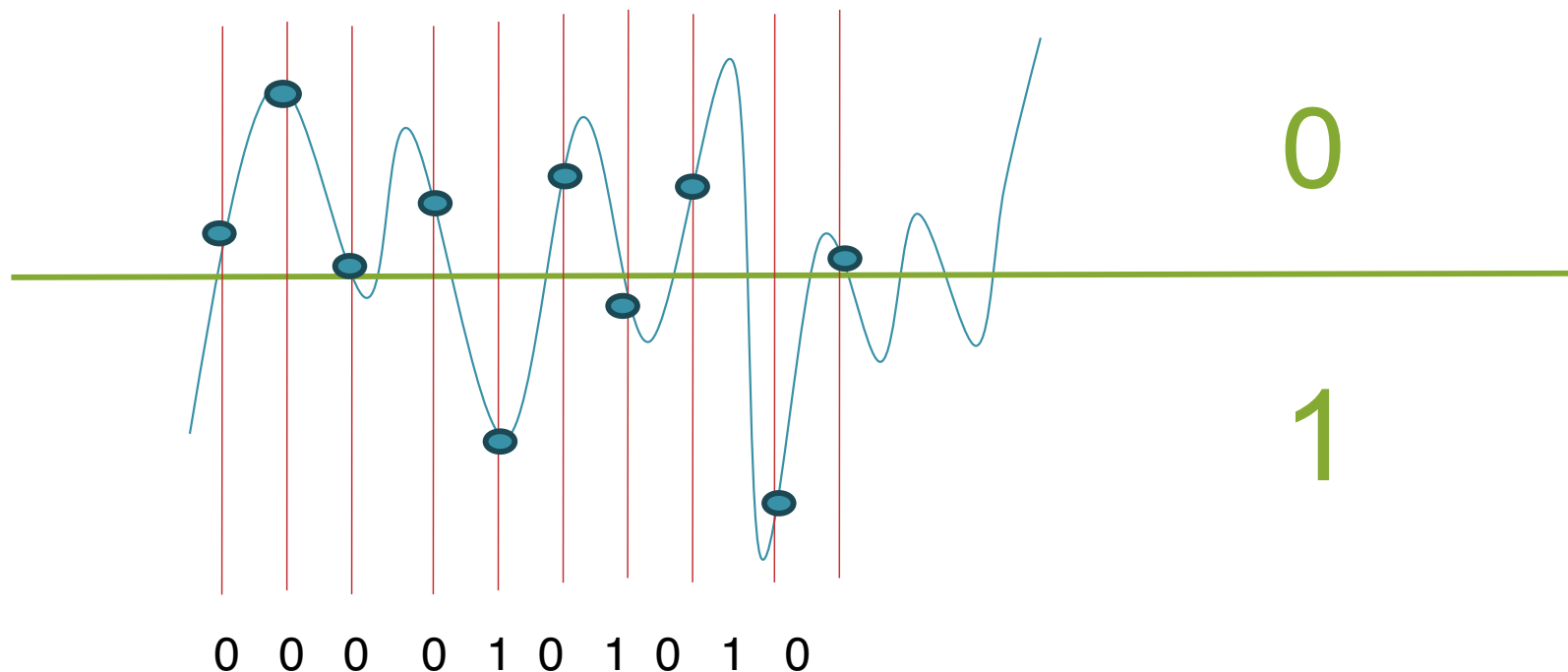
Sample Size

How about 2 bit sampling? (this will only be 4 tones ☐ (thus not even as much as the notes in one scale, so you would just have Doh, Ra, Me, Fa but NO So, La, Te, Doh. Keep in mind though that the bits represent tones **not** notes!)

01 00 01 01 11 01 10 01 11 01
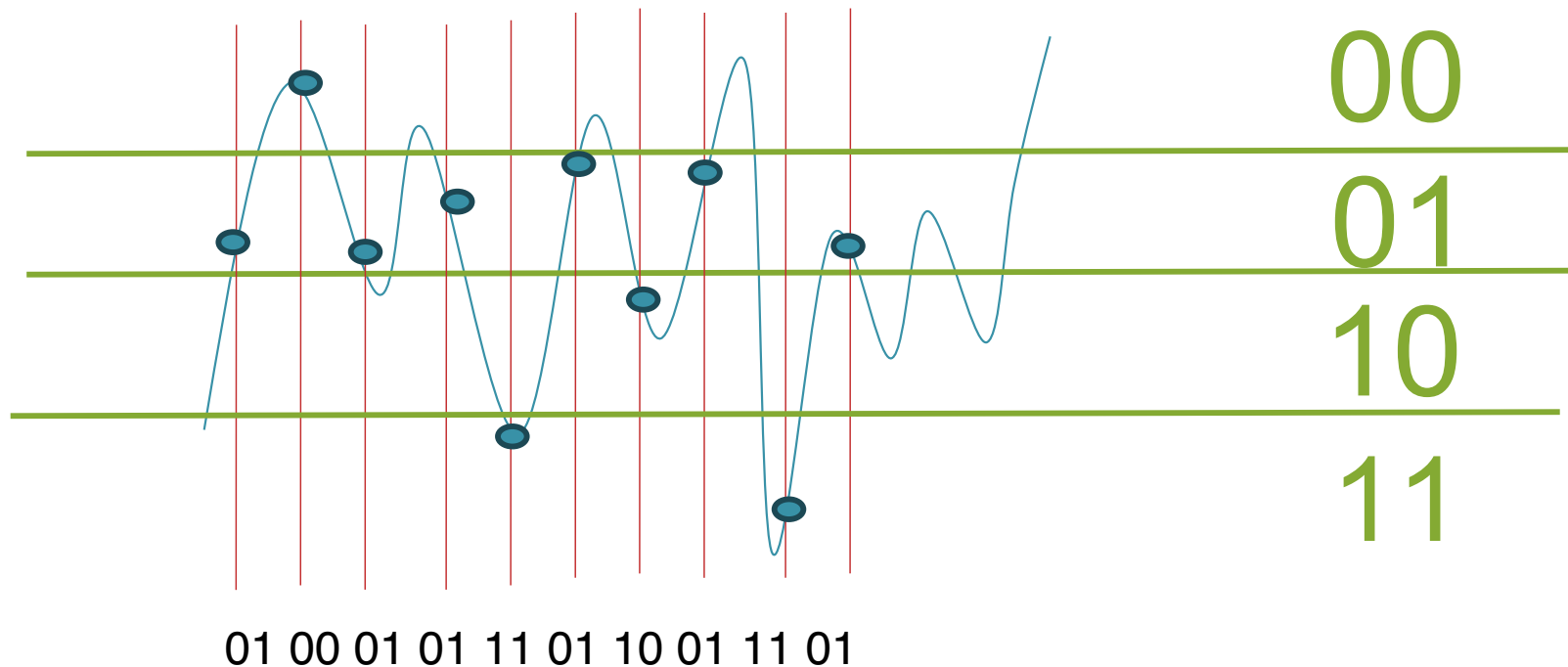
Sample Size

CDs use 16-bit rate (65,536 possible values could be given to each sample)

Question: What is the advantage of having a higher bit rate for the sample size?

Question: What is the disadvantage of having a higher bit rate for the sample size?
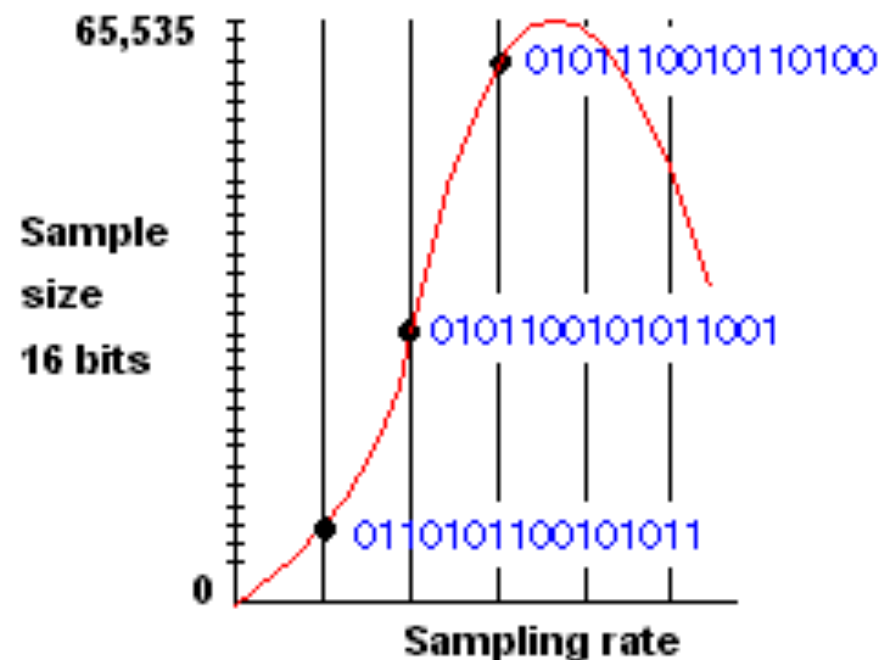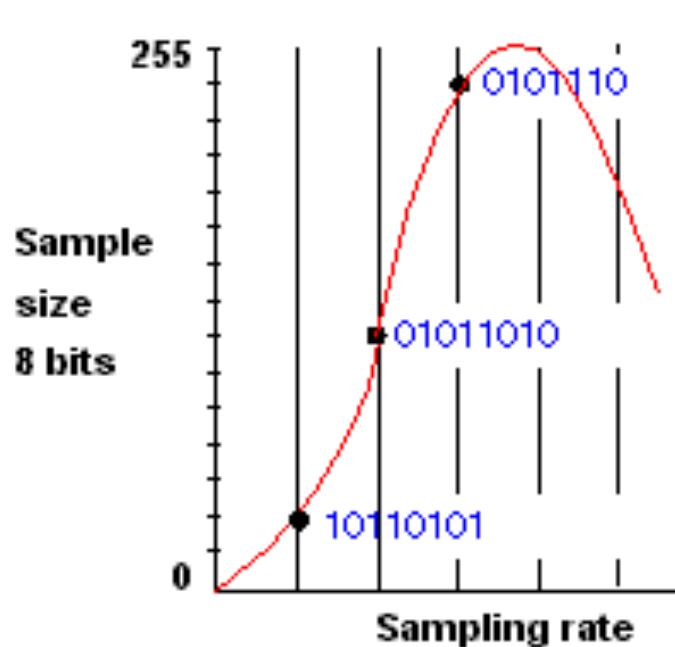
Sample Size

Sample	Sample Height (Decimal)	Sample Height (Binary)
1	130	10000010
2	140	1000110
3	160	10100000
4	175	10101111
5	185	10111001

The height of each sample is converted into a binary number and stored. The height of sample 3 is 160 (decimal), so it is stored as its binary equivalent—10100000.

To digitize a wave, it is sliced into vertical segments, called samples. For purposes of illustration, this one-second sound wave was sliced into 30 samples.
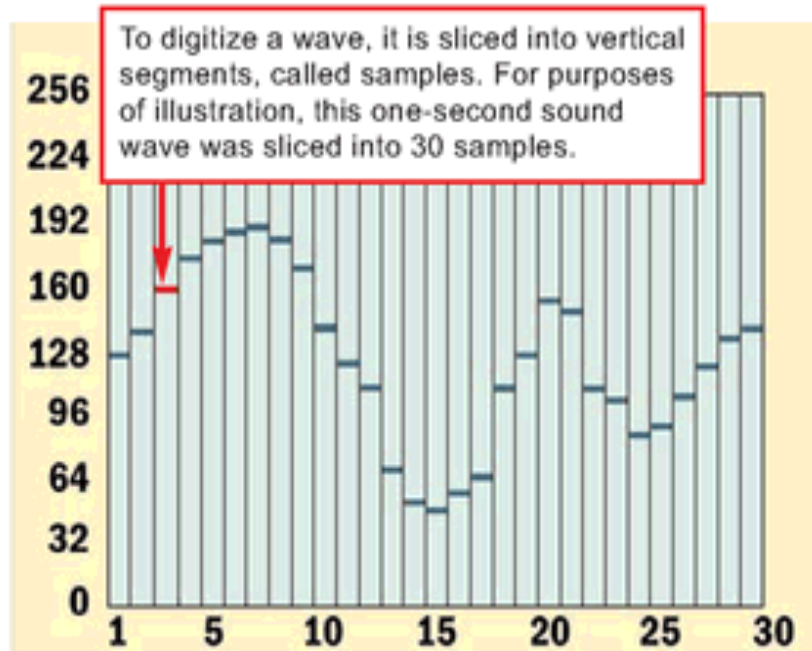
Sample Size

Question: Can you tell which is better quality?

- One
- Two
- Three
- I can't ⍰

How does the sound wave get converted to be stored on our computer?

Computers have a sound card which samples (sets the number of sample and quantizes) the sound wave from a microphone.

Sound card has an Analog-to-Digital Converter (ADC) for recording, and a Digital-to-Analog Converter (DAC) for playing audio.

Operating system (Windows, Mac OS X, Linux, etc.) talks to the sound card to actually handle the recording and playback

Test your Hearing

- https://www.npr.org/sections/therecord/2015/06/02/411473508/how-well-can-you-hear-audio-quality

- https://www.theverge.com/2017/4/5/15168340/lossless-audio-music-compression-test-spotify-hi-fi-tidal

Now we have the sound in the computer, let's edit the sound bit. What can we do to it?

Rearrange the Waveform

○ Cut, copy, drag, trim parts of the waveform

○ Overlap two or more pieces of audio

○ Find words you want to edit out and cut them from the wave form.

Modify the Volume

○ Use amplify, fade-in, fade-out, envelope, normalize

● Sometimes songs from some CDs playing much louder than others, even at the same volume setting. **Normalization** corrects this by scanning audio files to find peak or average level and proportionally increasing or reducing the levels to obtain the desired volume level.
http://www.hometracked.com/2008/04/20/10-myths-about-normalization/
(go to myth 2, snare drum vs. entire clip)

Sound Editing

Noise Reduction

- **Hiss Reduction** ⬚ noise within a given frequency range

- **Noise Reduction/Removal** ⬚ software examines the audio and finds unusual differences from waveform and removes them. Need a longer piece of audio than for Hiss Reduction because software had to analyze the audio to generate stats on what is unusual. http://www.alpinesoft.co.uk/vinylstudio/samples.aspx (go to Hiss Sample 4)

Special Effects

- Adding echo, changing the pitch of a portion

Downsample and reduce the bit depth ⬚ i.e. compress, WHY COMPRESS?
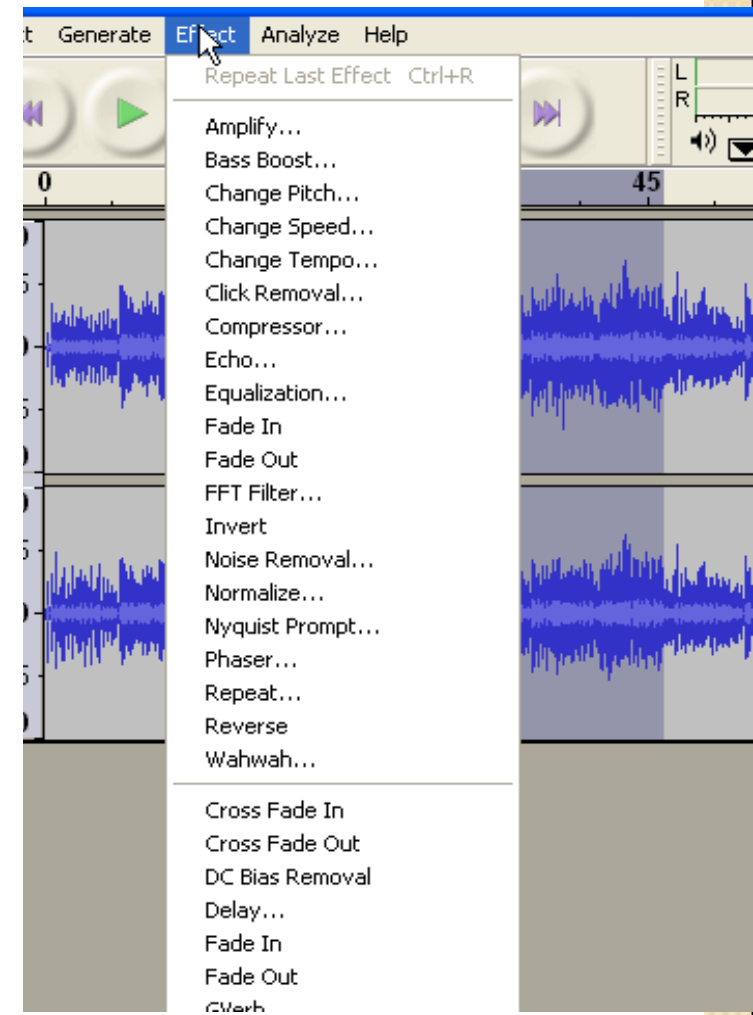
Why compress sound?

An example of uncompressed sound with CD quality for 1 minute of audio:

- 1 minute of recording ⍰ 60 seconds

- 60 * 44,100 samples/second ⍰ 2,646,000 samples

- 2,646,000 samples * 16bits per sample ⍰ 42,336,000 bits

- 42,336,000 bits * 2 (stereo, 2 channels) ⍰ 84,672,000 bits

- 84,672,000 bits / (8bits per byte) ⍰10,884,100 About 10 MB (Megabytes)!!!

- A typical CD can hold about 737MB (or 80 minutes of audio)

Sound Compression Strategies

4 Basic Strategies:

Reduce the number of samples (sample rate)

Reduce the bit depth (sample size)

Reduce the channels

Compress using the appropriate codec

Reduce the Sample Rate

Go from 44KHz to 22KHz (this will affect the quality)

Example: Go to Audio Demo on this page: http://www.cs.cf.ac.uk/Dave/Multimedia/node150.html

Note: All else staying equal, halving the number of samples will approximately half the file size

File Type (all at 8 bit)	File Size
44 KHz	1.3 Mb
22 KHz	424 Kb
11 KHz	120 Kb

Reduce the Sample Size

Go from 16 bit to 8 bit (this will affect the quality)

─ http://www.cs.cf.ac.uk/Dave/Multimedia/node150.html

Note: All else staying equal, halving the bit depth will approximately half the file size

File Type (all at 22KHz)	File Size
16-Bit	740 Kb
8-Bit	424 Kb

Reduce the number of channels

In mono there is one channel

In stereo there is two channels

Changing from stereo to mono will ½ the size of the file
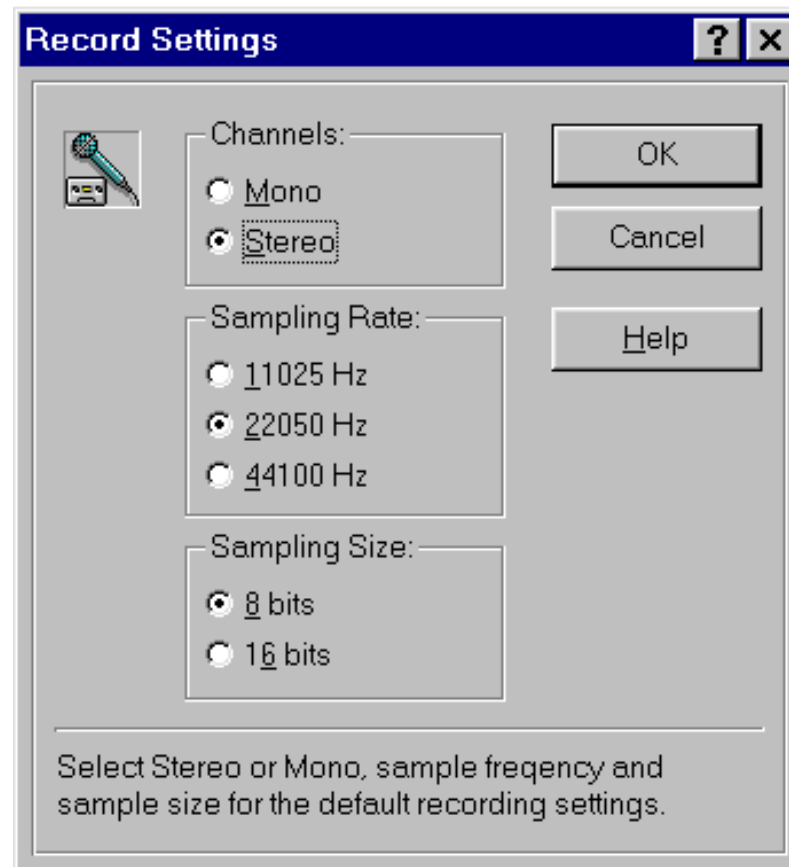
Pick the appropriate codec

Codecs for audio can be either lossy or lossless. NOTE: almost all are lossy!

File Formats that use lossy codec:

○ **Question**: Does anyone know the most famous audio file format that does lossy compression?

○ **Hints:**

- Start to become popular in the early 90s

- Can compress a song from a CD (songs on CDs are 44KHz, 16bit and uncompressed) to:

  - **1/11 of its size!**

- Based on the idea that some tones become unable to hear when another tone is present

Karlheinz Brandenburg

In a 2009 documentary about the history of the song by Swedish SVT, Brandenburg said:

I was finishing my PhD thesis, and then I was reading some hi-fi magazine and found that they had used this song to test loudspeakers. I said "OK, let's test what this song does to my sound system, to mp3". And the result was, at bit rates where everything else sounded quite nice, Suzanne Vega's voice sounded horrible.[8]Brandenburg adopted the song for testing purposes, listening to it again and again each time he refined the scheme, making sure it did not adversely affect the subtlety of Vega's voice.

From Wikipedia

• Researchers heard this song and because of the nuances in her voice used it to perfect the compression (Tom's Diner)

Audio Compression

File Formats that use lossless codecs/compression:

○ There are a few but not very common

Common File Formats that are uncompressed:

○ .wav (very common, 44KHz, 16bit)

○ .aiff

○ CDDA(Compact Disc Digital Audio defined in the Red Book which contains audio standards) ⬚ standard for CDs, 44KHz, 16 bit per sample, 2 channels.

- Thus 1 second of music must be played at a bit rate of: 44100*16*2*1=1,411,200 bits per second = 1411.2Kbits per second

- Compare with: mp3 ⬚128Kbits per second is most common, makes it good for the Internet!

Audio Compression

NOTE: .wma and .mp4 are lossy AND allow for built-in lockdowns which is why Microsoft and Apple are pushing them ;-)

Used to be if you put sound into your Flash animation you would never have to worry about the sound not playing because every computer comes with a Flash Player ▯ (no need to download a plugin)

○ However, ipads and other Apple products won't play flash so this isn't as true as it used to be!

Audio File Formats

Audio Format	File Extension	Advantages	Disadvantages
Advanced Audio Compression	.aac	• Good sound quality • Used on iTunes • Used on YouTube, iPhone, PlayStation, BlackBerry	• Copy protected • Limited to approved devices
Audio Interchange Format	.aif /.aiff	• Excellent sound quality • Supported without a plug-in • Mac format	• Uncompressed so large files
MP3	.mp3	• Good sound quality even though compressed • Can be streamed over the Web	• Requires standalone player or browser plug-in
Real Audio	.ra, .rx	• High Compression • Very small files • Can be streamed over the web	• Sound quality not great • Requires a player or plug-in
Wave	.wav	• Good sound quality • Supported without a plug-in	• Uncompressed, very large files
Windows Media Audio	.wma	• Good sound quality even though compressed • Used on music download	• Files can be copy protected • Requires Windows

MIDI Sound

There is another completely different way to make sound (rather than manipulating the waves).

Question: How does a MIDI file works?

MIDI Music

MIDI deals with music and synthesized sound, it does not handle voices or noise well.

There is no sampling or quantizing when storing MIDI files.

MIDI files hold information about music or sound such as:

- Which instrument is supposed to be represented
- The note being played
- How hard the note was pressed
- **Question**: Can any of you musicians think of one more thing it would need to store about a note?
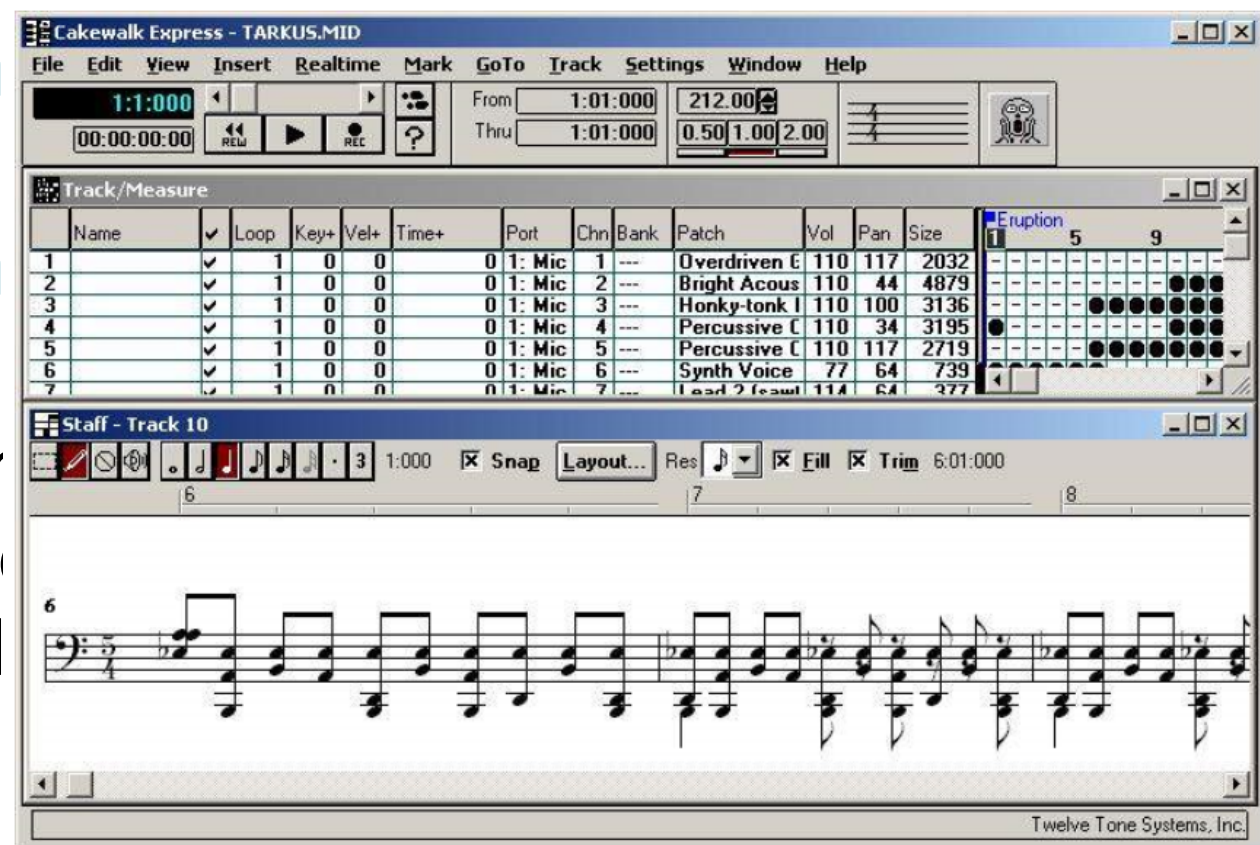
MIDI Files

Software such as Cakewalk, Cubase and Finale can be used to create and edit MIDI music.

Question: MIDI software offers a **Staff View,** what do you think that means?

Question

files?

Question

files?

NOTE: 3 m

3 minutes

about 15M

Take the MIDI test!

http://www.caseyrule.com/projects/piano/

Problem with MIDI recordings is that they are sometimes too perfect. See if you understand what we mean, listen to both of these recordings:

- One
- Two

QUESTION: Could you tell which one was live and which was a MIDI file?

Audio can be streamed too!

Downloadable Audio		Streamed Audio	
Advantages	Disadvantages	Advantages	Disadvantages
Once downloaded, can be replayed, edited over and over (don't need to wait again for download)	Takes a long time to download, especially for big files	Plays immediately	Cant rewind, pause, etc.
Don't need a special streaming web server to post the file	Takes up disk space on the computer to store it	Consumes RAM only while being played, then purged after	Need a special server to post it
Example: Audio Files on Limewire		Example: cbc radio	

Posting Sound on the Web

Can either:

○ Have a link to music that the user clicks on. Music will never start playing on the web page until the user clicks on link:

- *<p>Download a*
  *sound file *
  </p>

○ Have the music embedded in the web page:
<audio controls loop>
  <source src="dearmom.wav" type="audio/mpeg" >
</audio>

Things to think about when incorporating sound into your site:

- Will I have to edit the sound again (don't compress it just yet)?
- Will it need to be on the web, need good compression?
- Will it need to be streamed, need VERY good compression?
- Will be downloaded?
- Will the user listening to this sound require a plug-in?
- Is it voice only (can lower the number of samples)?

REMEMBER…

Please fill in the Feedback form:

https://feedback.uwo.ca

We left in this slide from the spring of 2020 ...

in a WORLD *where you can be anything* BE KIND