Basic acoustics (pt. 1)

Rogers Chapters 7 and 8

Sound

- What is sound?

Sound

- What is sound?
  - Vibrations (usually in air) that can be heard
    - From Wikipedia: Sound is vibration, as perceived by the sense of hearing.
- Sound waves
  - Compression/rarefaction wave carrying the vibrations

Waves

- Compression/rarefaction wave carrying the vibrations
- From Wikipedia:

  "In more technical language, sound is ...[a] series of mechanical compressions and rarefactions or longitudinal waves that successively propagate through media that are at least a little compressible ...

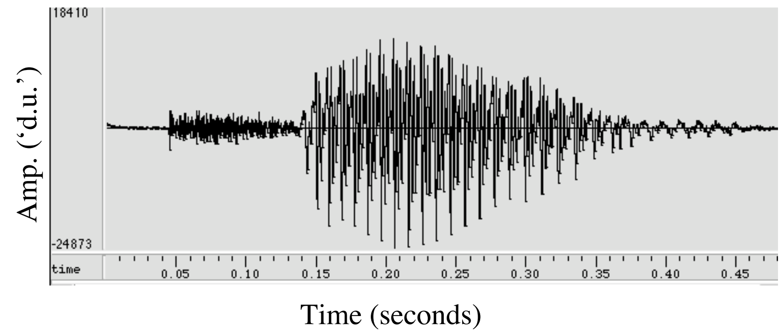
Waves transverse and longitudinal

- Transverse - (not sound)
  - Motion particles in
    - Stadium wave
    - Ripples on pond
    - Rubber tubing or rope
- Longitudinal (sound)
  - Pinched slinky
  - Sound
- Great demos (esp. balloon)
  - http://myweb.dal.ca/mkiefte/

Compression waves to waveforms

- Propagation of sound
  - Not so important for us
- What ***is*** important for us:
  - Compression/rarefaction wave strikes microphone and is recorded
  - Software allows us to see WAVEFORM of sounds
- Waveform
  - Display showing the amplitude of a sound at each instant of time
  - Amplitude is proportional to pressure 'seen' at microphone

Waveform of the word 'two'



Note: Amp. ('d.u.') = amplitude in 'digital units'
(proportional to voltage at microphone- scaled by computer hardware)

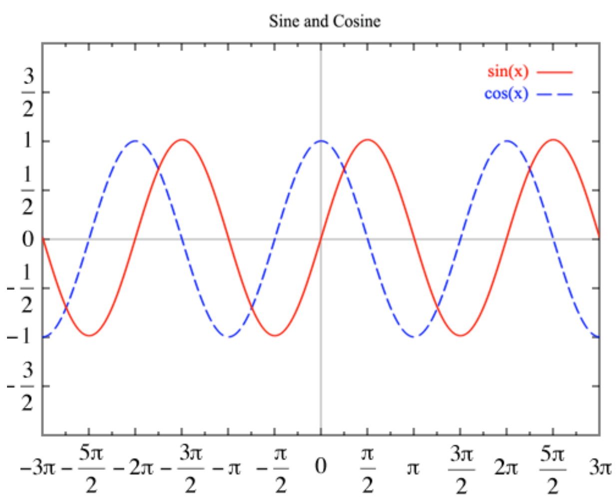
Speech waveforms are complex

- We need to start with something simple
- Sine waves
  - We can study some basic properties of simple sounds
  - Later we see that more complex sounds can be broken down to such simple sounds

Sine waves (sinusoids): simple periodic wave

- Sine wave: **Simple** shape (unlike speech)
  - Sine waves have the same shape as the sine or cosine functions of high school trigonometry
  - Shape repeats itself **periodically**
    - Periodic means ‘exactly repetitive’
    - The largest pattern that repeats itself is called a cycle or period

The basic shape (Wikipedia):

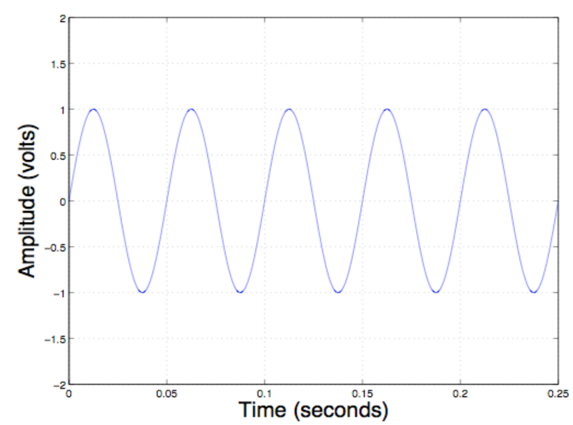


Horizontal or X-axis is angle, Vertical axis is value

Waveforms of sinusoids

- Waveforms of sinusoids have same shapes as the trig functions
- Waveform plots involve
  - Horizontal (x-) axis: **time**
    - seconds (s) or milliseconds (ms = s/1000)
  - Vertical (y-) axis: **amplitude**
    - Units may vary (volts, micropascals, computer digital units)
    - **Proportional to sound pressure** changes in air
      - » And to voltage changes from microphone
      - » Results from diaphragm of microphone moved by ‘vibes’

Waveform of a sine wave



Amplitude and frequency(Rogers Figs. 7.4 and 7.5)

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Same frequency Different frequencies

Sinewaves (sinusoids) : simple periodic sounds

- Sine wave : simple sound
  - Sound of a tuning fork is very close to sine wave
  - A steady whistle is fairly close to a sine wave
  - Electronic examples

Demo Whistle

- Recording of a whistle (WaveSurfer)
  - http://www.speech.kth.se/wavesurfer/
  - Stockholm KTH (Royal Institute of Technology)
  - Kåre Sjölander and Jonas Beskow
- DEMO of PROGRAM

Period and frequency

- Time span it takes complete pattern repeats is called the **period** of the sine wave
  - Measured in seconds (s) or milliseconds (ms)
- **Frequency** is number of complete periods per seconds
  - Measured in hertz (Hz)

Converting period to frequency

- 1 Hz = 1 complete period per second or one full cycle per second
  – (old name for Hz was ‘cycles per second’)
- Example: period = .01 s
  – If a cycle repeats in .01 s = 10 ms, there are 100 cycles in one second so frequency is 100 Hz
- General formula

  [Freq in Hz] = 1/[Period in seconds]

  = 1000/[Period in milliseconds]

Demos: single sine wave

- Demonstration of sine waves ESynth
  – http://www.phon.ucl.ac.uk/resource/sfs/esynth.htm
    - UCL (U. College London)
    - Mark Huckvale
  – Can create sines and combinations of sines
  – Can analyze chunk of speech as sines
    - Spectral analysis

Demos-combinations of sines

(subject to time and software limits)

- Demonstration of combinations of sine waves ESynth
  – Can create sines and combinations of sines
  – Can analyze chunk of speech as sines
    - Spectral analysis

The spectrum

- All sounds can be **thought of** as combinations of sinusoids
- All sounds can be **analyzed** that way
- Useful way to represent sounds is via spectrum
  – X- axis is frequency
  – Y- is amplitude (or intensity)
    - Amplitude units often expressed in decibels (dB)
      – But may be in pressure units or volts (V) or ‘d.u.’ (digital units)

Adding sine of different frequencies

Rogers Figs 7.8 & 7.9

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Waveform A: Sum of 3 components

Waveforms of B, C, D: the components separately

Spectrum of A
X- axis frequency
Y- axis 'Intensity'
(What happened to time?)

Spectrum: where is time?

- Ideal spectrum is 'timeless'
  - Assume signal goes on forever
- A practical spectrum: the spectral section
  - Applies to a limited time-stretch (or section) of a signal
  - Similar to the ideal spectrum of an infinite signal that matches our signal for the time-section of interest