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Summary

### Introduction to Acoustic Phonetics

G. Moroz

3 February, 2018

### About course

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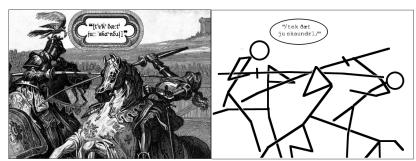
Addition waves

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- · Here is a course website.
- · Here is a course program.
- · We expect some theoretical knowledge
  - · read 2. chapter from [Gussenhoven, Jacobs 2011]
  - · be able to use IPA symbols
- · We expect some basic R skills:
  - · import .csv files to R
  - · dplyr, ggplot2

### Phonetics?...



Phonetics

**Phonetics** 

from http://specgram.com/CLIII.1/09.parenchyma.cartoon.e.html

Phonology

Phonetics is generally assumed to be a subfield that deals with articulatory, acoustic and perceptional aspects of phonological units. Phonology and phonetics together are supposed to describe organization of sounds in languages.

This course is about acoustic phonetics.

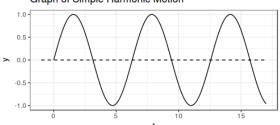
## Simple Harmonic Motion

**Periodic Motion** is any type of motion that repeats itself after successuve equal time intervals.

**Simple Harmonic Motion** is specific type of periodic motion that arises from

- · existence of some **equilibrium position** for a described object;
- **linear restoring force** that tending to pull the described object back to its equilibrium position.

# Graph of Simple Harmonic Motion



SHM

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## Simple Harmonic Motion

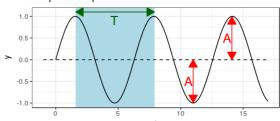
Amplitude is the maximum displacement of the equilibrium position.

**Period** (T) is the duration of time of one cycle in a repeating event. (s)

Frequency (f) is the number of period (cycles) per second. (Hz)

$$f = \frac{1}{T} \qquad \qquad T = \frac{1}{f}$$

### Graph of Simple Harmonic Motion



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### Sound as SHM

We can correlate the physical properties of sound waves with our perception:

- · We perceive changes in frequency as **pitch**
- · We perceive changes in amplitude as loudness

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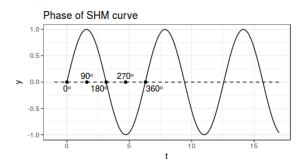
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### Phase of SHM

One period of SHM can be devided into  $360^0$  of **phase**  $\varphi$ .



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## SHMs comparison

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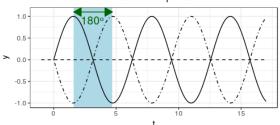
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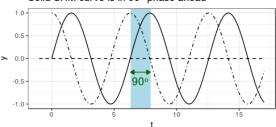
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#### These SHM curves are out of phase



#### Solid SHM curve is in 90° phase ahead



## Wave representation

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Waves can be represented by formula:

$$s(t) = A \times \cos(2\pi f t + \phi)$$

- $\cdot$  *A* amplitude
- $\cdot f$  is the fundamental frequency
- $\cdot \phi$  phase
- · *t* time

### Harmonic motion

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Sound

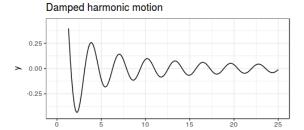
Phase

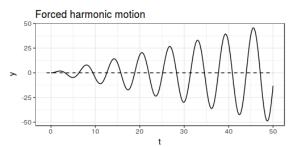
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### Harmonic motion

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Harmonic motions are closely related with the phenomena of **resonance** and **antiresonance**.

**Resonance** is a phenomenon in which a vibrating system or external force drives another system to oscillate with greater amplitude at specific frequencies.

Antiresonance is a phenomenon in which a vibrating system or external force drives another system to oscillate with smaller amplitude at specific frequencies.



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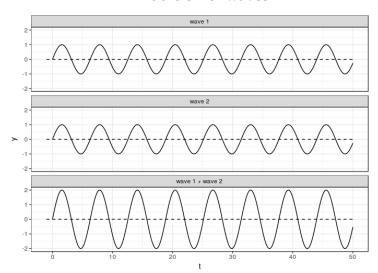
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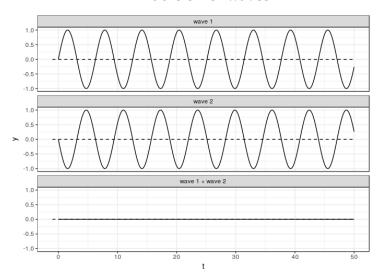
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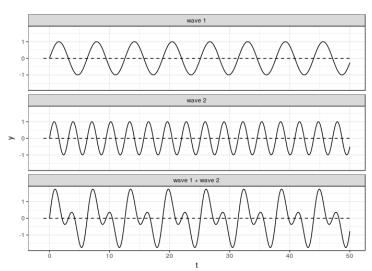
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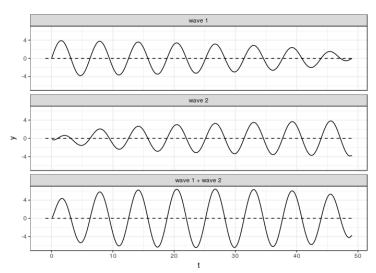
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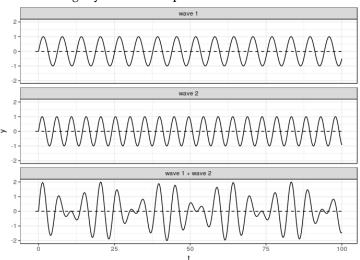
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### **Beats**

**Beats** is a phenomenon of the change in amplitude of the sum of two waves with slightly different frequencies.



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Addition of

waves

### Fourier Transform allows to extract components of the complex wave.



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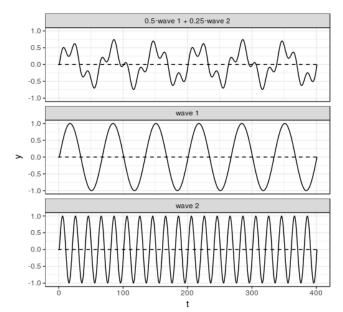
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Fourier Transform allows to extract components of the complex wave.

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smoothie complex wave

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1 banana, cut in chunks
1 cup grapes
1000 Hz

vanilla yogurt
1/2 apple, cored and chopped
1.5 cup fresh spinach leaves

## Spectrogram



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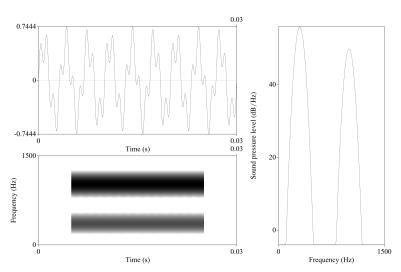
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## Spectral slices

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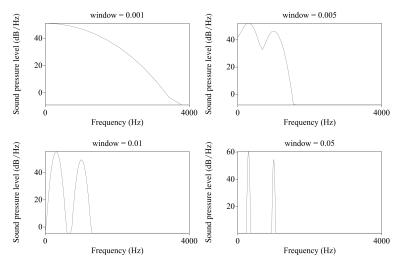
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#### Spectrogram

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### Spectrograms are differ in window length



## **Spectrograms**

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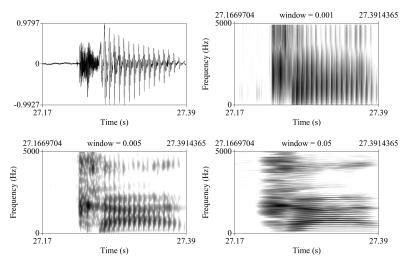
Addition waves

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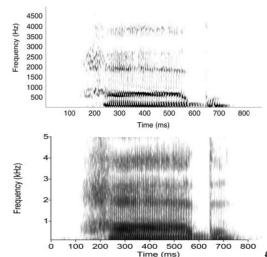
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### Syllable [ka]



## Not by Fourier alone

Conventional spectrogram and Zhao-Atlas-Marks distribution of the English word *had*, computed using a Kaiser tapering function.

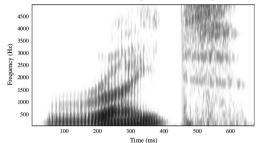


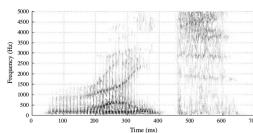
Spectrogram

from [Fulop 2011: 119]

## Not by Fourier alone

Conventional and reassigned spectrograms of the English word *right* 





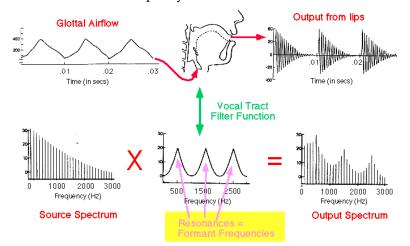
Spectrogram

from [Fulop 2011: 142]

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## Source-Filter Model of Speech Production

The output energy (at the mouth) for a given frequency is equal to the amplitude the source harmonic, multiplied by the magnitude of the filter function for that the frequency.



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- Summary

- · sounds are waves (with amplitude, frequency and phase)
- · simple waves can be combined to the complex one
- Fourier transform allows to extract components of the complex wave
- · It is not only Fourier transform that allows to extract components of the complex wave
- · Source-Filter Model: vocal tract is a resonator that filters some frequencies of the wave produced by vocal folds vibration.

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# Thank you!

Please, don't hesitate to write me agricolamz@gmail.com

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