# LIGN 110 Section 25202 Week 6

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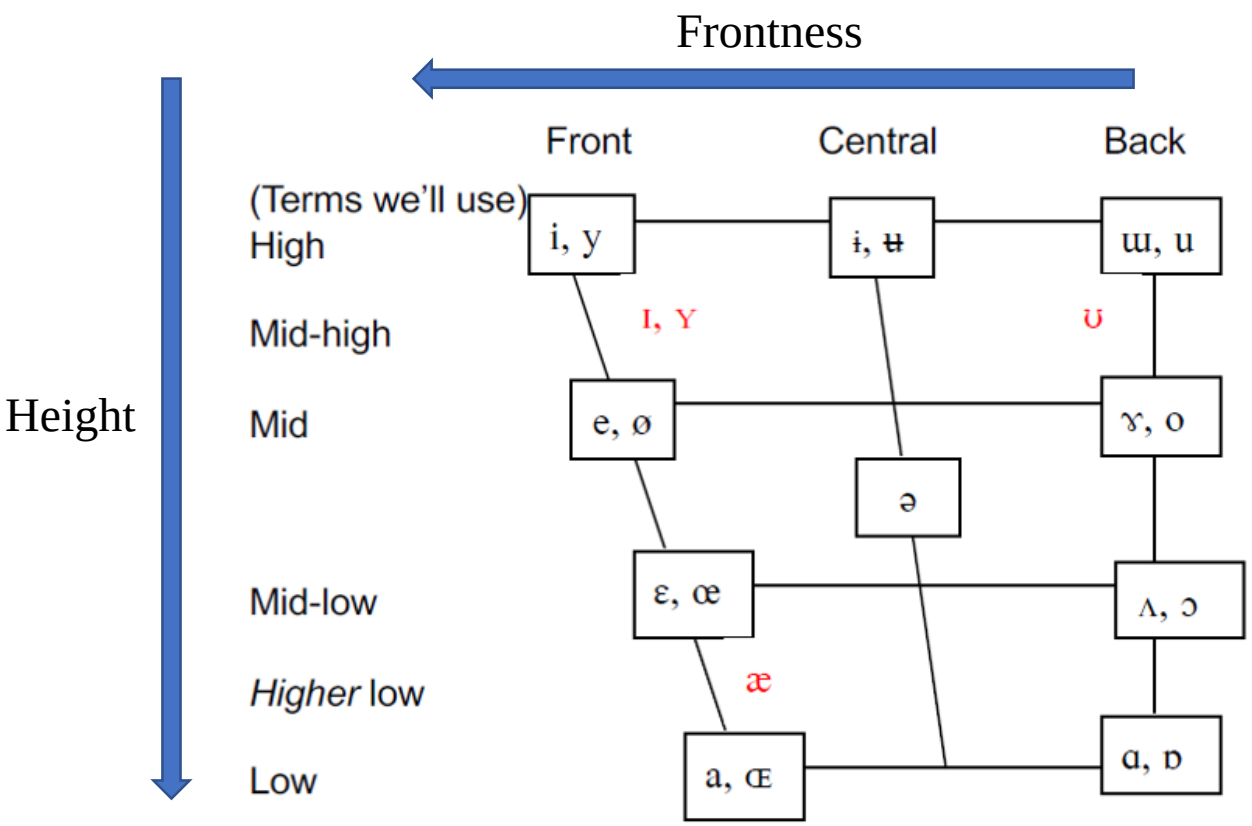
# Reminder

- Questions on lecture materials, quizzes, homework, final project?
- Reminder: Quiz Week 6 & Homework 2 due on Nov. 12 (this Thursday)

# Review of vowels

- How to name vowels

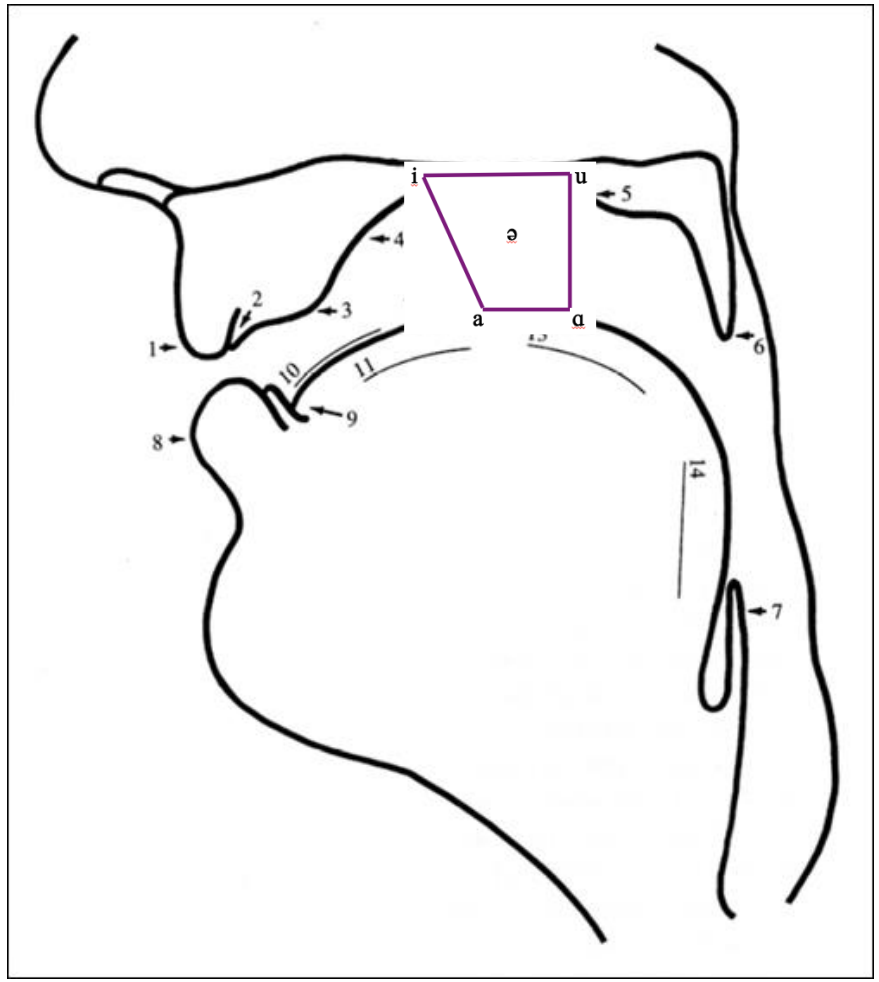



- On each vertical line, the ones on the **left are unrounded**; the ones on the **right are rounded**.

- [æ] is unrounded
- [ə] is unrounded
- [ʊ] is rounded

# Review of vowels

- How to name vowels




- **Frontness** refers to whether the tongue positioning is closer to the palate or the velum. If it is positioned closer to the palate, it is more front; closer to the velum, it is more back.

- **Height** refers to the tongue/jaw height. When the jaw is closed, it is high; when open; low.

# Exercise

- How to name vowels
- (diacritic) Height frontness rounding vowel
- [eː] long mid front unrounded vowel

- Please provide IPA symbols of the following sounds:

1. Mid-low back unrounded vowel: [ʌ]

2. Breathy-voiced low front unrounded vowel: [a̤]

3. Retracted-tongue-root high front unrounded vowel: [ i̘ ]

# Diacritics and secondary articulations

- Advanced tongue root: [ɻ̟]
- Retracted tongue root: [ɻ̠]
- Labialization: [tʷ]
- Palatalization: [tʲ]
- Velarization: [tˠ]
- Pharyngealization: [dˤ]
- What is the difference between [tʲ] and [tj]?
  - [tʲ] is one segment; [tj] is two segments;
  - [tʲ] is produced with a complete closure between tongue tip and alveolar, and an approximation between tongue front and palate simultaneously;
  - [tj] is producing [t] and [j] consecutively.

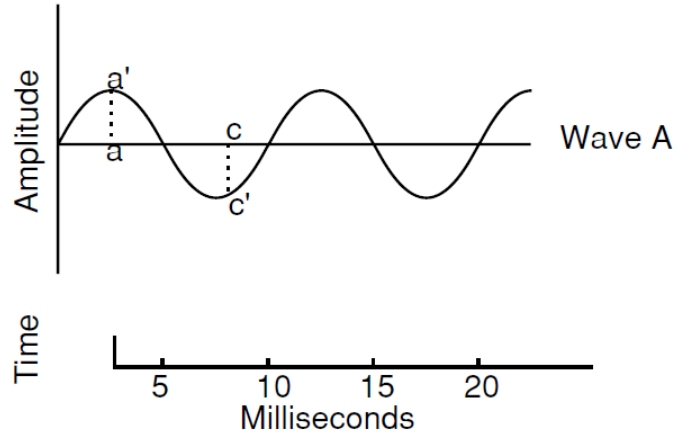
# Exercise

- Please provide IPA symbols of the following sounds:

1. Palatalized voiced alveolar stop: [dʲ]
2. Pharyngealized voiceless palatal fricative: [çˤ]
3. Labialized alveolar lateral approximant: [lʷ]

# This week: acoustics

- Key concepts: Waveform
- Waveform: the displacement of air pressure over time
- x-axi: time; y-axis: amplitude
- What CANNOT be seen from the waveform (directly): frequency




Graph: Figure 7.4; p.134

# This week: acoustics

- Key concepts: Amplitude
- How powerful is the sound?
- Pressure deviation (from atmospheric pressure) = Amplitude (dB)
- Perceived as loudness
- higher amplitude sounds perceived as louder*

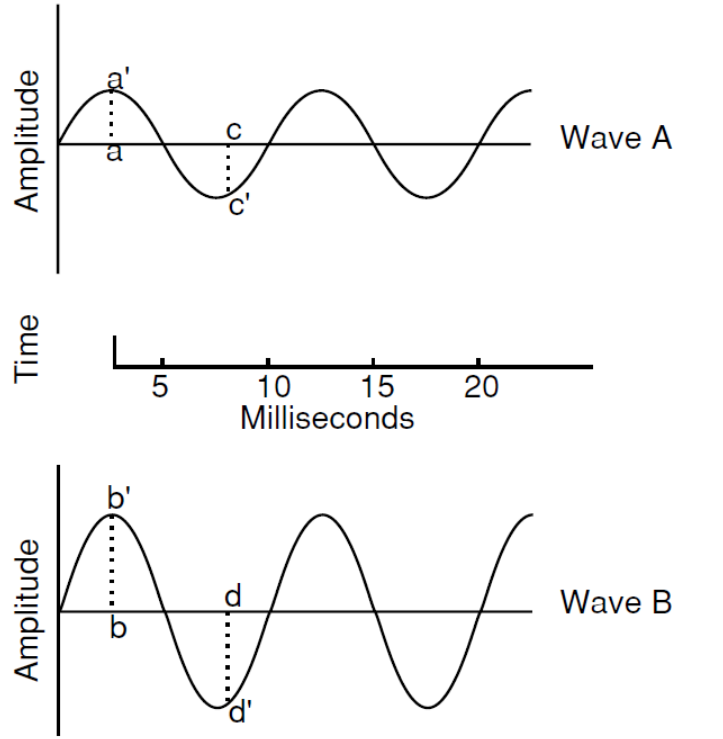
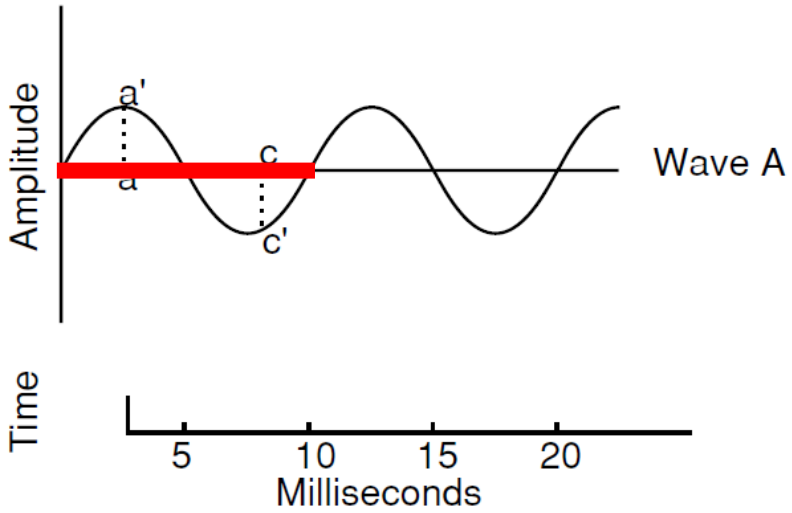



**Figure 7.4** Two sine waves with different amplitudes

Graph: Figure 7.4; p.134

# This week: acoustics

- Key concepts: Period
- Periodic = wave with regularly repeating pattern
- Some sounds are periodic (voiced sounds, musical notes)
- Period time of one whole cycle of the sound wave

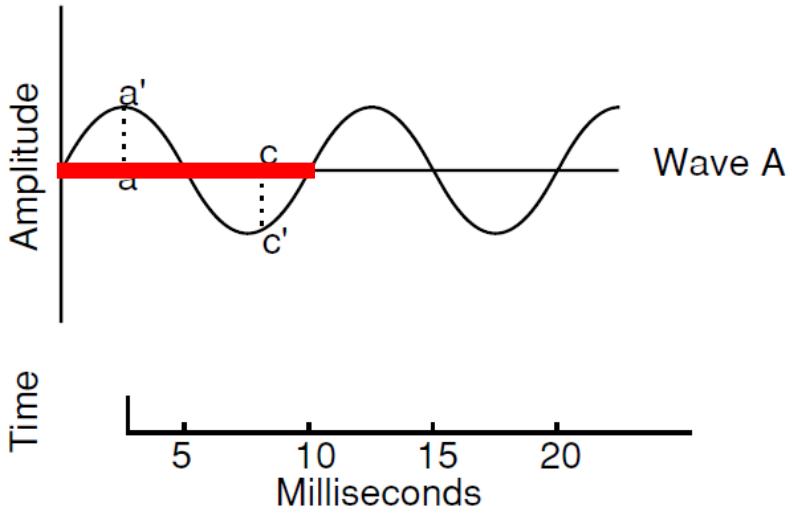



Period: 10 milliseconds (ms) = 0.01 second (s)

Graph: Figure 7.4; p.134

# This week: acoustics

- Key concepts: Frequency
- Frequency = How many cycles in **a second**?
- Rate of repetition (cycles per second) = Frequency (Hz)
- Perceived as pitch
- higher frequency sounds are higher pitched*
- Calculate: Frequency = 1 (second)/period (in second)




Period: 10 milliseconds (ms) = 0.01 second (s)

Frequency = 1/0.01 = 100 Hz

Graph: Figure 7.4; p.134

# This week: acoustics

- Key concepts: Fourier analysis
- Simple waves combined together → complex wave;
  - Simple waves are combined by adding their amplitudes at the same time point;
- Complex wave decomposed → simple waves → **Fourier transformation**
- **Fourier analysis in one sentence:** any wave can be thought of as a sum of simple sine waves

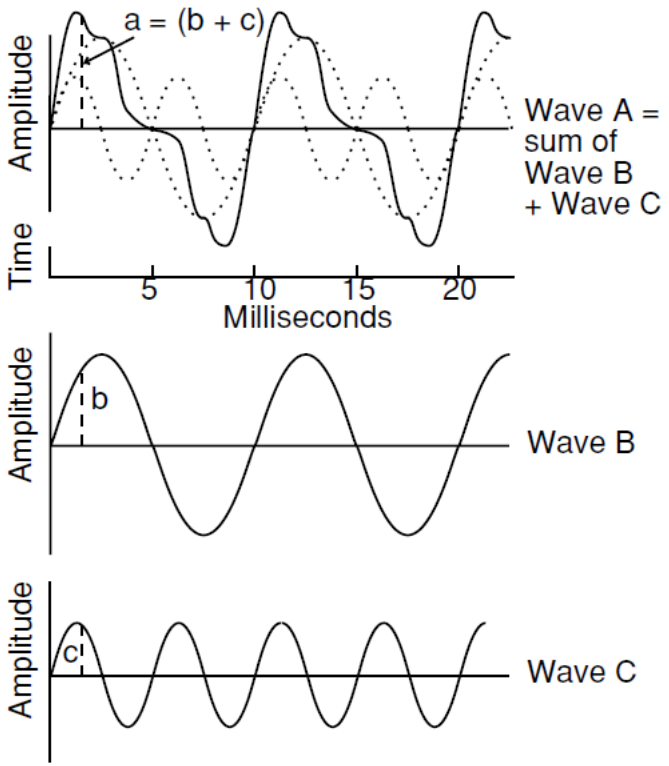



**Figure 7.7** The addition of two sine waves to form a complex wave

Graph: Figure 7.7; p.138

# This week: acoustics

- Key concepts: Fundamental frequency
- overall frequency of a complex wave
- lowest component frequency
- largest repeating pattern
- related to pitch
- Practice:
- What is the Fundamental frequency of the graph on the right?

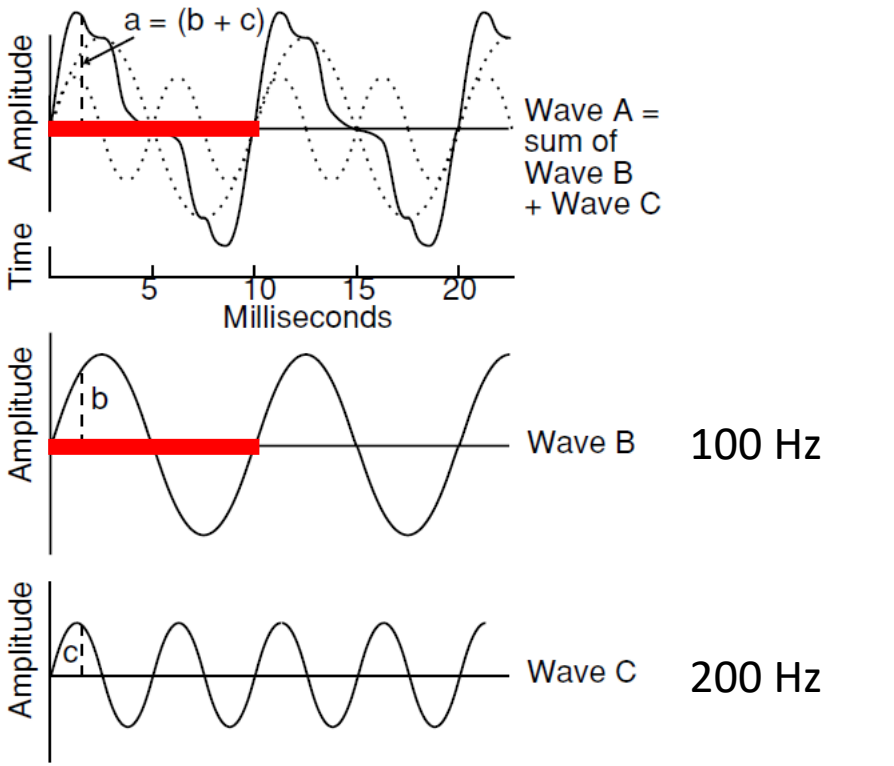
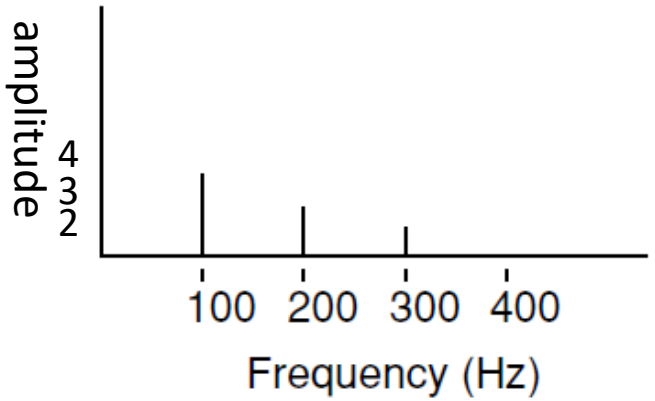



**Figure 7.7** The addition of two sine waves to form a complex wave

Graph: Figure 7.7; p.138

# This week: acoustics

- Key concepts: Spectrum
- Spectrum: display the frequency of all the component waves and the amplitude of them.
- x-axis: frequency; y-axis: amplitude
- What CANNOT be seen from spectrum: time




**ure 7.9** Spectrum of the complex wave of Figure 7.8

Graph: Figure 7.9; p.140

| Frequency | Amplitude |
|---|---|
| 100 | 4 |
| 200 | 3 |
| 300 | 2 |

# This week: acoustics

- Relation between waveform and spectrum
- Take an episode of the **waveform**, and draw the frequency of the component waves on x-axis and amplitude of the waves on y-axis, to get a **spectrum**

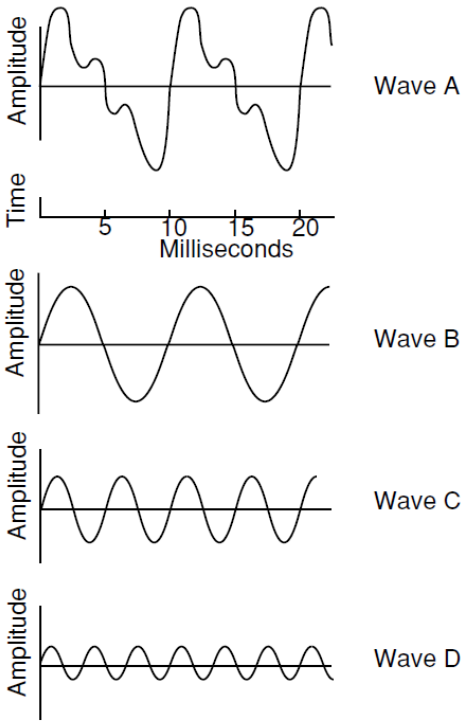



**Figure 7.8** The addition of three sine waves to form a complex wave

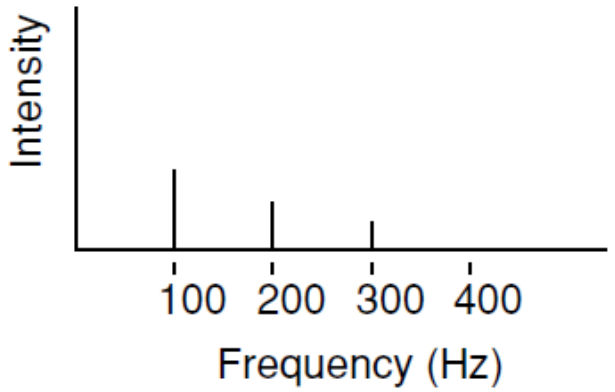



**Figure 7.9** Spectrum of the complex wave of Figure 7.8

# This week: acoustics

- Key concepts: Spectrogram

- Spectrogram: shows the frequency, amplitude of each frequency, and the frequency and amplitude over time

- x-axis: time
- y-axis: frequency
- darkness of the band: amplitude

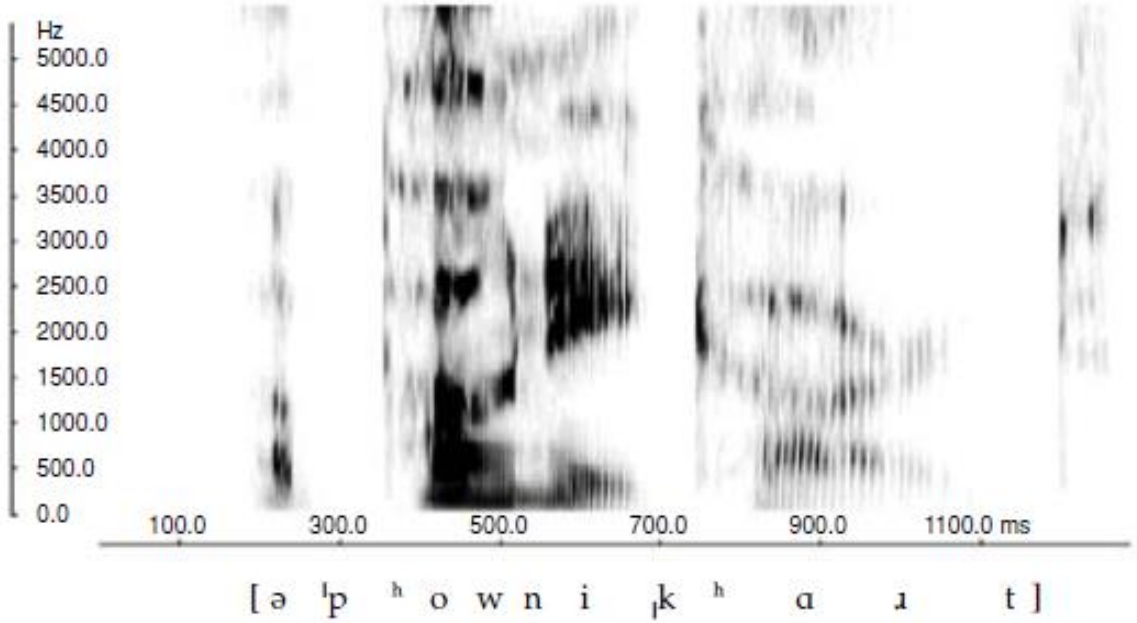
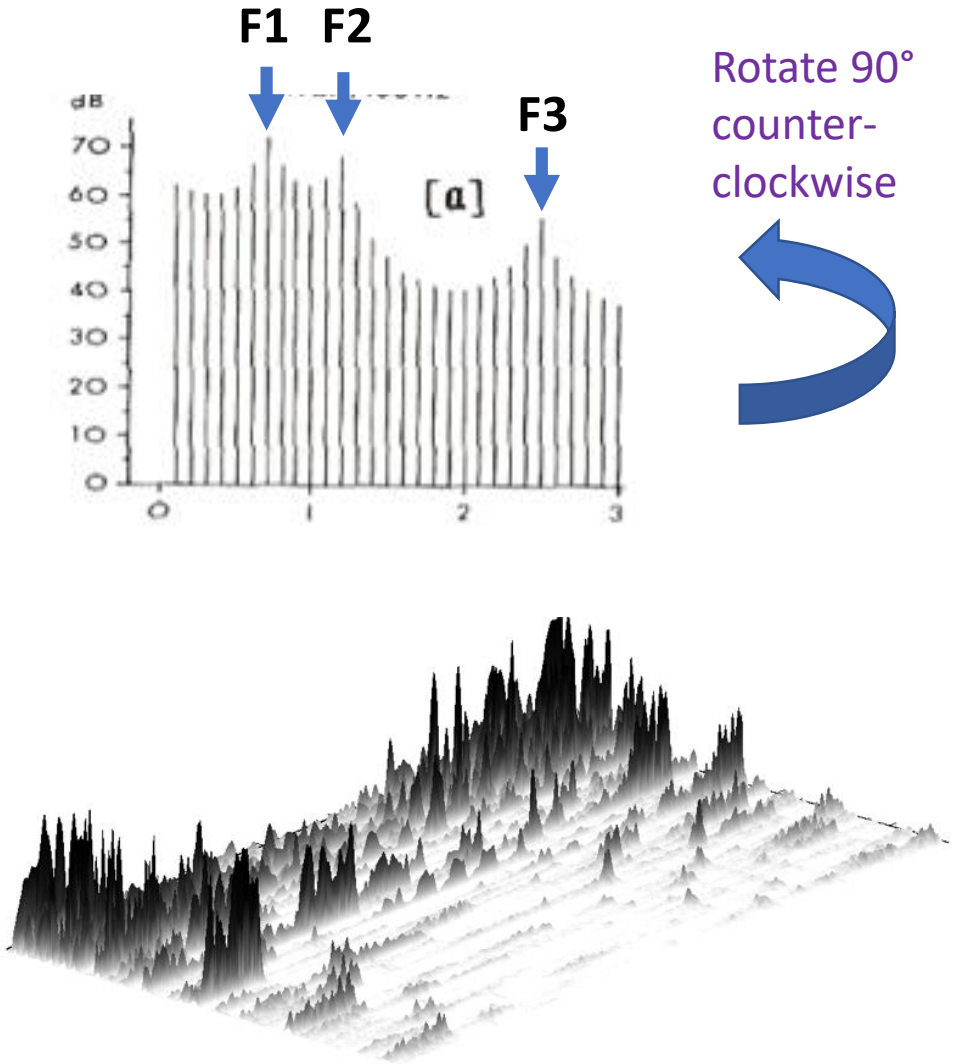



**Figure 8.2** Wide-band spectrogram of *a pony cart* (GA accent) (time in milliseconds)

Graph: Figure 8.2; p.151

- Relation between spectrum, and spectrogram
- One way to visualize spectrogram: it's a bunch of spectra turned on their sides and stacked up next to each other, then turned again so the peaks of the spectra face you. Those peaks that are highest (FORMANTS) are thus closer to you, so they are DARKER.



# This week: acoustics

- Key concepts: Harmonics

- Harmonics: component frequency that is a multiple of the fundamental frequency

- H1 = 100 Hz
- H2 = 100*2 = 200 Hz
- H3 = 100*3 = 300 Hz
- Hn = 100*n Hz

# This week: acoustics

- Key concept: Formants
- All objects have resonant frequencies, frequencies they tend to "amp up"
- rooms, musical instruments, tubes all have resonant frequencies
- the vocal tract is sort of like a little room on top of your vocal chords
- In speech, the resonant frequencies of the vocal tract are called **FORMANTS**

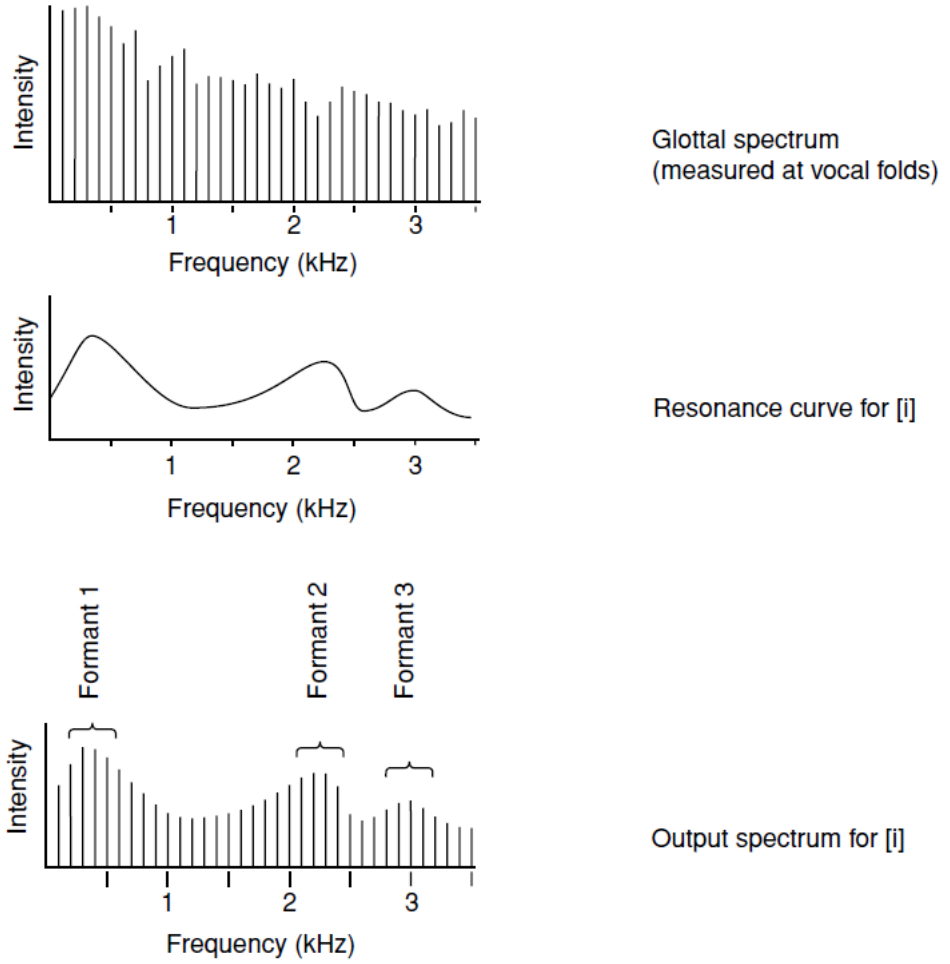
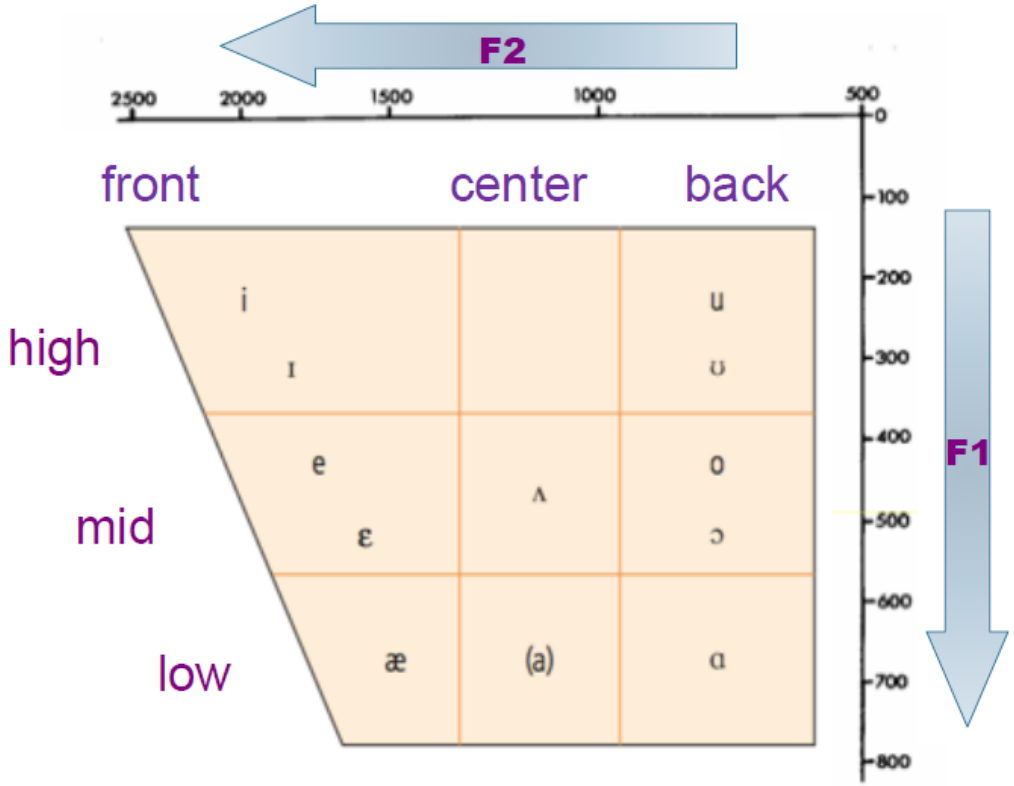



**Figure 7.14** Glottal spectrum, resonance curve, and spectrum (after passing though the resonating vocal tract). The vocal tract is shaped for [i]

Graph: Figure 7.14; p.144

# Vowel acoustics

- Relation between vowel height and frontness and formant frequency
- The lower the vowel, the higher the F1
- The fronter the vowel, the higher the F2



# Vowel acoustics

- Relation between vowel height and frontness and formant frequency
- The **lower** the vowel, the **higher** the F1
- The **fronter** the vowel, the **higher** the F2

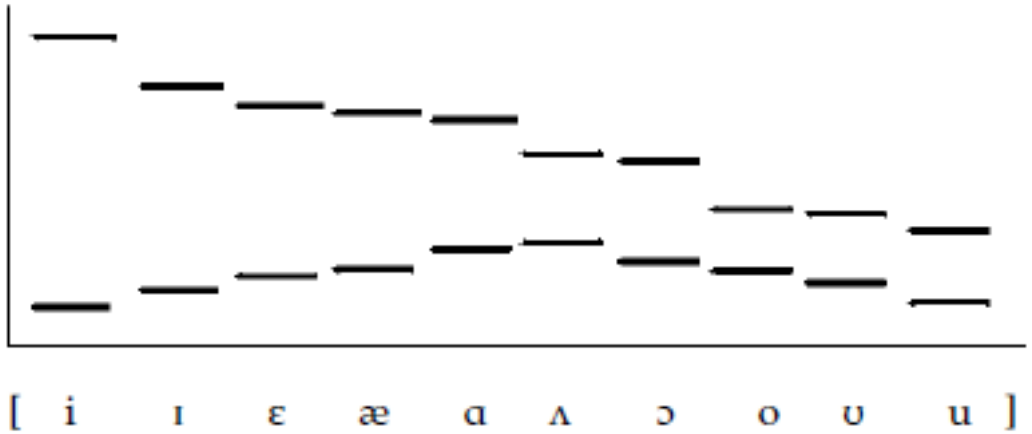



**Figure 8.4** The pattern of the first two formants for the simple vowels of English

**Exercise:**

1. Comparing [i] with [u]:
Is the F1 of [i] higher or lower than [u]?
Is the F2 of [i] higher or lower than [u]?
Why?

2. Comparing [i] with [æ]
Is the F1 of [i] higher or lower than [æ]?
Is the F2 of [i] higher or lower than [æ]?
Why?

# Vowel acoustics

- Relation between vowel height and frontness and formant frequency
- The **lower** the vowel, the **higher** the F1
- The **fronter** the vowel, the **higher** the F2

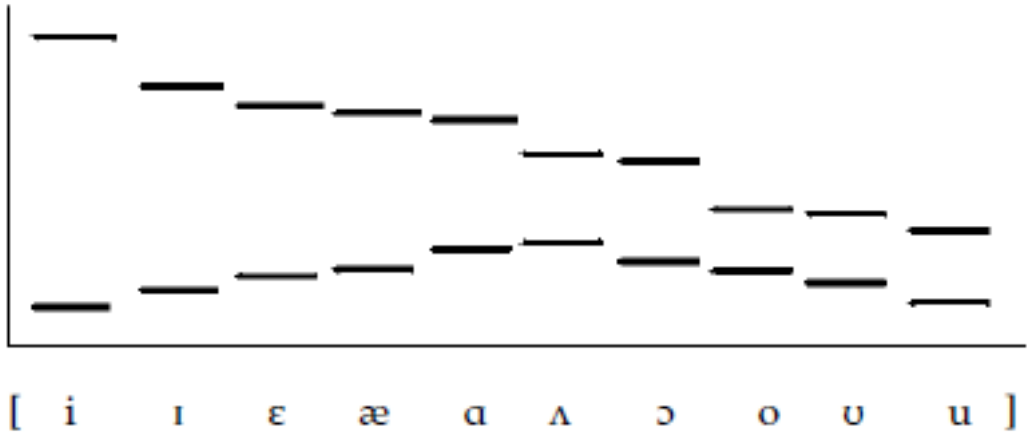



**Figure 8.4** The pattern of the first two formants for the simple vowels of English

**Exercise:**

1. Comparing [i] with [u]:
Is the F1 of [i] higher or lower than [u]? Same
Is the F2 of [i] higher or lower than [u]? Higher
Why? Because [i] is of same height as [u]; and is fronter than [u]

2. Comparing [i] with [æ]
Is the F1 of [i] higher or lower than [æ]? Lower
Is the F2 of [i] higher or lower than [æ]? Higher
Why? Because [i] is higher than [æ]; and is fronter than [u]

# Acoustics

- Exercise:

- Which of the following graphs does NOT provide information of time?

- A. Waveform
- B. Spectrum
- C. Spectrogram

# Acoustics

- Exercise:

- If you produce a vowel [u], and want to make the frequency of F2 higher, how should you move your articulators?

- A. Move tongue forwards
- B. Move tongue backwards
- C. Close jaw more
- D. Open jaw more

# Acoustics

- Exercise:

- A complex waveform is composed of waves of 100 Hz, 200 Hz, and 250 Hz. What is the fundamental frequency of this complex waveform?

- A. 100 Hz
- B. 200 Hz
- C. 250 Hz
- D. 550 Hz

# Acoustics

- Exercise:

- If you produce a vowel [u], and increases the fundamental frequency, which of the following will most likely happen?

- A. The vowel will become a [i] vowel
- B. The perceived pitch of the vowel increases
- C. The perceived loudness of the vowel increases
- D. The perceived duration of the vowel increases