LIVE Q&A Drafts hw1 hw2 hw3 hw4 hw5 hw6 hw7 hw8 hw9 hw10 project exam logistics other hardware_and_software_resources
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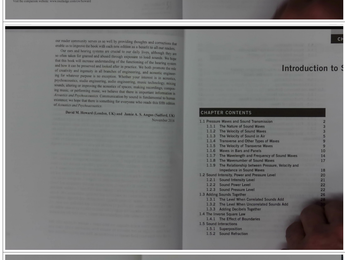
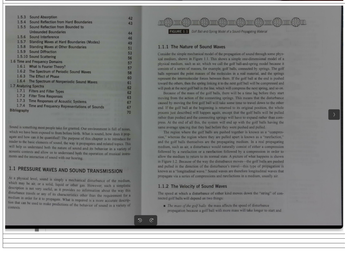
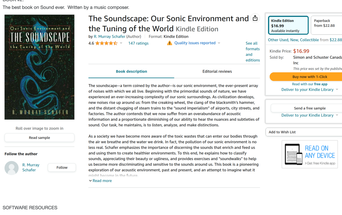




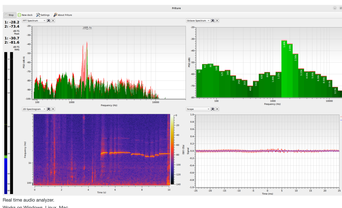
BOOK #2:
The best book on Sound ever. Written by a music composer.



SOFTWARE RESOURCES

DEMO #1 :FRITURE
https://friture.org/download.html

NOTE: you can start and stop program and measure frequencies with the cursor !!!
This is a good sanity check if you need a quick measurement



Real time audio analyzer.
Works on Windows, Linux, Mac.

<DEFINE TERMS>
Frequency: cycles per second
Spectrum:
2D spectrum (aka sonogram, aka moving spectrum)
Scope (signal voltage vs time)

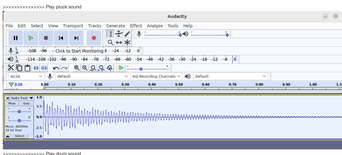
DEMO #2 Audacity.
Read, write and process WAV files.

>>>>>>>>>>>>>>>> Generate Sine wave Bb. 238.04 Hz.

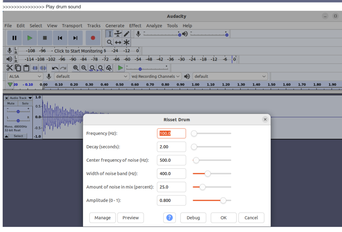
>>>>>>>>>>>>>>>> Generate Triangle Wave

>>>>>>>>>>>>>>>> Square Wave

>>>>>>>>>>>>>>>> Play pluck sound



>>>>>>>>>>>>>>>> Play drum sound



Note impact on display.

<TERMS>
Fundamental frequency (F0).
Harmonic (any integer multiple of F0.

WAV FILE:
A raw uncompressed file. For this course, unless otherwise specified we will have MONO. 44.1kHz files.

44.1kHz, also known as CD sample rate, is common. Video often uses 48kHz.

WAV files may be 16 bit samples (signed integer) or most recently, float (four bytes).

WAV files of 16 bit samples have signed values (-32768 , 32767) normalized to a range of -1.0 to +1.0 when loaded into a software package.

WAV files of float will typically have a value between -1.0 and 1.0, but may have larger or smaller values.

NB: the "effective number of bits" of a float is 24 bits (three bytes). The rest is used for sign and exponent. Float are preferred way to work as you will not lose data.

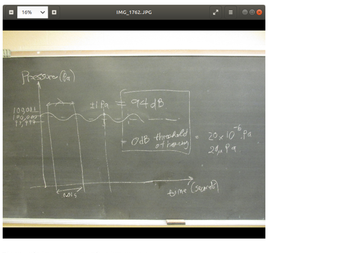
GNU Octave
https://octave.org/download
You will need "signal" package for filtering later in course.

INTRODUCTION TO SOUND.

Sound pressure level, Pascal (Pa).
Air static pressure is 101.3kPa = 101,300 Pa. Local barometric pressure.
Air pressure depends on:
- local weather barometric pressure (so to xx Pa)
- elevation changes (approx 12 Pa/ m)
- temperature

For now let's just take Air pressure as 100,000 Pa unless otherwise noted.

Sound waves: local variations that "ride on top" of local pressure.

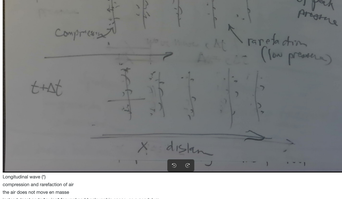


Total pressure P is the sum of local pressure P_0 and "over pressure" p.
$P = p + P_0$

The figure above shows a signal going from +/- 1 Pa at the rate of twenty cycles per second.
1 Pa corresponds to 94 dB (Decibels), a high sound level.
The over pressure p is very small, 1/100,000 of the atmospheric pressure!

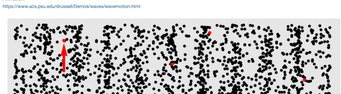
Waves and the speed of sound
λ=c/f
λ : wavelength, meters (m).
f: frequency Hertz (Hz, aka cycles per second cps)
c: speed of sound, approx 343 m/s @ 20C, (1,125 ft/s, 1,235 km/h, 767 mph)
A 20 Hz wave has a wavelength of 343/20 = 17.5m
A 100 Hz wave has a wavelength of 343/100 = 3.43m
A 1000 Hz wave has a wavelength of 343/1000 = 0.343m (1.125 ft).

Wave propagation by Longitudinal wave.



Longitudinal wave (?)
compression and rarefaction of air
the air does not move en masse
instead, local parts "swing" forward and backward in space, as a pendulum

Animation.
https://www.acs.psu.edu/drussell/Demos/waves/wavemotion.html



(*) we can have transverse, and other waves in strings, solids, and plates.

SOUND WAVES, ACOUSTICS

Engineering reference, acoustics radiators and detectors, electro acoustics, loud speaker enclosures and microphones.

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Richard Mann answered AQ Grades in 29 min. 2 weeks ago

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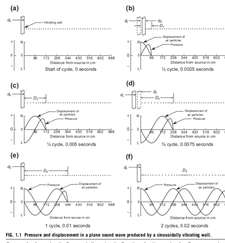


FIG. 1.1 Pressure and displacement in a plane sound wave produced by a sinusoidally vibrating wall.

D_1 = one-fourth wavelength, D_2 = one-half wavelength, D_3 = three-fourths wavelengths, D_4 = one wavelength, D_5 = two wavelengths. *P* means displacement of the air particles to the right, *L* means displacement to the left and *O* means no displacement. Crowded dots mean positive excess pressure and spread dots mean negative excess pressure. The frequency of vibration of the piston is 100 Hz

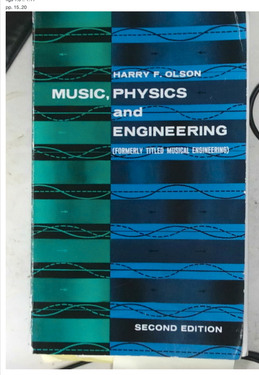
In the figure above, a piston moves forward and backward.
The compression and rarefaction of the air pressure is depicted by a row of dots that becomes closer together (compression) or farther apart (rarefaction).

Note that the volume of air does not move (in aggregate).
Compression in one place is offset by expansion in another place

Sound waves diffuse, reflect, and refract like regular waves.
If you have ever seen a "wave pool" in physics class, acoustics waves behave the same way.
They may be show "schematically" by lines at regular intervals (at the peaks or valleys in pressure).

From a point source, waves radiate outward, peaks (or valleys) in pressure shown by lines.
Wavelength is distance between lines.

Diffraction, reflection, diffusion
Harry F. Olson, MUSIC PHYSICS and ENGINNEERING, 2nd Ed.
figs 1.6 .. 1.11
pp. 15, 20



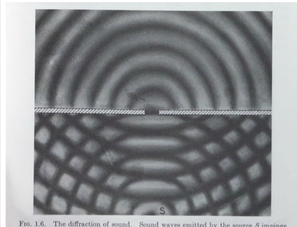


FIG. 1.6. The diffraction of sound. Sound waves emitted by the source *S* impinge upon the reflecting wall and the small aperture in the wall. The dimensions of the aperture are small compared to the wavelength of the sound. A major portion of the sound wave which impinges upon the wall is reflected. A small portion of the incident sound wave is transmitted through the small aperture. The sound waves which pass through the aperture radiate in all directions in the same way as though the aperture were a source of sound waves. The spreading of sound waves due to the passage through an aperture is termed diffraction.

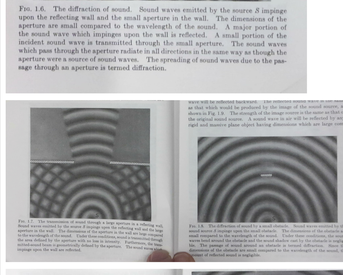


FIG. 1.7. The transmission of sound through a large aperture in a reflecting wall. Sound waves emitted by the source *S* impinge upon the reflecting wall and an large aperture in the wall. The dimensions of the aperture in the wall are large compared to the wavelength of the sound. The sound waves which pass through the aperture radiate in the same fashion as if the aperture were not there. Furthermore, there is a well-defined beam is geometrically defined by the aperture. The sound waves which impinge upon the wall are reflected.

FIG. 1.8. The diffraction of sound by a small obstacle. Sound waves emitted by the source *S* impinge upon the small obstacle. The dimensions of the obstacle are small compared to the wavelength. Under these conditions the obstacle does not cast almost a perfect sound shadow. Since the dimensions of the obstacle are small compared to the wavelength, the obstacle does not cast a sound shadow. The sound waves are reflected. The wavelength and intensity of the reflected sound waves are the same as that produced by a sound source of the same strength as the original source. The image of the original sound source.

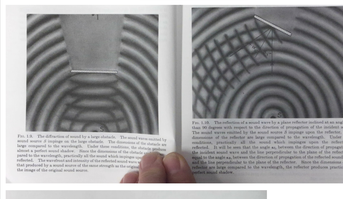


FIG. 1.9. The diffraction of sound by a small obstacle. Sound waves emitted by the source *S* impinge upon the small obstacle. The dimensions of the obstacle are small compared to the wavelength. Under these conditions the obstacle does not cast almost a perfect sound shadow. Since the dimensions of the obstacle are small compared to the wavelength, the obstacle does not cast a sound shadow. The sound waves are reflected. The wavelength and intensity of the reflected sound waves are the same as that produced by a sound source of the same strength as the original source. The image of the original sound source.

FIG. 1.10. The reflection of a sound wave by a plane reflector inclined at an angle to the incident sound wave. The sound waves emitted by the source *S* impinge upon the reflector. The sound waves emitted by the sound source *S* impinge upon the reflector. The dimensions of the reflector are large compared to the wavelength. Under these conditions the sound waves are reflected in a well-defined manner. The sound waves are reflected. It will be seen that the angle α_1 between the direction of propagation of the incident sound wave and the line perpendicular to the plane of the reflector, is equal to the angle α_2 between the direction of propagation of the reflected sound wave and the line perpendicular to the plane of the reflector. Since the dimensions of the reflector are large compared to the wavelength, the reflector produces practically a perfect sound shadow.

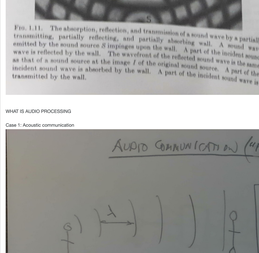
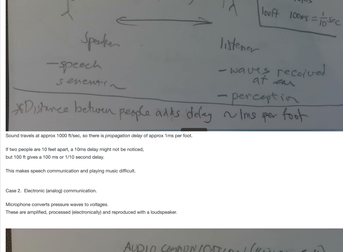


FIG. 1.11. The absorption, reflection, and transmission of a sound wave by a partially transmitting, partially reflecting, and partially absorbing wall. A sound wave emitted by the sound source *S* impinges upon the wall. A part of the incident sound wave is reflected by the wall. The wavefront of the reflected sound wave is the same as that of a sound source at the image *I* of the original sound source. A part of the incident sound wave is absorbed by the wall. A part of the incident sound wave is transmitted by the wall.

WHAT IS AUDIO PROCESSING

Case 1: Acoustic communication



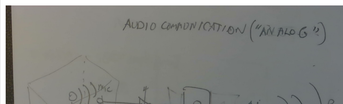
Sound travels at approx 1000 ft/sec, so there is propagation delay of approx 1ms per foot.

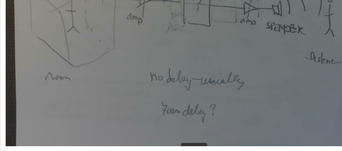
If two people are 10 feet apart, a 10ms delay might not be noticed,
but 100 ft gives a 100 ms or 1/10 second delay.

This makes speech communication and playing music difficult.

Case 2. Electronic (analog) communication.

Microphone converts pressure waves to voltages.
These are amplified, processed (electronically) and reproduced with a loudspeaker.

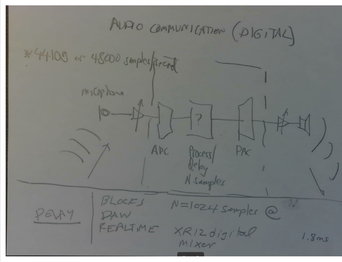




Case 3. Audio communication, Digital

The same as above except that the "wire" is replaced by conversion to digital, processing and returning to analog.

Think Zoom call.



HARRIS AND ANGUS 5th ed, Section 4.1.

Treat musical instrument as a "black box" that interacts with person and room.

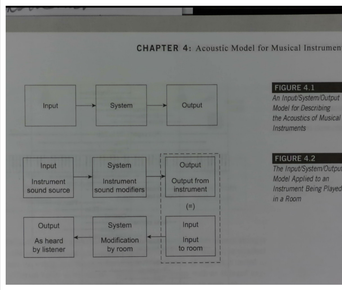


FIGURE 4.1
An Input/System/Output Model for Describing the Acoustics of Musical Instruments

FIGURE 4.2
The Input/System/Output Model Applied to an Instrument Being Played in a Room

AUDIO PROCESSING
A simple algorithm says,

Algorithm:
System Problem:
- input
- processing (algorithm)
- output

This processing can be in any device, analog or digital.
It is built into microphones, hearing aids, music players, synthesizers, and just about everything else.

A critical factor in audio algorithms is whether they operate in realtime, with a slight delay, or completely offline

The signals are digitally sampled (analog to digital conversion) at 44100 or 48000 samples per second:
This is called the sample rate, denoted f_s.

Sample time
1/44100=2.2676e-05 = 23 micro seconds = .023 ms (milli seconds)
1/48000=2.0833e-05 = 21 micro seconds.= .021 ms

Samples used

	fs 44100	fs 48000
1	0.023 ms	0.021 ms
10	0.23 ms	0.21
50	~1.2 ms	
100	~2.4ms	
1024	~24ms	

The delay is then determined by the number of samples processed to compute the current output.

The simplest system use a fixed block size, eg. 1024 samples.

Realtime or near realtime processing is much better and the only reliable way.

Problem	Input	Computation	Output	Realtime
Batch processing	WAV file	compression		"near real time" for streaming delay ?
Digital Audio Workstation writer notes (midi), sequencing, analog effects: EQ, compression, reverb, etc. Example: ProTools, Garage Band, Cubase, Linux: Ardour	analog inputs, WAV files,	capture, mix, sequence		"near real time" block size approx N=10-30 samples.
Digital Audio Mixer (?) effects: EQ, compression, reverb, etc. Example: Behringer X-Air series	analog inputs	DSP realtimeOS	analog outputs	NEAR FEAL TIME latency 0.8ms)

logistics other

good note 3 Updated 3 months ago by Richard Mann

followup discussions *for lingering questions and comments*

Start a new followup discussion

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Course Outline 1/5/24
ETR, course outline is in today's **lecture**, just 1
posted. 1/5/24
+ 1 **Unresolved followup**

CS485/685 Section 004 — Ad... 1/5/24