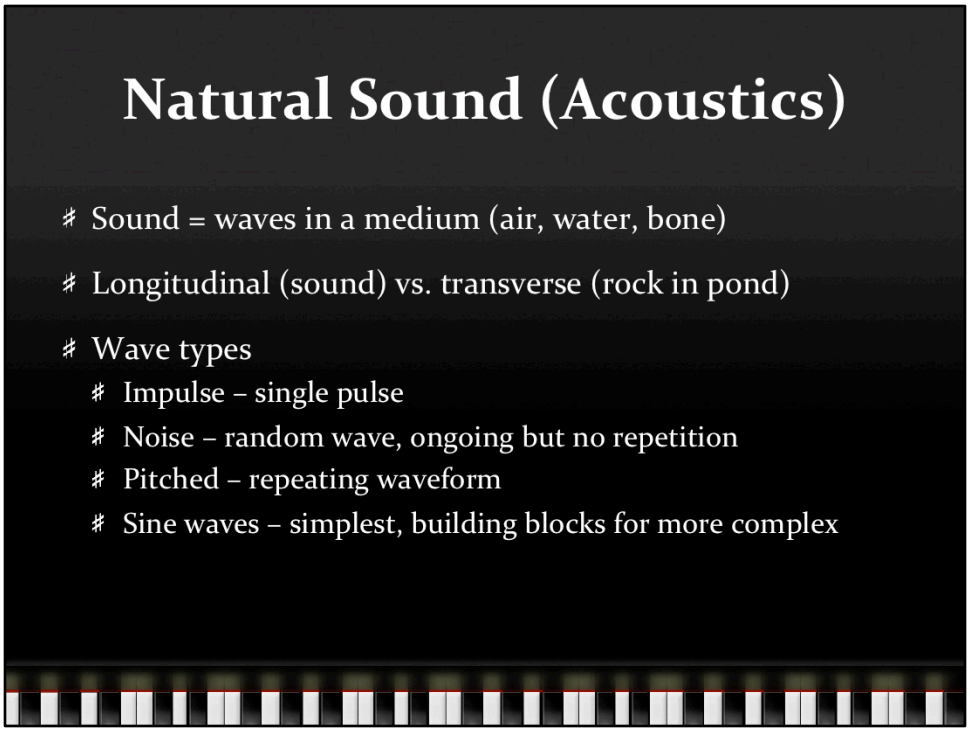
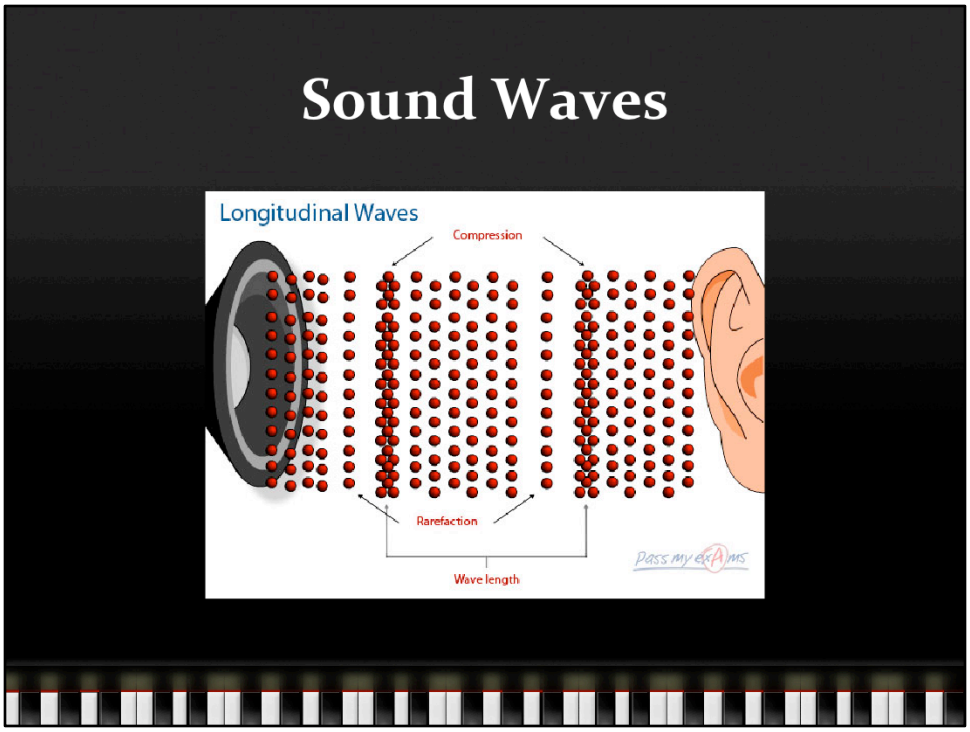
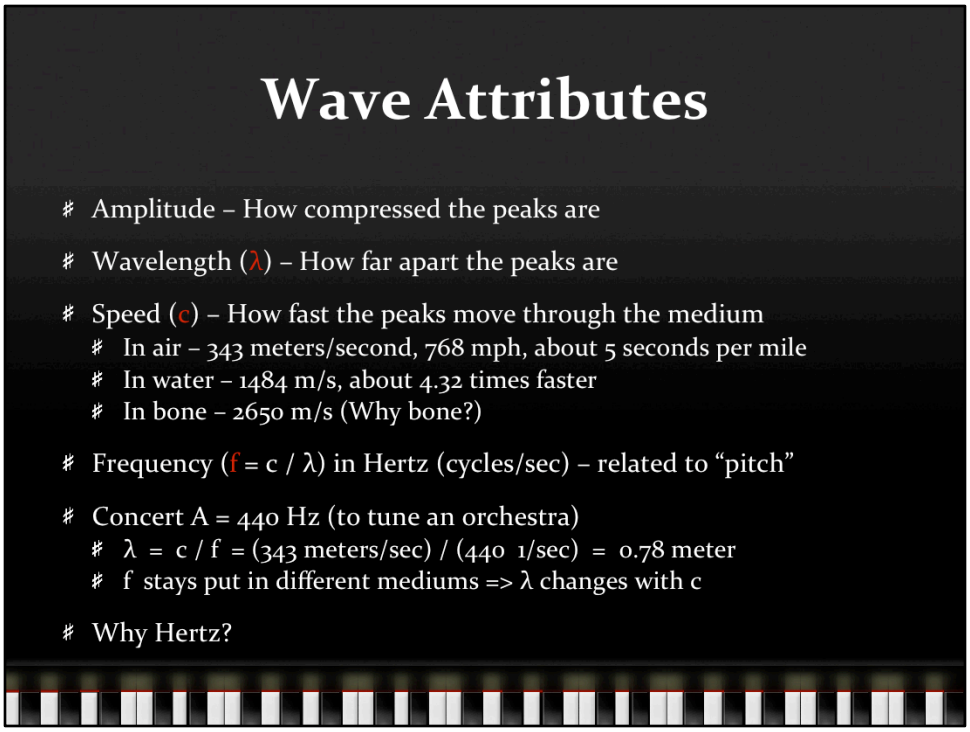


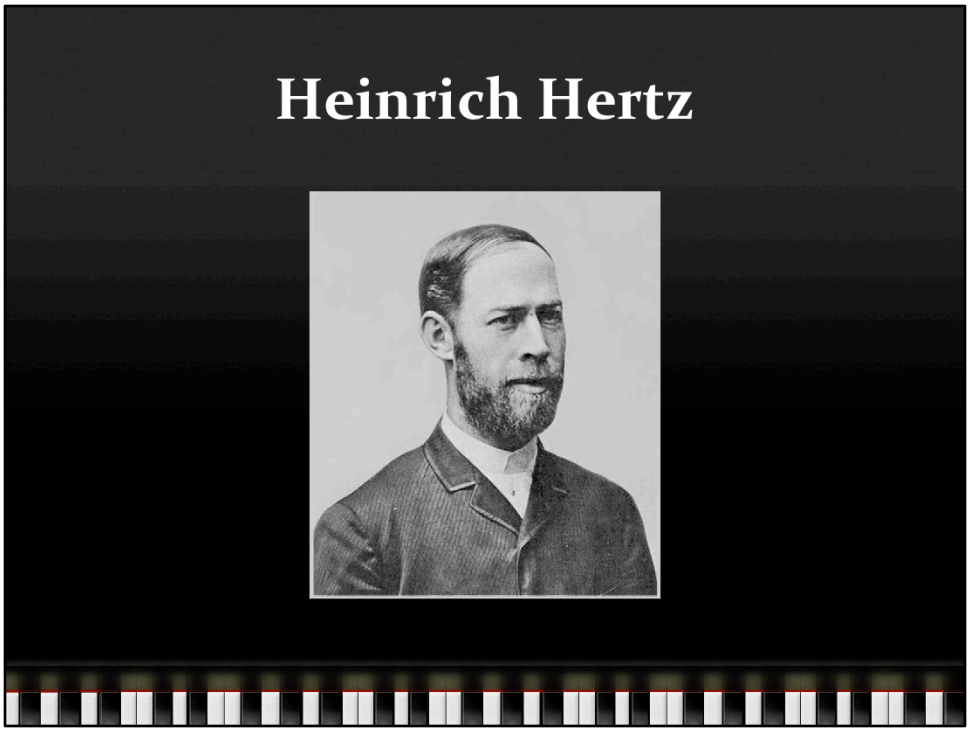
Single pulse: slap 2x4s together
Noise: rub two pieces of sandpaper together
Pitched: play a couple of notes on trumpet
Sine: strike a tuning fork?



From http://passmyexams.co.uk/GCSE/physics/Basic%20Waves%20Theory.html



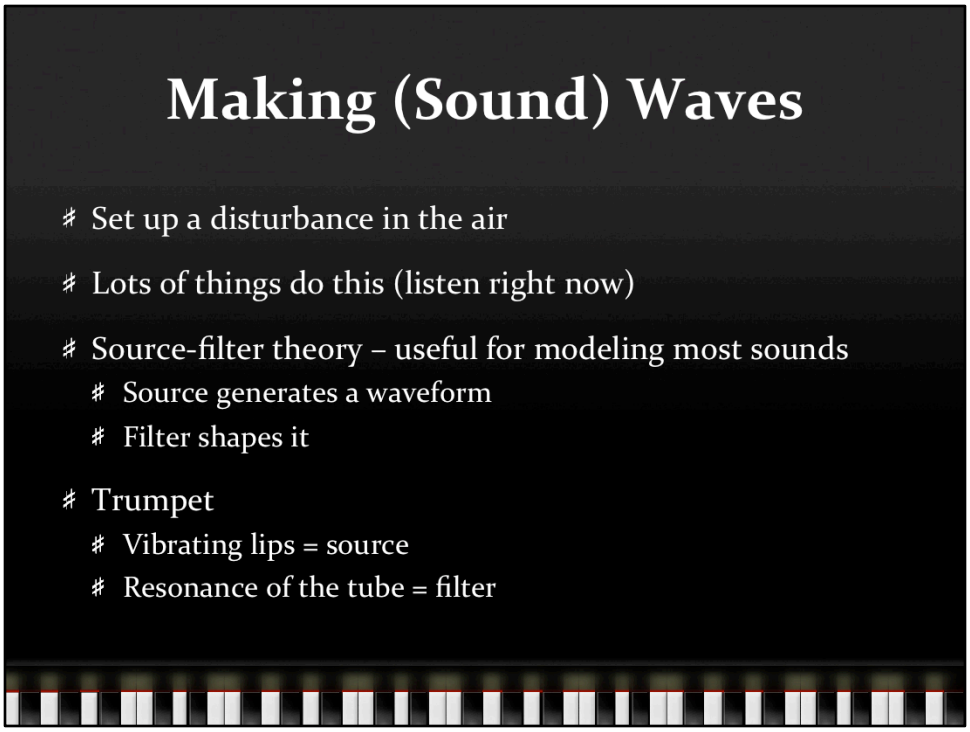
Why bone? Because that's a big part of how you hear yourself talk, which is one reason why recordings of yourself sound so weird.
Wavelengths in feet for frequencies in the audible sweet spot become an issue for multiple mic placements in recording (phase effects) – Don't go there for this lecture…



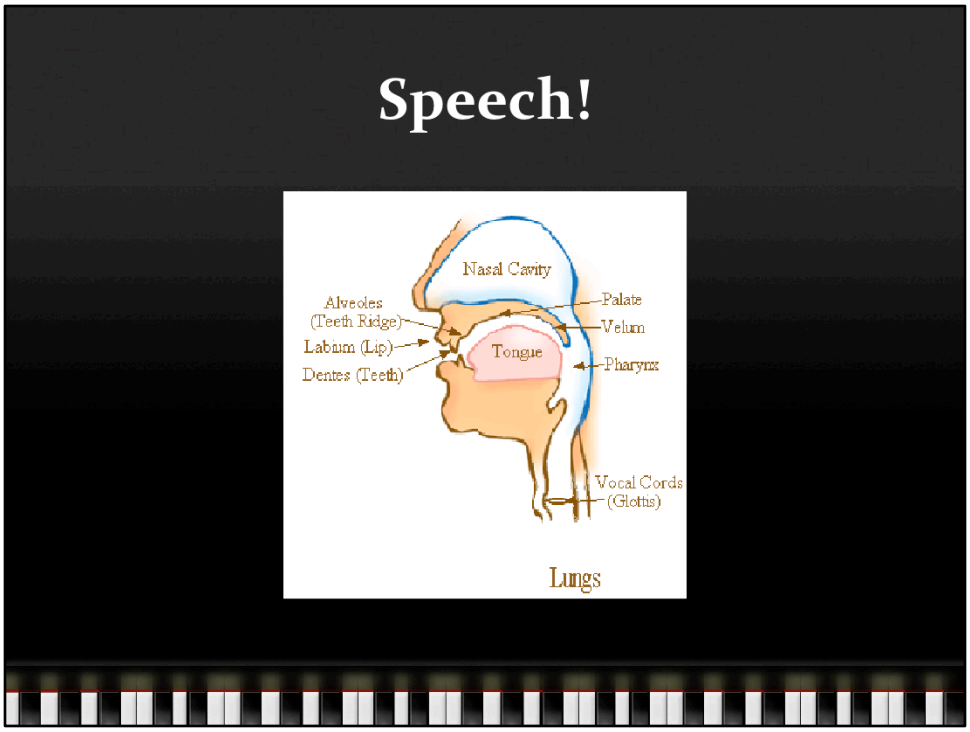
From http://www.scientific-web.com/en/Physics/Biographies/HeinrichRudolfHertz01.html

Image from http://www.jhu.edu/advising/scholarships/infopages/hertz.htm

Image from http://gustomobil.wordpress.com/2009/07/11/asyiik-bisa-sewa-lotus/

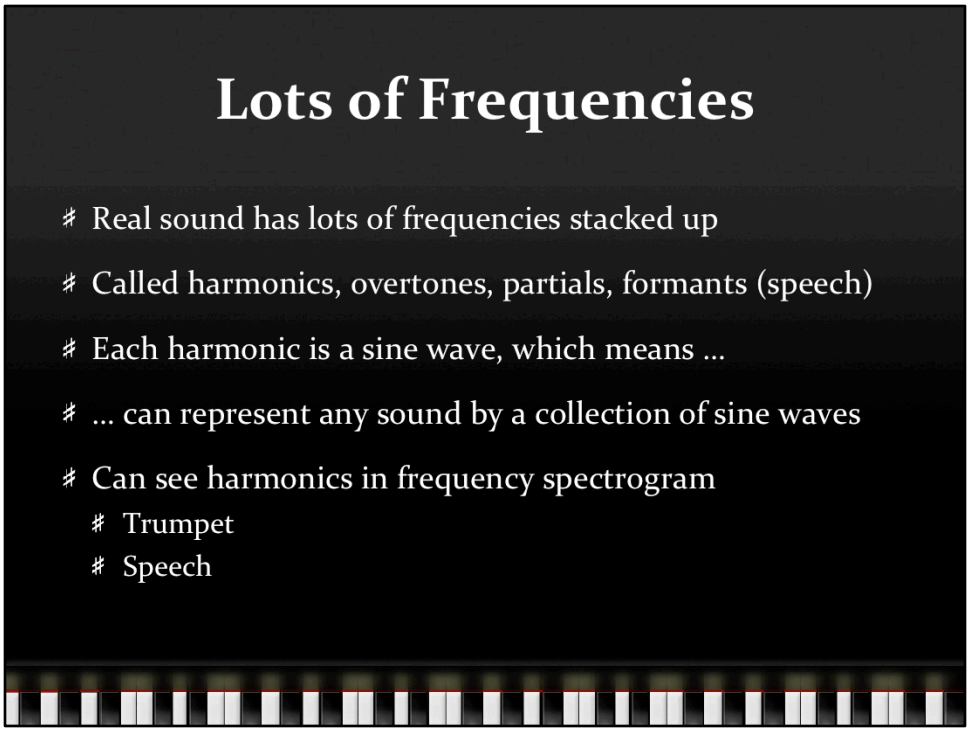


Do resonant tuning demo with trumpet



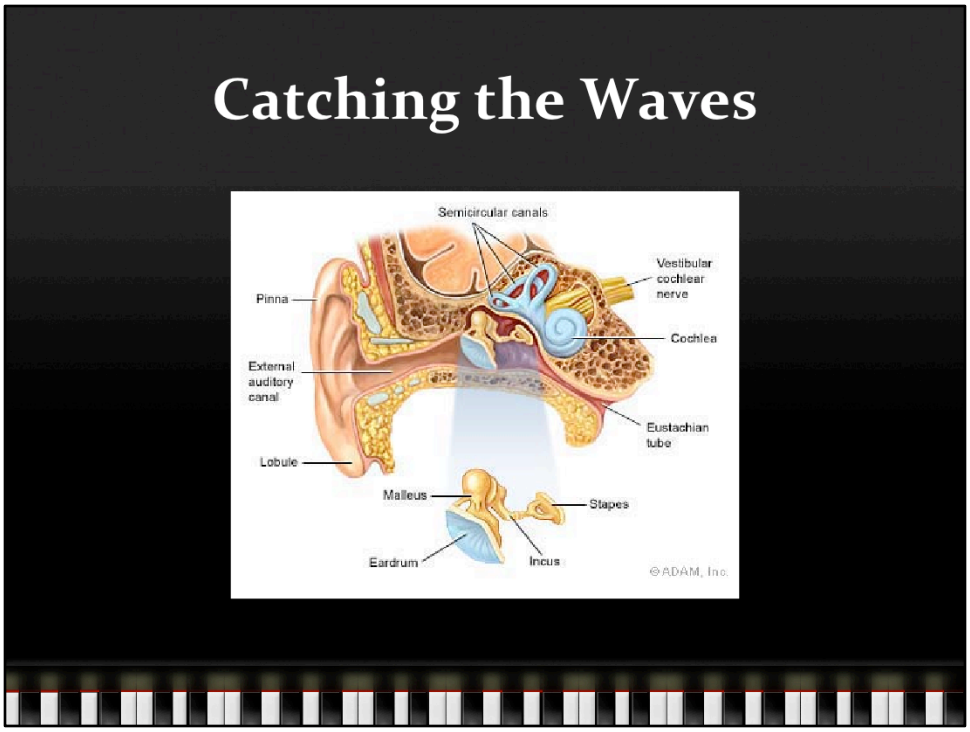
All this stuff from http://home.hib.no/AL/engelsk/seksjon/SOFF-MASTER/Organs.htm

The speech sounds often have their names from the Latin name of the vocal organ:
Nasal sounds: through nose (velum down)
Oral sounds: through mouth (velum up)
Stops: full oral closure
Fricatives: partial oral closure (friction)
Approximants: narrowing (no friction)
Labial: from labium, lip(s) active
Dental: from dentes, teeth active
Alveolar: Alveoles, teeth ridge active
Palatal: Palate, hard palate active
Velar: Velum, soft palate active
Glottal: Glottis, vocal cords active



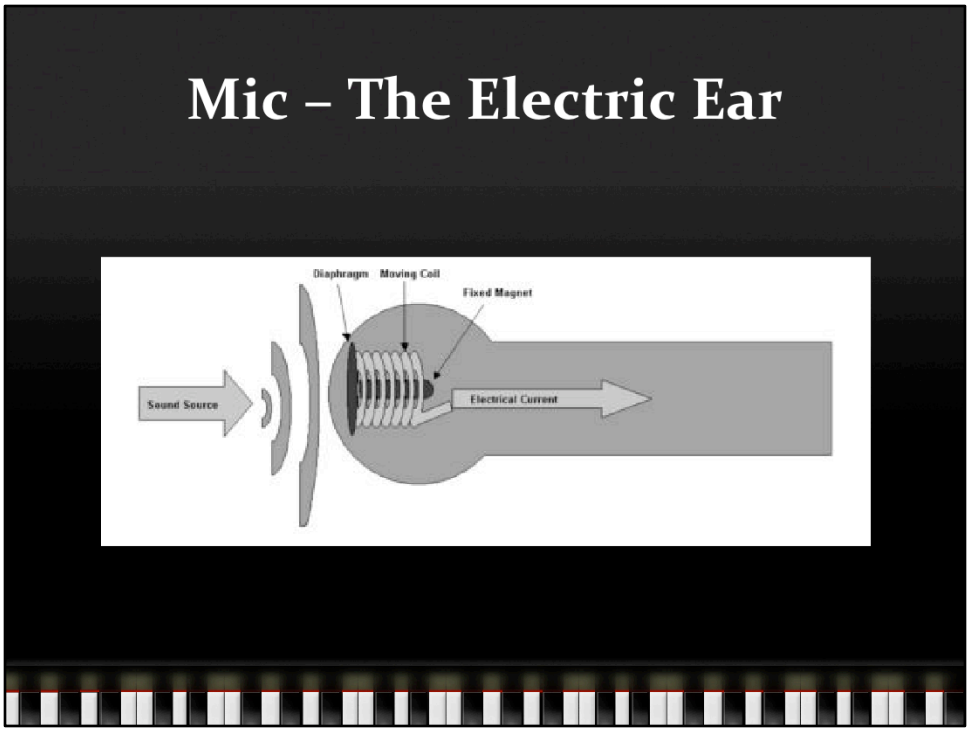
Bring up audacity to record stuff and display spectrograms

Waveform is in time domain: X axis is time, Y axis is amplitude
Spectrogram is in frequency domain: X is time, Y is frequency, darkness is amplitude



From http://www.nytimes.com/imagepages/2007/08/01/health/adam/1092Earanatomy.html

Waves get to your head, bounce around your head/ear flap, work down ear canal
Waves reach ear drum and excite it in sympathy
Moves the bones (hammer, anvil, stirrup)
Stirrup kicks the cochlea, which moves the liquid inside
Liquid moves hair cells on wall of cohchlea, which fire and send signals down cochlear nerve to brain
Brain interprets, etc., etc., etc.



From http://www.soundware.co.uk/pages/microphones

Mic, basically takes waves to the stirrup step in the ear – Sets up continuous (analog) current flow in sympathy with waveform much as the stirrup sets up sympathetic vibrations of fluid in the cochlea.
The nerve pulses through the cochlear nerve are more in the frequency domain, while the current coming from the mic is strictly in the time domain.

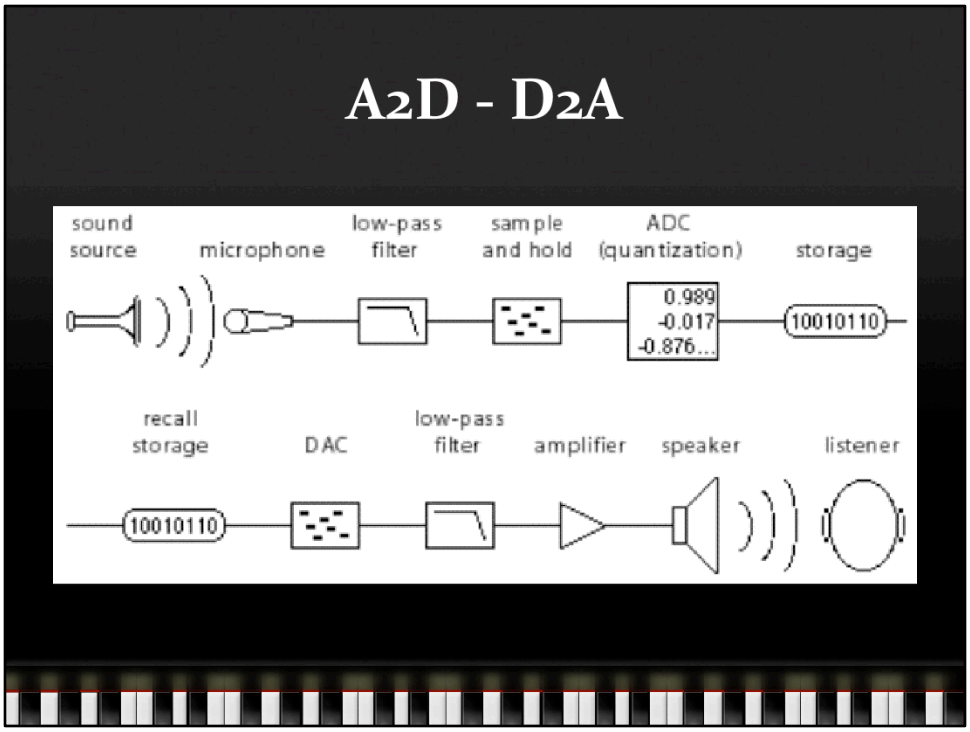
Recording

- Capture and store the waves on something …
- … that can be used to (re)generate them at a future time
- Basically a time machine for a time-based medium
- Mechanical (Analog) – Needles making scratches on moving tinfoil, wax, shellac, vinyl
- Electric (Analog) – Continuous voltage curves stored as magnetic fields on moving wire, cylinder, tape
- Digital – Voltages sampled at discrete times and stored on tape, disk, flash memory as sequence of discrete numbers

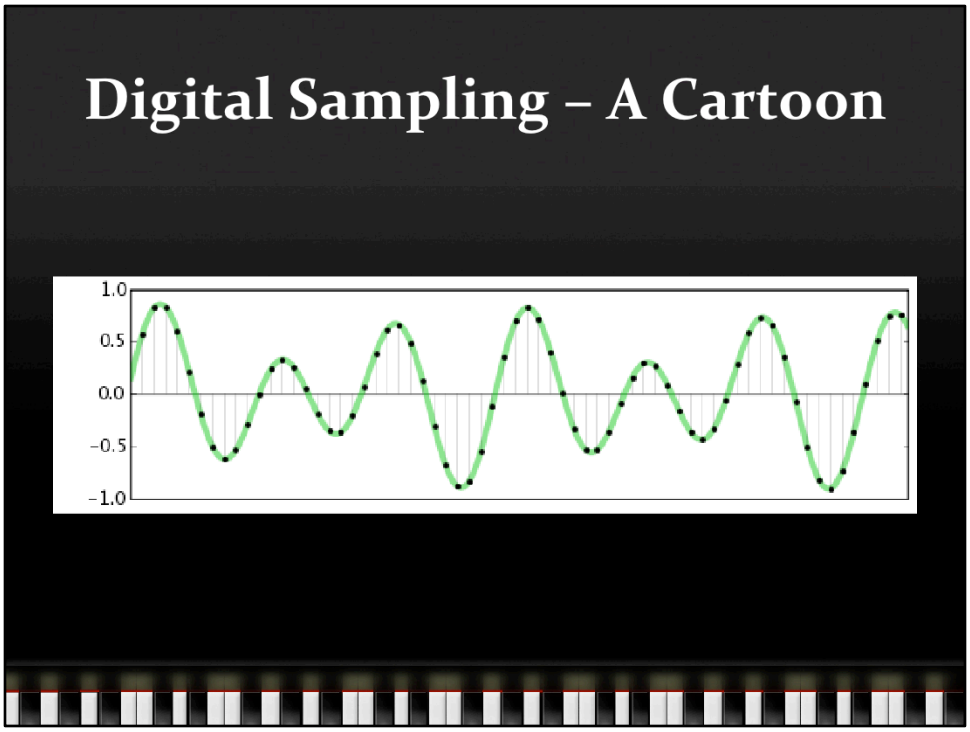
From http://pagesperso-orange.fr/jlf/enphonos.htm

Go to this website to hear modern recordings of the old records played on these machines.

From http://www.recording-history.org/HTML/musictech6.php

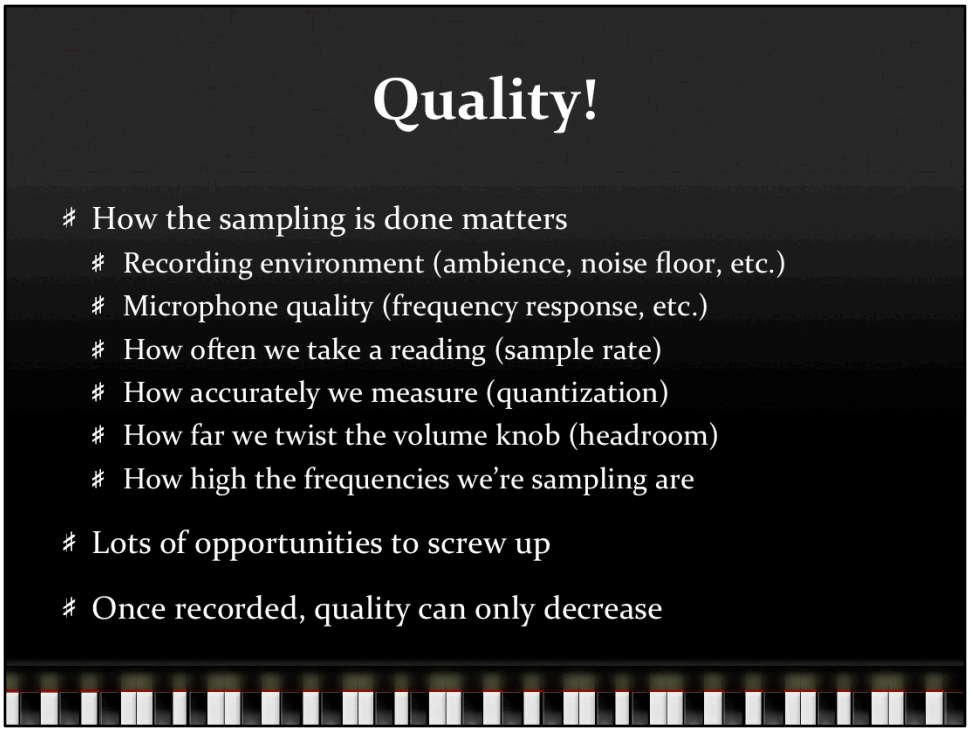


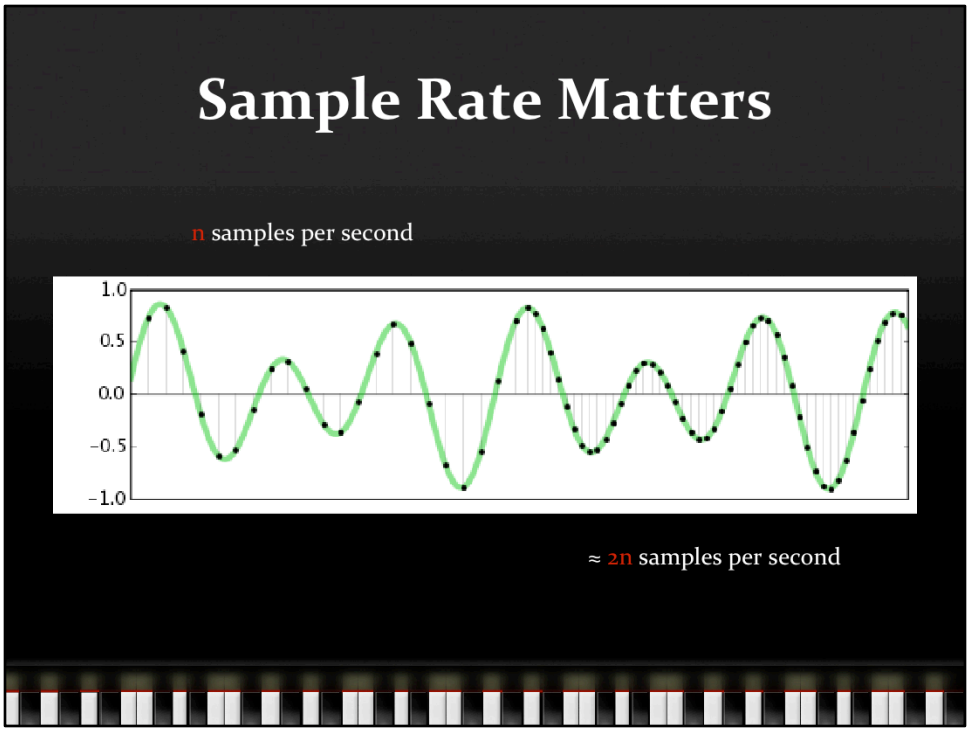
From http://www.cycling74.com/docs/max5/tutorials/msp-tut/mspdigitalaudio.html
Low pass filter eliminates frequencies that would be aliased on A2D
Quantization maps the floating point sample values to n-bit integers
DAC generates smooth voltage curves from discrete samples



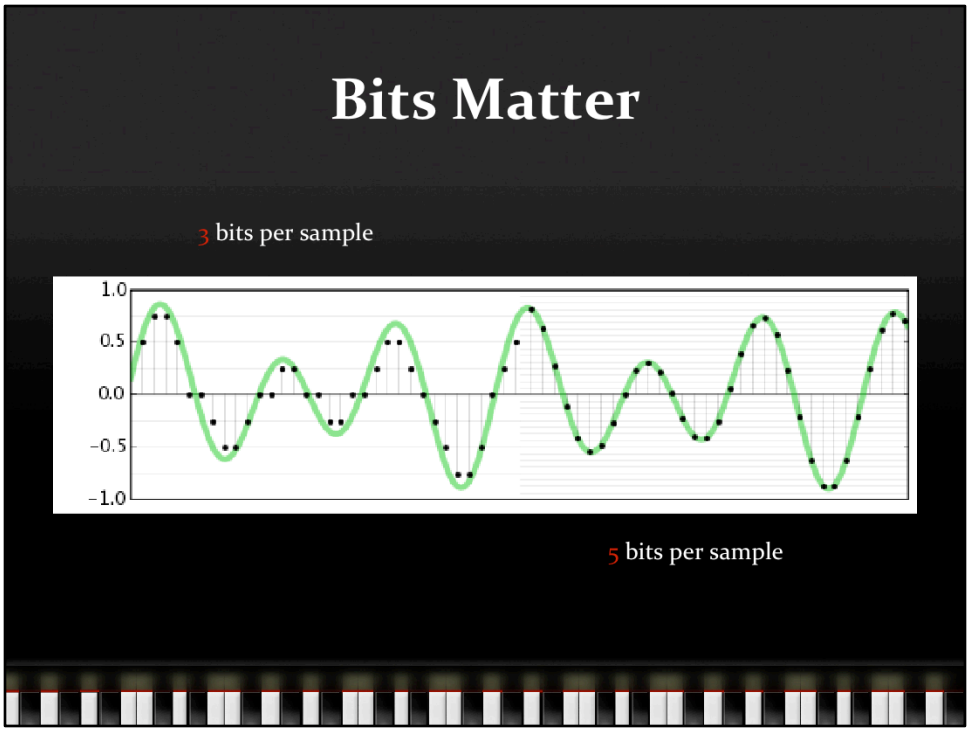
From http://manual.audacityteam.org/index.php?title=Digital_Audio

Smooth green voltage curve sampled at discrete points in time, results in a discrete (digital) approximation of the continuous waveform, basically a histogram



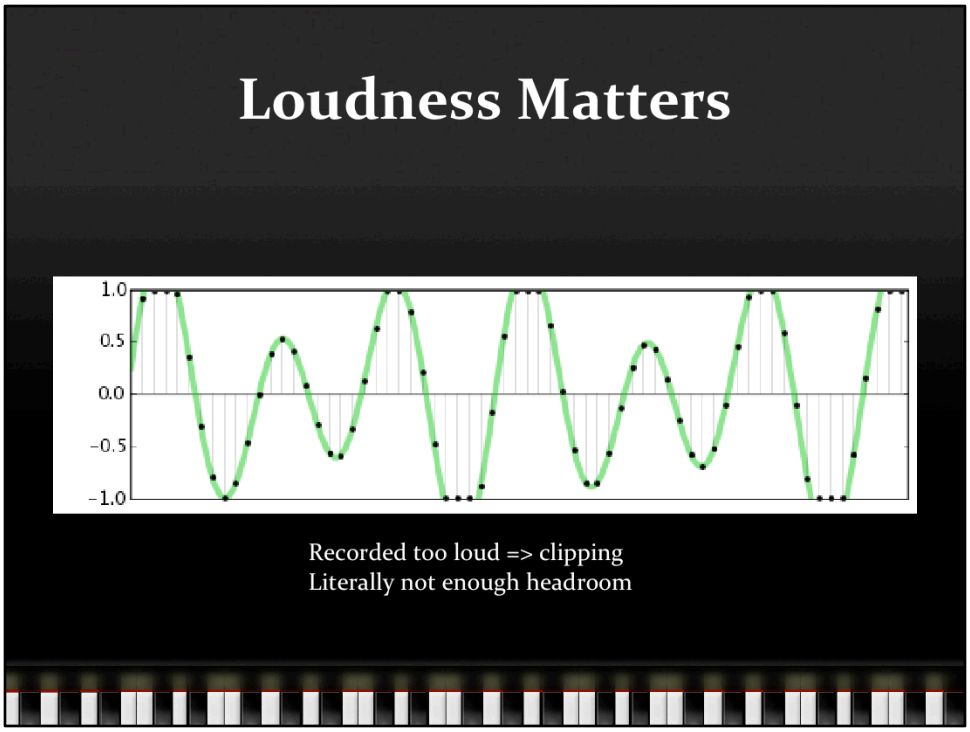


From http://manual.audacityteam.org/index.php?title=Digital_Audio



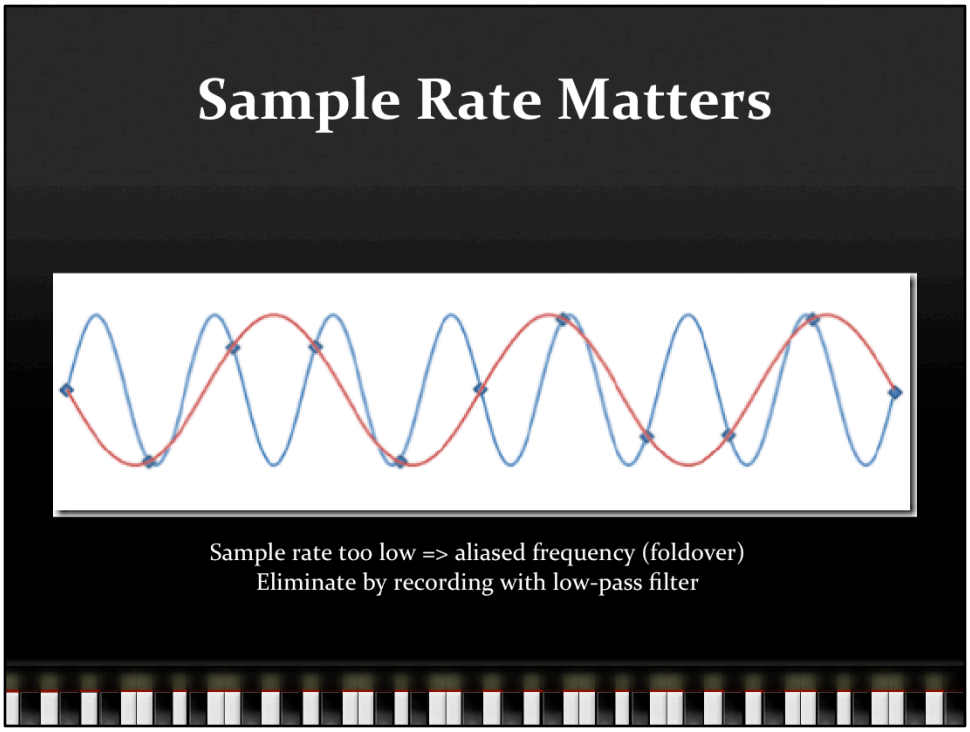
From http://manual.audacityteam.org/index.php?title=Digital_Audio

8 amplitude levels on the left, 32 on the right



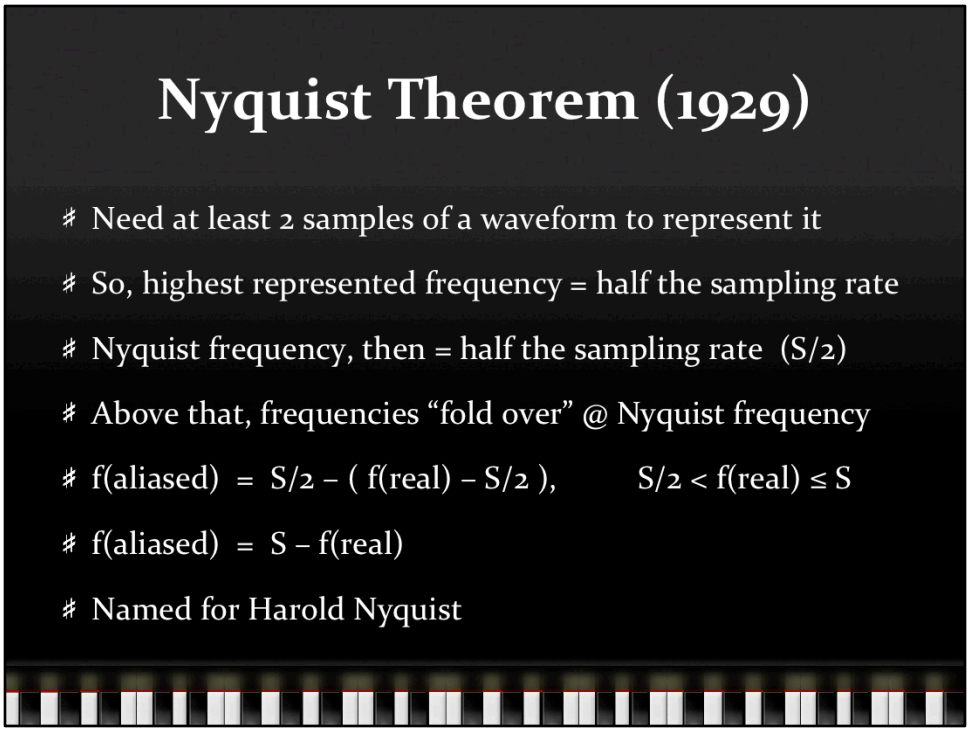
From http://manual.audacityteam.org/index.php?title=Digital_Audio

Literally hitting your head on a ceiling (not enough headroom)
If recorded too soft, you're not taking advantage of all the bits (not using the available headroom)
Any clipping is bad, especially if it's with repeating waveforms because it imposes a square wave over the waveform at high amplitudes



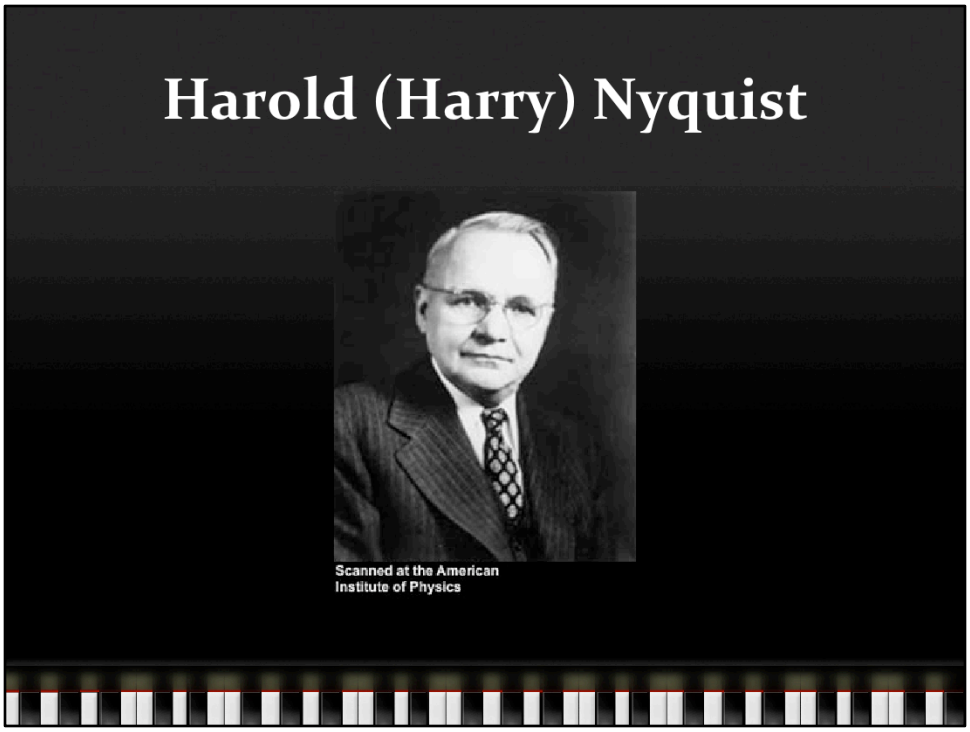
From http://blogs.msdn.com/audiofool/archive/2007/02/15/digital-audio-aliasing.aspx

Any frequency above the Nyquist frequency (half the sampling frequency) will be aliased down into the sub-Nyquist-freqency range
Basically it bounces linearly off the Nyquist frequency ceiling.
For real frequencies between the Nyquist frequency and the sampling frequency (S), the aliased frequency is the sampling frequency – real frequency or …
f(aliased) = S – f(real), for S/2 < f(real) <= S
Frequencies above S get aliased too, bouncing off 0 (the floor), but we don't see this in typical audio.



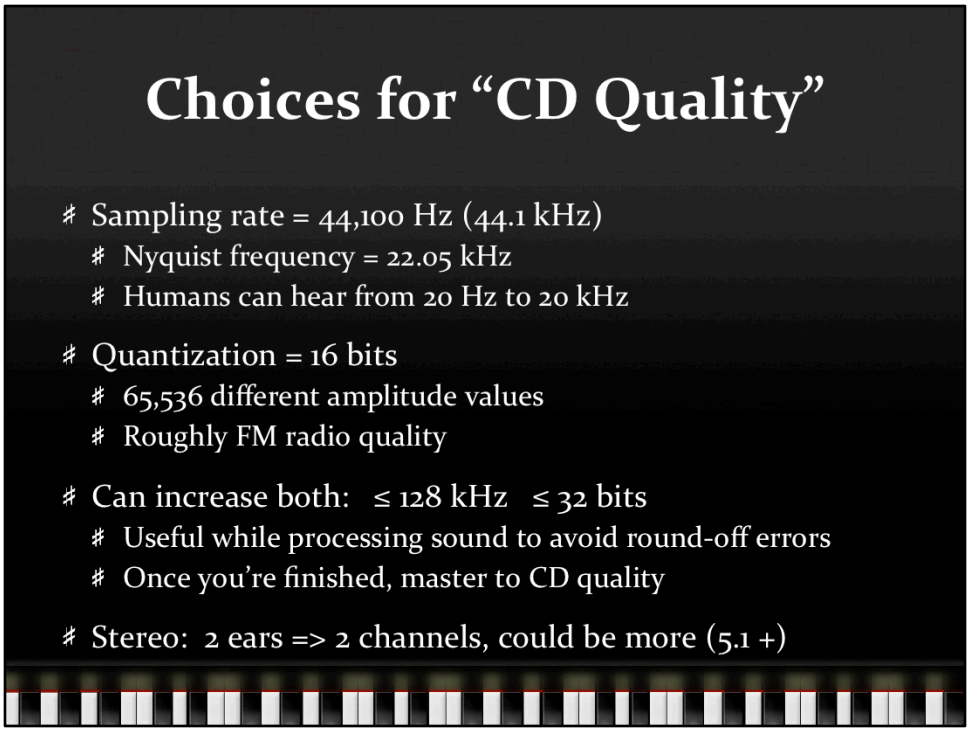
For sampling rate S and S/2 < f(real) <= S:
f(aliased) = S/2 – (f(real) – S/2)
= S/2 + S/2 – f(real)
= S – f(real)

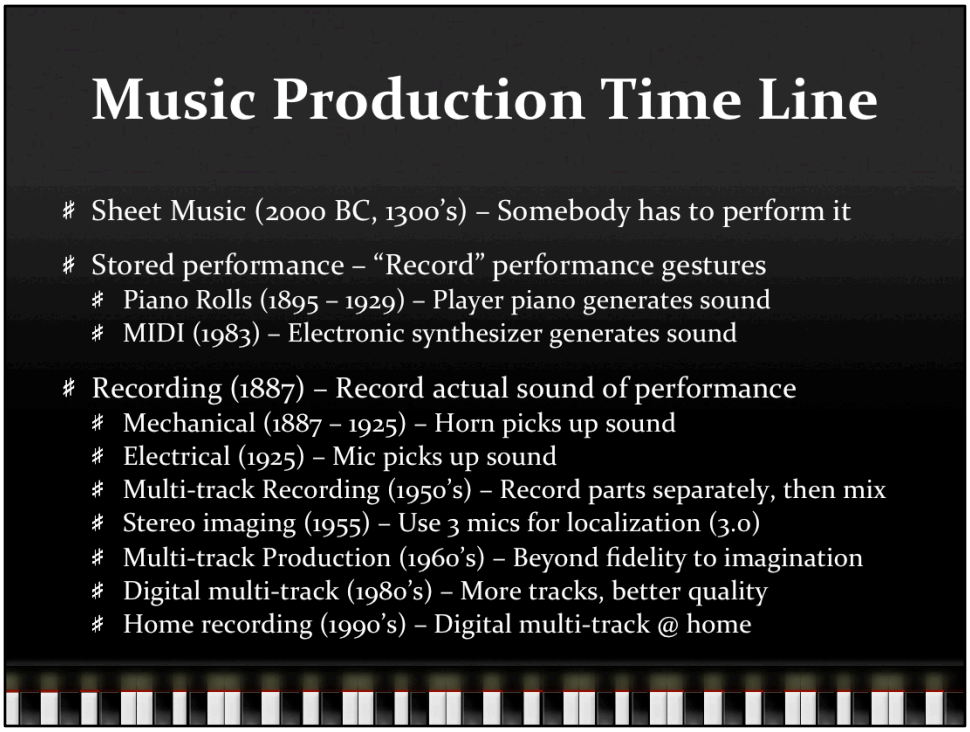
Draw diagram on board:
X axis = real f from 0 to S
Y axis = aliased frequency from 0 to S/2, draw ceiling at S/2 (horizontal line)
Graph is a tent that touches the S/2 line



From http://www.geocities.com/bioelectrochemistry/nyquist.htm

Harold (Harry to his friends and everyone else) Nyquist





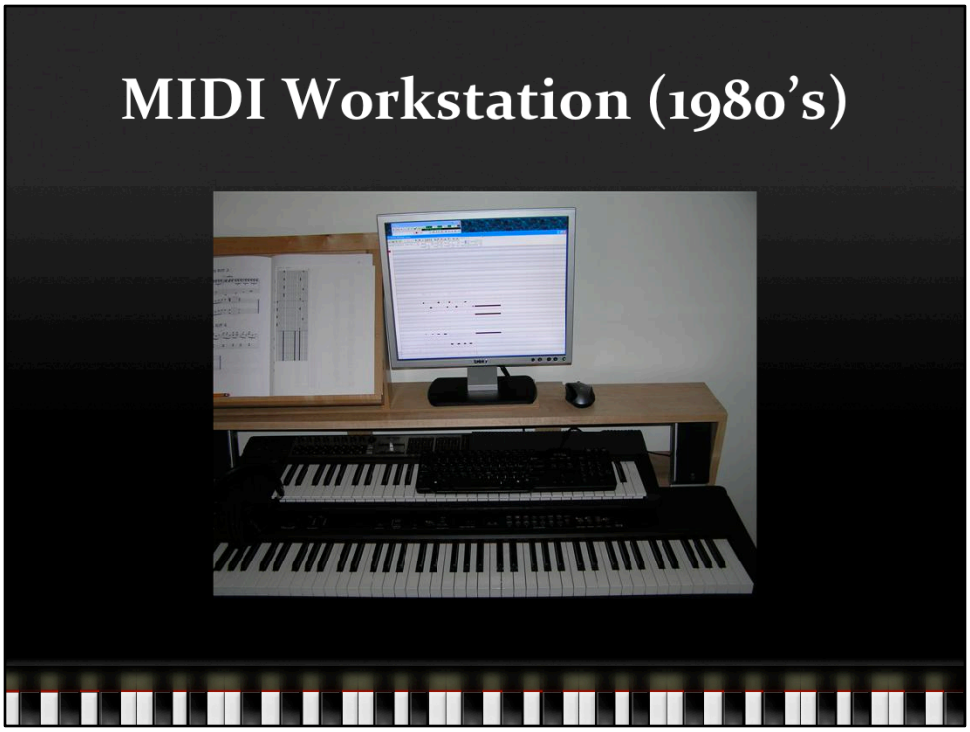
Sheet music:
2000 BC Cuneiform tablet in Nippur (Sumerian city)
6th century BC Greeks had notation for pitches, durations, limited harmonies
Mid 1000's Guido D'Arezzo invented stave (four-line)
1300's Today's 5-line staff introduced

Player piano companies: largely killed off by 1929 crash and great depression
MIDI = Musical Instrument Digital Interface

Recording history: long and convoluted …

http://www.immortalpiano.com/?page=player-pianos

Pneumatic technology – Have to pump foot pedals to play it
Killed off by 1929 crash and subsequent depression



http://shazware.com/piano/rig.html

Shows "piano roll notation" on screen in MIDI sequencer software.

http://www.mainspringpress.com/studio_photos.html

Tenor Jacques Urlus and the boys recording a disc in Edison's Fifth Avenue studio (New York), 1916. (ENHS)

http://www.mainspringpress.com/studio_photos.html

The International Novelty Orchestra, a Victor house group under the direction of Nat Shilkret (center, holding baton), prepare to get down and get funky,
after the introduction of Western Electric equipment. (LOC)

Les Paul and Mary Ford layering who knows how many tracks with the old Ampex 8-track recorder
http://www.classicaldomainli.com/lespaul2.html

Timeline from http://en.wikipedia.org/wiki/History_of_multitrack_recording
1947 Paul releases first multi track recording (8 guitar parts layered one track at a time with shellac disks!)
1948 Paul got first Ampex reel-to-reel tape recorder as gift from Bing Crosby, modified it with multiple play and record heads to facilitate layering (sound on sound)
1953 Paul commissioned Ampex to build first 8-track recorder (custom)
1955 First commercially available 2 and 3 track analog tape machines available
1958 Atlantic first studio to install 8-track
1968 Beatles use two 4-track recorders for Sgt. Pepper, 8-track for White Album

http://www.soundfountain.com/amb/mercury.html

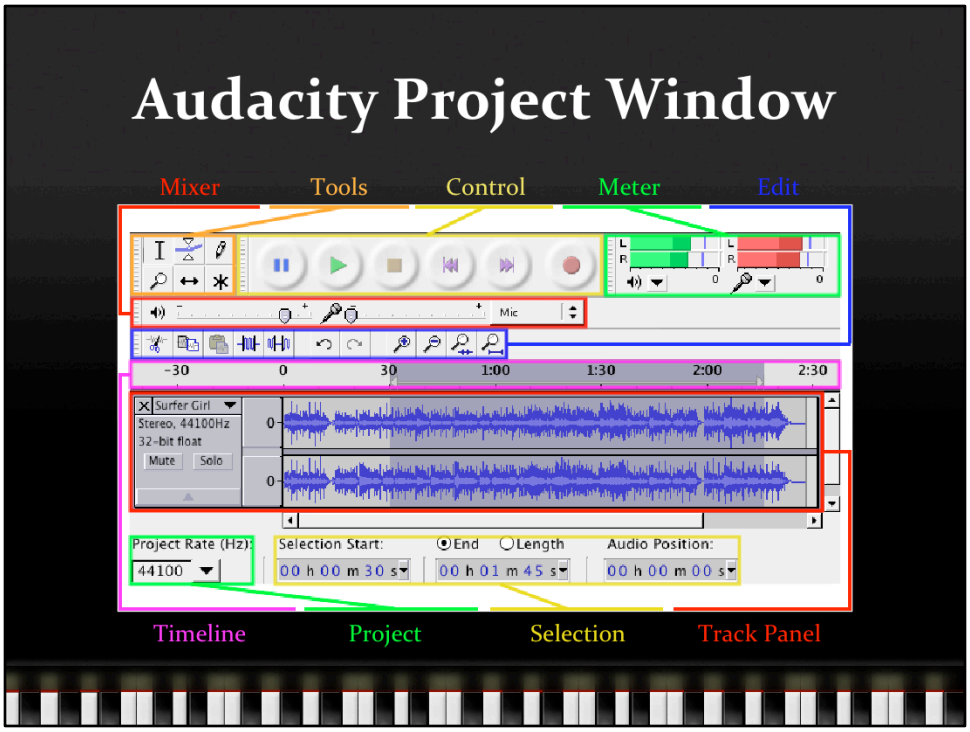
Really three channels (3.0 in today's parlance), probably because the best tape machines at that time were 3-track Ampex machines

http://www.bbc.co.uk/programmes/b00ml584

They weren't the first, but they exploited it the most by using multi track as a compositional technique, not just for recording
Before 1964, they recorded 2-track mono
With Sgt. Pepper, used two 4-track recorders and lots of effects (pitch shifting, ADT (automatic double tracking), flanging, reverse, etc.
Treated recorded track as source for effects that altered the content in artistic ways

http://www.seymourduncan.com/forum/showthread.php?t=156523

Bring the studio to the artist, instead of the other way around
Once recording went digital, it became an "IT" problem, subject to Moore's law, with predictable results.
These days, who needs to pay a recording studio? Just put that money into gear!



http://manual.audacityteam.org/index.php?title=Quick_Guide