

COURSE TITLE:
**BASIC PHONETICS AND
ENGLISH PHONOLOGY**

TOPIC: ACOUSTIC PHONETICS

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INTRODUCTION

- In our previous lessons, we discussed articulatory phonetics.
- This week, we look at acoustic phonetics.
- We saw that in articulatory phonetics, speech organs are used to produce sounds.
- The sound then travels through the air.
- Acoustic phonetics deals with transmission of sound.
- When sounds are produced in the mouth, they have specific, measurable effects on the air.

INTRODUCTION

- Acoustic phonetics studies these effects:
- Just as speech sounds can be distinguished by their manner of articulation
- (i.e stops vs fricatives), they can be distinguished by specific physical properties:
- (e.g the acoustic correlates typically associated with obstruents and sonorants).

ACOUSTIC PROPERTIES

- Waves
- Frequency
- Amplitude
- Pitch
- Quality

WAVES

- An illustration each of us may have engaged in:
- Drop a pebble into a basin of water. You will notice some movement- waves.
- This is the same way sound moves through air waves.
- Imagine dropping the pebble and the waves are moving across the surface.
- Then cut the slice of the waves from the slide:

Waves

Picture of sound waves

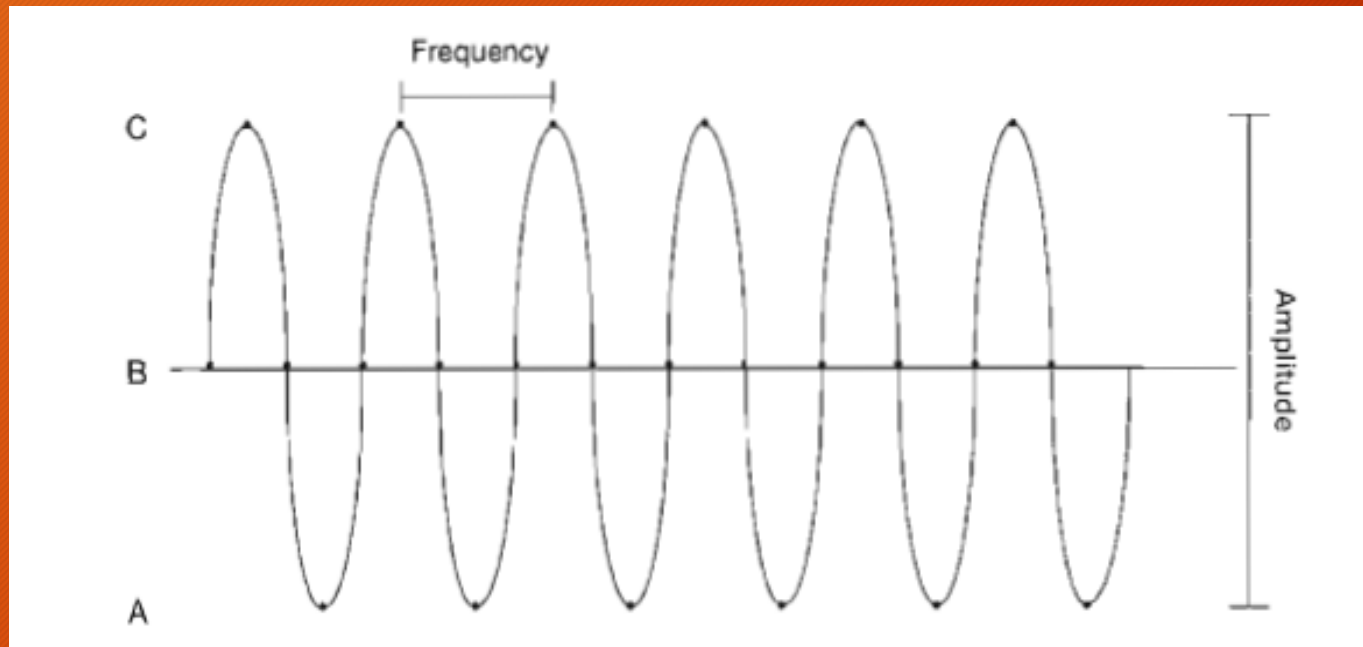


Figure 1: Davenport, M & Hannahs, S.J. (2005). *Introducing phonetics and phonology*. New York: Arnold Hodder.

- The line labelled 'B' represents the surface of the water at rest;
 - 'C' represents the highest point, the peak of the wave;
 - 'A' represents the lowest point, the trough of the wave.
-
- This is equally how the sound waves behave.
 - We shall now discuss the characteristics of waves

Frequency

- Frequency: How close together the waves are.
- Frequency is measured in cycles per second (cps) or Hertz.
- Amplitude- The maximum distance the wave moves from the starting point to the point of rest B, and either the peak, C of the trough.
- Note:
- Understanding the behaviour of waves is fundamental to an understanding of acoustic phonetics.

Waves

Picture of sound waves

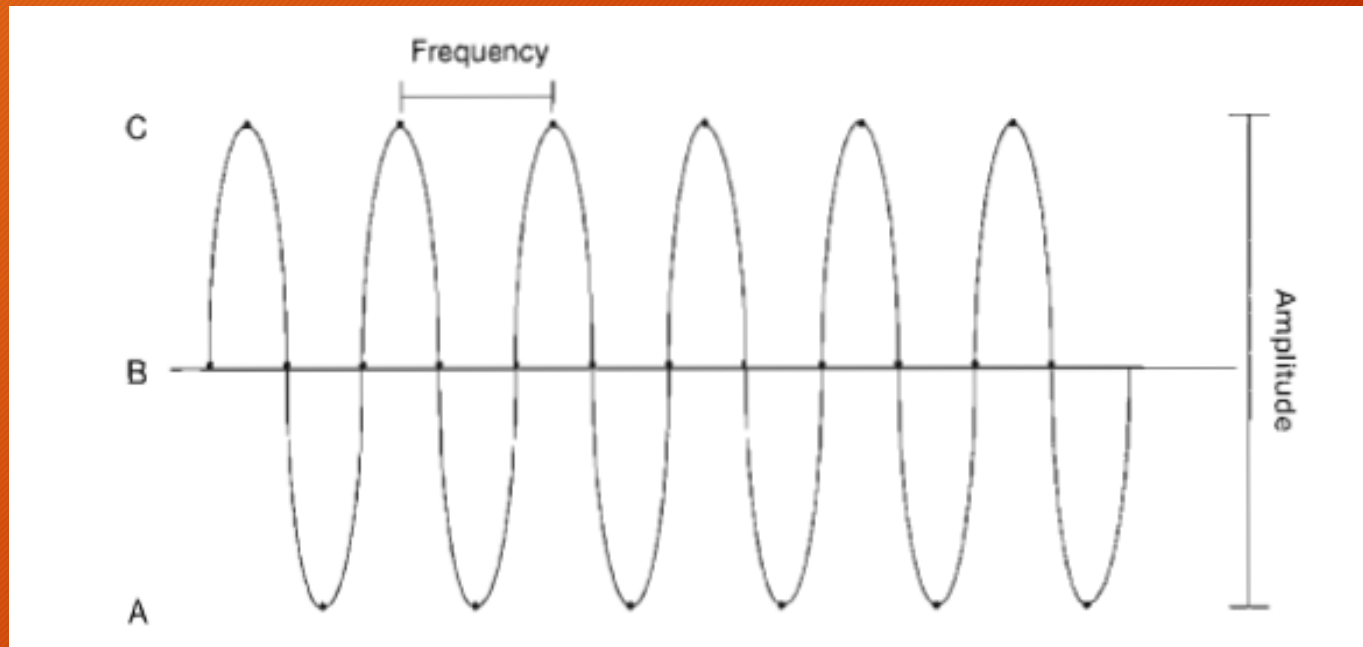


Figure 1: Davenport, M & Hannahs, S.J. (2005). *Introducing phonetics and phonology*. New York: Arnold Hodder.

SOUND

- Soundwaves are produced by vibration carried by a **propagating medium** (i.e the substance through which sound travels).
- Considering the illustration of the pebble in water; water is the propagating medium.
- For purposes of sounds, the propagation medium is air.
- The vibrations may be regular (i.e periodic) or irregular (i.e aperiodic)

- **Periodic vibrations** -produced within the range of human hearing have a musical quality and consist of regular repeated patterns.
- regular and associated more closely with vowels and sonorants.
- **Aperiodic vibrations** have less musical quality like the sound of a jet engine.
- They are non-regular and help to characterize obstruents.

- In order to be heard, the vibration of periodic waves must be between 20 to 20,000 vibrations per second.
- This makes the normal audible range for human beings.
- The higher the frequency, the higher the pitch.
- The difference between the terms frequency and pitch lies on a technical distinction:

- Frequency is an objective, measurable property.
- Pitch is subjective-resulting from human perception.
- This means that under specific conditions:
 - two sounds produced at two different frequencies may be perceived as having the same pitch.

AMPLITUDE

- Along with propagation medium and frequency,
- the size or intensity of vibration, its amplitude is important.
- Amplitude is the intensity of vibration.
- Consider the diagram of sound waves:

Waves

Picture of sound waves

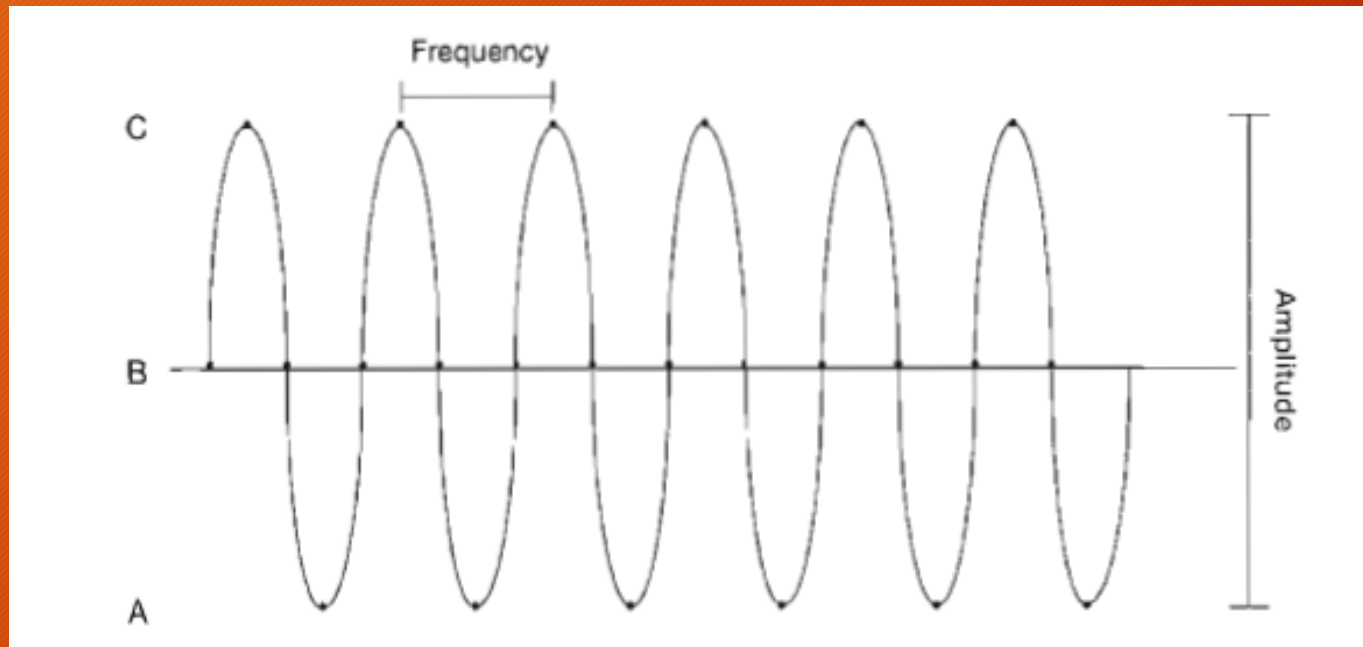


Figure 1: Davenport, M & Hannahs, S.J. (2005). *Introducing phonetics and phonology*. New York: Arnold Hodder.

- Amplitude relates to loudness in much the same way as frequency relates to pitch.
- Amplitude is the objective quality
- Loudness is subjective
- As amplitude diminishes, sound becomes less audible.
- Distance and the efficiency of the propagating medium also affect amplitude.

Quality

- Another aspect of sound and our perception is quality.
- Even when sounds are at the same frequency and amplitude, they can differ in quality or colouring.
- It is quality that allows us to tell the difference between,
- for example, between a flute and a piano playing the same note and same loudness.
- Differences in quality arise from the differences in shape of the propagation medium and material enclosing that medium.

- The different shapes and materials tend to emphasize different harmonics
- (i.e vibrations at whole number multiples of the note being played).
- The note produced at 120 Hz will produce harmonics at 240, 360, 480 and so on.
- Some of these will be emphasized by the shape and material of whatever is producing the note.

MACHINE ANALYSIS

- In order to see and analyze the kind of properties of sounds we have discussed, phoneticians use a machine called a spectrograph
- It allows measurement and analysis of frequency, durations, transitions between speech sounds.
- The output of the spectrograph is a spectrogram, either printed on a paper or a computer screen.

Machine analysis output

Sample machine
output analysis

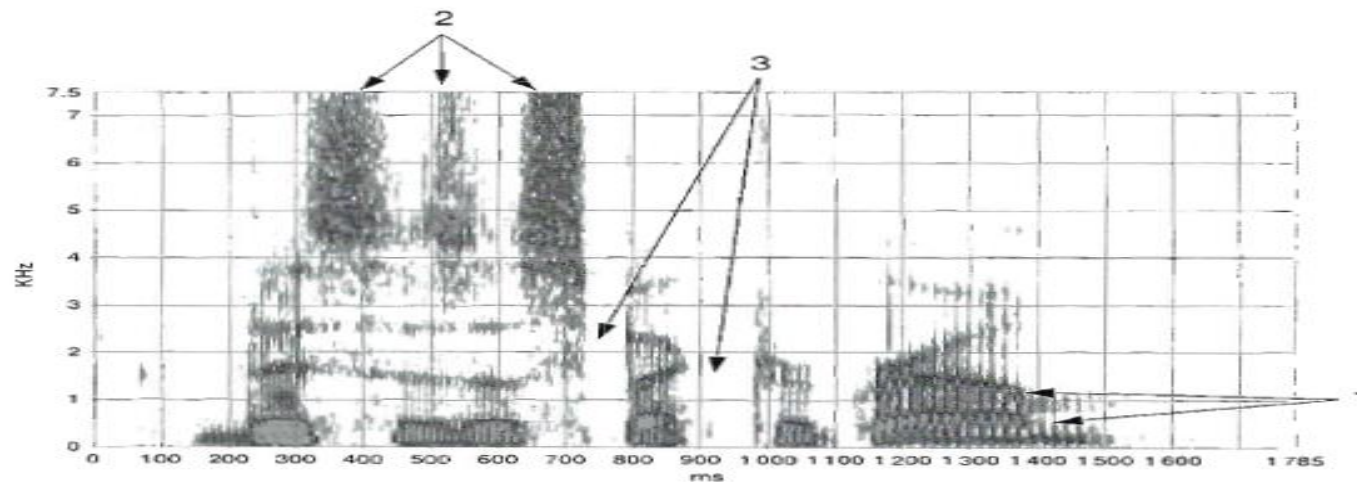


Fig. 5.3 Spectrogram for [ðisizəspekʰtɪgæm]

Notes:

- 1. Vowel formants
- 2. Aperiodic vibration in the higher frequencies, associated with fricatives
- 3. Absence of spectrographic activity, associated with voiceless stops

Figure 2: Davenport, M & Hannahs, S.J.
(2005). *Introducing phonetics and phonology*. New
York: Arnold Hodder.

- Certain frequencies are emphasized by darker marks.
- These patterns are called formants.
- They are both periodic and aperiodic.

Waveforms

- In addition to the spectrograph, a waveform can also be used to analyze speech sounds.
- Waveforms show the pulses corresponding to each vibrations of the vocal cord.
- Along with other patterns visible on a spectrogram,
- the corresponding waveform records the variations in air pressure associated with speech sounds.

- Hence,
- Vocal sounds show up in the waveform as larger patterns than voiceless sounds.
- Consonant and vowels are also distinct from one another,
- thus allowing fairly precise measurement of various segments.
- With voiceless stops, there is an absence of vibration; characterized by a straight line.

- The release corresponds to either aspiration or voicing of consonants.
- Aspiration is also visible in the waveforms.
- With voiceless stops, there is an absence of vibration characterized by a straight line.
- Voiced consonants show up as subdued wiggly lines.
- The stop closure and release can also be seen contrasted with the surrounding vowels (or silence)

- Different places of articulation cannot be distinguished on a waveform.
- For example,
 - [p] looks like [k],
 - [k] may look like [b]
- However, waveforms allow us to see differences in voicing and manner of articulation.

SPEECH SOUNDS

- This analysis can help us to see how the physical properties relate to speech sounds.
- Speech sounds include periodic and aperiodic components.
- Vowels and sonorants such as [a] and [n] are associated with regular waves.
- Fricatives like [f] and [s] are associated with irregular waves.

Waveforms
of various
sounds

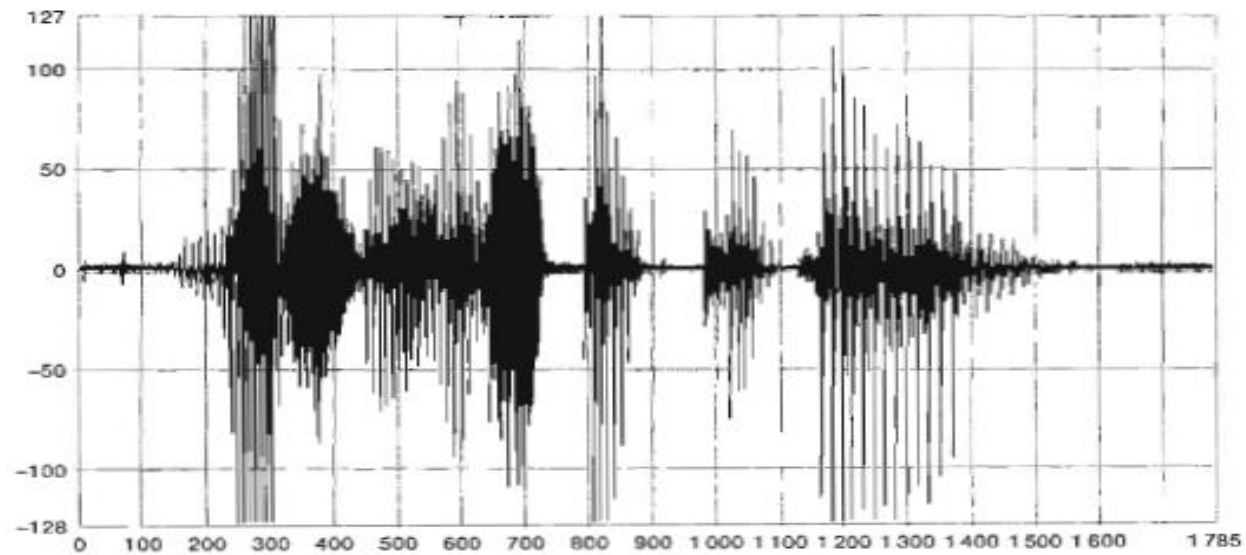


Fig. 5.4 Waveform of [ðɪsɪzəspɛktɪvəjəm]

Figure 3: Davenport, M & Hannahs, S.J. (2005). *Introducing phonetics and phonology*. New York: Arnold Hodder.

- There are also speech sounds which are associated with both regular and irregular waves
- (e.g. voiced fricatives like [v] and [z]).
- The fricative part of these sounds is aperiodic while the voicing part is periodic.
- Vowels [ɪ] and [u] differ because of differences in the shape of the oral tract.
- The position of the tongue changes the shape of the air in the oral cavity thus, [u] and [ɪ] have a different quality.

Vowels and sonorants

- For voiced speech sounds, we distinguish the fundamental frequency (F0).
- This is a representation of the vocal cords vibrating.
- Given the differences in the size of the vocal apparatus,
- men, women and children tend to have different fundamental frequencies.
- Roughly speaking, the human voice produces speech sounds at fundamental frequencies of about 80- 200 Hz for adult males; 150-300 Hz for adult females, and 200-500 Hz for children.

- In addition to the fundamental frequency,
- the production of a voiced sound causes the vocal tract to resonate in specific ways depending on the shape of the tract.
- Thus, apart from the fundamental frequency,
- this resonating emphasizes certain frequencies above the fundamental frequency.
- Speech resonances that are above fundamental frequencies are called ‘formants’ or ‘formant frequencies’.

Formant frequencies

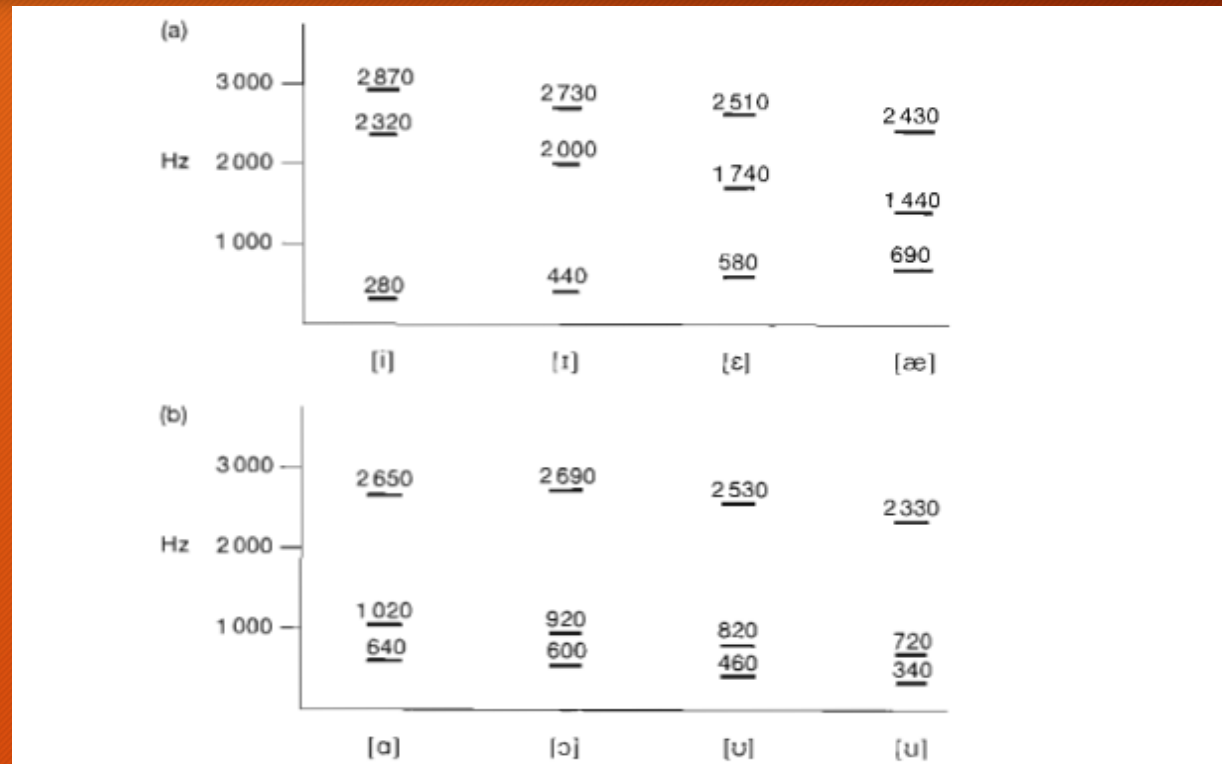


Figure 4: Davenport, M & Hannahs, S.J. (2005). *Introducing phonetics and phonology*. New York: Arnold Hodder.

- Consider the vowel sound in the word 'sad' /æ/.
- During the production of this vowel, the vocal cords may be vibrating at about 100 Hz and the first formant F1 is about 500 H
- (i.e five times the frequency of the fundamental frequency).
- The spectrogram in figure 4 illustrates the General American English vowels .
- They represent the increased energy at these frequencies.

- Note:
- Earlier in the course, it was seen that it is difficult to describe vowels in articulatory terms
- Articulators do not make contact in the production of vowel sounds.
- However, with acoustic analysis of vowels,
- precise statements can be made in distinguishing one vowel from another in terms of formant patterns.
- Thus, distinction between vowels are often more easily expressed in acoustic terms than in articulatory terms.

References

- Davenport, M & Hannahs, S.J. (2005). *Introducing phonetics and phonology*. New York: Arnold Hodder.