Acoustics of Speech and Hearing

UCL Psychology & Language Sciences

Information for Students

1. Official Title

On Portico and Moodle the course is referenced as: SPSC2003: Phonetic Science 2: Acoustics of Speech and Hearing. However most people just call it “Acoustics”.

2. Aims

This course gives an overview of the processes of spoken language communication that are concerned with how phonological units are encoded in sound, propagated and perceived. Taking as a basis knowledge of articulatory phonetics and relevant anatomy, the course describes the acoustics of speech production, the instrumental analysis of speech sounds and the analysis of speech sounds in the ear.

The course is organised around the concept of **measurement** of speech. That is: how we can use physical models and quantitative methods to describe speech communication.

Here are some questions that you'll be able to answer by the end of the course:

- **Signals & Systems**: What is sound? What physical properties of sound lead to changes in loudness, changes in pitch or changes in timbre? How can we measure sound? How are sounds changed by systems? How can we measure a system?
- **Instrumentation**: What do amplifiers, attenuators, filters and level meters actually do? How can we measure the quality of an audio recorder? How can we make good recordings of speech? How can we display the dynamic structure of speech? How can we measure larynx activity during speech?
- **Vocal Tract Acoustics**: How is the vocal tract able to generate such a wide variety of sounds? How are sounds generated and shaped in the vocal tract? What job does the larynx have? How are fricatives made? Why do vowels sound different to one another?
- **Speech Sound Production & Perception**: How does the larynx generate different voice qualities? How can we measure intonation? How are different speech sounds generated? Why do speech sounds vary across accents, speakers, styles or contexts? How do listeners identify articulations from their sound?
- **Hearing**: How does the ear detect sound? How can we measure human sensitivity to sound? How does the ear analyse the frequency content of sounds? How can we explain hearing loss, or the masking of one sound by another, or the sensation of pitch?

3. Course Structure and Attendance

The course runs over both the Autumn and Spring terms and comprises:

- 20 lectures of 1 hour
- 9 tutorials of 1 hour in groups of about 10.
- 18 laboratory sessions of 2 hours in groups of about 20.

In addition there will be a revision lecture and revision tutorials in the Summer term.

A timetable and student groups are given on a separate sheet. Please do not change your lab group without the permission of the course organiser. The morning and afternoon groups will be switched round next term. If you are unable to attend a tutorial, please let your tutor know in advance. A record of attendance at laboratory sessions will be kept. If you are unable to attend a laboratory session you must provide a written explanation to the course organiser in each case. **If you miss more than two laboratory sessions during the course without adequate explanation, your eligibility for entering for the final examination may be withdrawn.**

4. Course Assessment

Your final course mark is based on:

- a 3 hour written examination (70%). Past exam papers are available in DMS Watson library and on the Web.
- 4 assessed laboratory reports and 2 class tests (each 5%, total 30%). These will be marked and returned within one week of submission but the marked work must be re-submitted in a folder in the summer term for moderation of marks.

For each laboratory experiment you will be asked to write either:

- **a brief report** - to be completed in the lab and which must be checked by the demonstrators at the end of the laboratory session or
- **a full report -** to be handed in for marking no later than **one week** after the experiment. **Late reports will not receive a mark**. Your tutor will mark the report within one week and return it to the lab for you to collect.

You should provide an A4 ring binder (marked with your name, tutor and year) to hold all your laboratory work. If you wish you may leave these in the laboratory.

5. Staff

Mark Huckvale	020 7679 4087	m.huckvale@ucl.ac.uk	Course Organiser
Paul Iverson	020 7679 4237	p.iverson@ucl.ac.uk	Tutor
Steve Nevard	020 7679 4014	s.nevard@ucl.ac.uk	Tutor
Dave Cushing	020 7679 4016	d.cushing@ucl.ac.uk	Technician

Some graduate research students will also be helping out in the lab.

6. Learning Resources

The **Language and Speech Science Library** contains copies of the books and journals referred to in the readings.

A **Moodle** course is also available (http://moodle.ucl.ac.uk/course/view.php?id=242). This has a week-by-week summary of the course with links to all relevant resources, such as slides, readings, quizzes, FAQs, etc. You can use this to discuss topics with tutors and other students, and to test your understanding with some quizzes.

Although more information is available on the Moodle site, most files can also be accessed directly though the **Acoustics Web site** at:

http://www.phon.ucl.ac.uk/courses/spsci/acoustics

7. Reading

Each week one or more **recommended readings** are shown on the lecture handout. It is important that you read these to consolidate and deepen your understanding and to back-up the material presented in the lectures and labs. Many are taken from the recommended text books, some are available within Moodle.

Each year we ask students which text books they have found most useful. Listed below are the best currently available texts in this area. **You are not expected to read all the books listed here**. Unfortunately, no single book adequately covers all aspects of the course so you need to use the list to help you decide which ones meet your requirements. Some of the books will be of use for other units (such as Hearing sciences and Clinical units). All of them should be available in the University libraries for reference or for loan. For information about other books, refer to the "Books" page on the web site.

- **The Speech Chain** (Peter Denes, Elliot Pinson, 2nd edition 1993). This is the classic introduction to speech communication, and while dated in parts, it still provides the essential information you need in a fairly easy-to-read style. The recent addition of chapters on digital technology don't help much - they don't match in style to the rest of the book. You'll get a more thorough grounding in physical acoustics from Rosen & Howell. Really you should read this before you start the course. [W H Freeman, ISBN: 0716723441].
- **New Elements of Acoustic Phonetics** (Peter Ladefoged, 2nd edition 1995). A very gentle walk through the basics without any of the discouragements that come from mathematics or rigour. Written by an academic phonetician for linguists it is rather too elementary by itself, but is good enough to get you started with some of the concepts. Only buy this if you're having trouble with Hewlett & Beck, or with Rosen & Howell. [University of Chicago Press; ISBN: 0226467643]
- **An Introduction to the Science of Phonetics** (Nigel Hewlett & Janet Beck, 2006). If you are only going to buy one book for the course, choose this one. It is not as detailed as Rosen & Howell in terms of signals and systems, and it is rather limited in its description of the acoustic-phonetics of consonants compared to Johnson. But it does have a general introduction to articulation, sound, hearing and perception that meshes well with the material that we cover in the course. If you can understand this book, then you'll have a good understanding of the majority of our course. [Lawrence Erlbaum, ISBN: 0805856722].
- **Signals and Systems for Speech and Hearing** (Stuart Rosen, Peter Howell, 2nd edition 2010). This book is perhaps the only non-mathematical text about signals and systems theory. There is a close match between the approach of this book and the approach we take on the acoustics course. You will find much in this book to back-up the material in term 1; you will find the concepts explained more thoroughly and more rigorously than in the lecture notes. Highly recommended. [Emerald Group Publishing Limited, ISBN: 1848552262].
- **Acoustic and Auditory Phonetics** (Keith Johnson, 3rd Edition, 2011). This covers the acoustic-phonetic material of term 2 very well, and is a possible alternative to Hewlett & Beck. Its early acoustics chapters are not so good - better to stick to Rosen & Howell for these topics. [Wiley-Blackwell, ISBN: 1405194669]

Your reading will help you to write better laboratory reports and to give more comprehensive answers in the examination. Ask your tutor if you need further guidance with your reading.

8. Learning

You will find the course easier to follow and you will obtain maximum benefit from the lectures, labs and tutorials if each week you come prepared to learn. Here is some general advice:

- Read the handout for the week's teaching before you get to the lecture. Identify the concepts that are new and those which you don't yet understand.
- If you find taking lecture notes difficult, consider downloading and printing the lecture slides from the web site and bring them to the lecture. You can then annotate these to get a better record of the lecture content. The lecture slides may be revised on the day before the lecture, but will usually be available by 1pm on the Monday.
- After the lecture, and before the tutorial, look through the Learning Activities on the handout to check that you are indeed able to perform all the tasks. Bring up in tutorial anything you don't understand.
- Check that you will have access to the recommended reading, either by downloading from Moodle, borrowing the book from the library, or sharing a copy with friends.
- At home after the teaching session, look again at the handout and make sure you understand the text and the diagrams. Also read through the recommended reading and associate the facts there with what we have discussed in class. **Attempt all the Learning Activities in the handout**. Make notes about things you don't understand to bring up in the lab or in the tutorial the following week.
- During the week think about and discuss the questions listed under the Reflections heading. Maybe a search on the web will reveal the answer, or look in text books.
- New concepts and facts will only stick in your memory if you rehearse them. Try putting them into your own words – by speaking them out loud or by writing them onto paper.
- Since our topic is speech, hearing and sound, you will find plenty of opportunities to relate the ideas in the course to the everyday world. Bring your discoveries to tutorial.

9. Guidelines for Writing Laboratory Reports

The lab reports for this course should be written in a style similar to that used for journal articles in the hearing and speech sciences (this style is formally documented in "The Publication Manual of the American Psychological Society"). Below we have adapted this style to fit the needs of this course, and it may differ from the styles that you have used previously for lab reports in other courses. Please pay careful attention to the style guidelines below.

Writing in a scientific style

All lab reports must be written in a scientific style, and the ability to write in this style is one of the transferable skills offered by this course.

The lab reports must be written so that they stand on their own. In other words, you should write the report so that it would make sense to an outside reader, who has a general knowledge of acoustics but no previous knowledge about our labs. This means that you need to write in a clear and organized way, with complete sentences and coherent paragraphs. *Do not* write your lab report as if you were simply listing answers to the questions on your lab sheets; such a lab report would be incomprehensible to an outside reader.

The lab reports must be written from an objective point of view, as if you were an impartial observer rather than someone with a personal interest in the project. You should avoid using any first-person pronouns such as *I* and *we*. For example, do not write *We then played a 1000-Hz square wave*. Instead, avoid first-person pronouns by writing in the passive voice (e.g., *A 1000-Hz square wave was then played*), changing the actor (e.g., *The signal generator then played a 1000-Hz square wave*), or removing the actor (e.g., *The next signal was a 1000-Hz square wave).*

Scientific writing must be clear and precise. The following are some of the most important rules that you will need to follow.

- Use standard grammar and spelling. Proof read what you've written before you hand it in.
- Eliminate unnecessary words. Every single word in your lab report must be there for a reason. Do not use long phrases, such as *based on the fact that*, when a single word, such as *because*, can be used. Organize your thoughts so that you can discuss each important issue once, rather than repeating the same points throughout the paper.
- Write in a formal style. Do not use slang words or contractions (e.g., *can't* or *don't*).
- Use the past tense for events that occurred in the past. For example, you should use the past tense when discussing any lab procedure that you followed or any data that you collected (e.g., *the resonant frequency of the tube was 1000 Hz*). Use the present tense when discussing general scientific facts or conclusions that are not tied to a particular event (e.g., *the resonant frequency of a tube is inversely related to its length*).
- Be precise and specific with word usage. For example, never use the word *pitch* when you really mean *frequency*. Never use vague words (e.g., *Sounds A and B were a lot different*) when you can be more precise (e.g., *The amplitudes of Sounds A and B differed by 20 dB*).
- Always make sure that you specify the units of measurement when listing numbers in text, calculations, tables, or figures.

The parts of a lab report

There will be two main parts to your lab reports: An *Introduction*, and a combined *Results and Discussion*. You will also need a *title page* which gives a title, your name, the date, and your tutor's name. No *Methods* section is required, because the technical procedures for running your experiments will have been given to you on your lab sheets. A *References* section at the end of the lab report will only be necessary if you choose to cite text books or research articles in your report.

Introduction

Your introduction should be similar in style to the introduction of a published scientific paper. The main difference is that you are not required to review the literature on this topic. Also, your introduction can be much shorter than in a published paper. You will probably want to write one or two paragraphs for each of the main topics listed below.

- Begin the introduction by explaining to the reader why the general topic of your lab report is interesting or important. Imagine, for example, that your reader is a speech therapist. You need to give that person a reason to continue to read the rest of your paper. Stick to your *general* topic here; specific details of your experiment will come later.

- Define and describe key topics that the reader will need to understand in order to make sense of the rest of the lab report. You can assume that the reader has a basic background in acoustics, but you should describe the most important concepts and/or pieces of equipment that you will use.
- After writing the background information above, start to narrow your focus to your particular experiment. Give the reader the specific aims of your study and/or the hypotheses that were tested. Make sure the reader understands exactly why you ran this particular experiment. Give the reader a summary of the experimental method and analyses. It is not necessary here to give the reader enough information to replicate the experiment. Instead, you need to give the reader a general idea of what you did, so that the reader has enough information to make sense of your Results and Discussion section.

Results and Discussion

The Results and Discussion is where you tell the reader what you found, what you can conclude from these findings, and why the conclusions are important.

The organization and length of the Results and Discussion will vary between labs. In general, you should discuss more narrow topics first (e.g., the results and conclusions), and then discuss broader issues (e.g., implications of your conclusions). Your lab sheet will list the key issues and questions that you will need to discuss. Make sure that you cover *all* of these points in your Results and Discussion, and use these points to help organize this section. End the Results and Discussion with a short summary paragraph that connects to the specific aims and/or hypotheses that you mentioned in the Introduction.

You will need to integrate the results with your discussion, rather than just listing your results at the beginning of this section. The idea is that you should use your results to support the points that you want to make, so that your reader can understand your logic. Your reader would be confused if you just displayed a bunch of graphs or numbers without any text to explain what is important.

You should put all of the pages of graphs and tables at the end of the manuscript. All graphs are called *figures*, and they should be labelled and numbered in the order that they are discussed in the text (e.g., Figure 1, Figure 2, etc.). All written data are called *tables*, and should also be labelled and numbered in the order that they are discussed in the text (e.g., Table 1, Table 2, etc.). The idea is that your written text can say, for example, *Figure 1 shows that the resonant frequency of this tube was 1000 Hz*, and then the reader can go to the back of the manuscript and clearly find the graph that you mentioned.

Make sure that you include *only* the figures and tables that you specifically mention in the text. You do not want to include extra material (e.g., written notes or calculations) unless it is important for the points that you want to make.

All figures and tables should be legible and clearly labelled. Be sure to include an informative title (e.g., *Figure 1. The frequency response for a 10-cm tube*), axis labels with measurement units, and additional notes if needed (e.g., when you have multiple sets of data on the same graph, you need to show which data is which).

Plagiarism

The college has severe penalties for students found plagiarising the works of others. Do be careful in referencing and quoting material taken from other sources, so that you can never be accused of presenting their concepts as your own. Significant plagiarism, including copying

material from other students, will lead to you being failed on the course and may prejudice your degree.

Miscellaneous details

- Word processed lab reports are strongly preferred. However, Figures and Tables can be written or drawn by hand.
- Double-space your lab report and use margins of at least 2.5 cm (1 inch). You need to give your tutor enough room to write comments.
- Your report must be written independently. You will collect your data in groups and we encourage you to discuss the data and conclusions with your fellow students. But the final written report must be entirely your own.
- There is an **example lab report** on the web site that you can download.
- You don't need to read more than this about writing lab reports, but you could consult Lobban & Schefter (1992) 'Successful Lab Reports' from Cambridge University Press which is in the library. We have also put links to some APA style guides on the web site.