Aalto University
School of Electrical
Engineering

Communication acoustics
Course overview and how to get it completed

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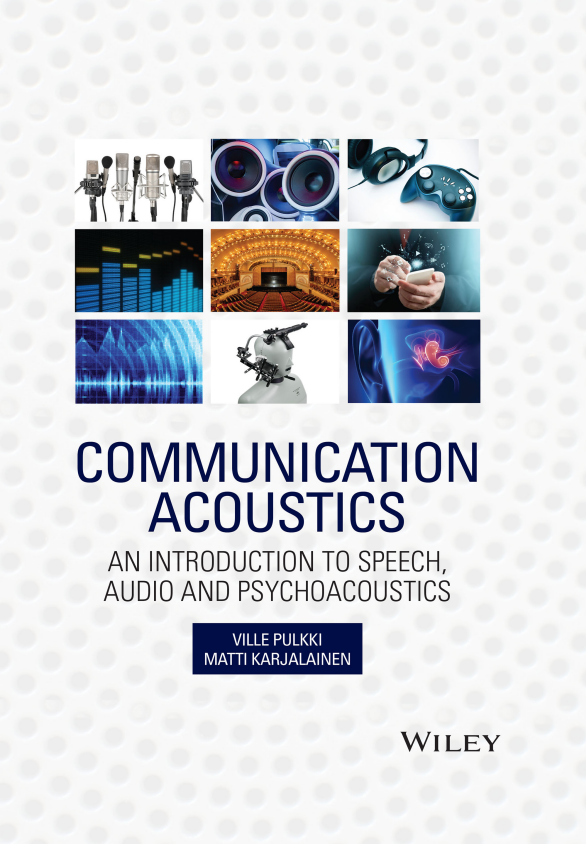
ELEC-E5600 Communication acoustics

- Lecturer: Prof. Ville Pulkki, email: Ville.Pulkki@aalto.fi
- Guest lecturers: Petteri Hyvärinen, Pedro Llado
- Teaching assistant: Pedro Llado
- Lectures: 5.9.2023 – 17.10.2023
- Course information: MyCourses, Slack

Book for the course

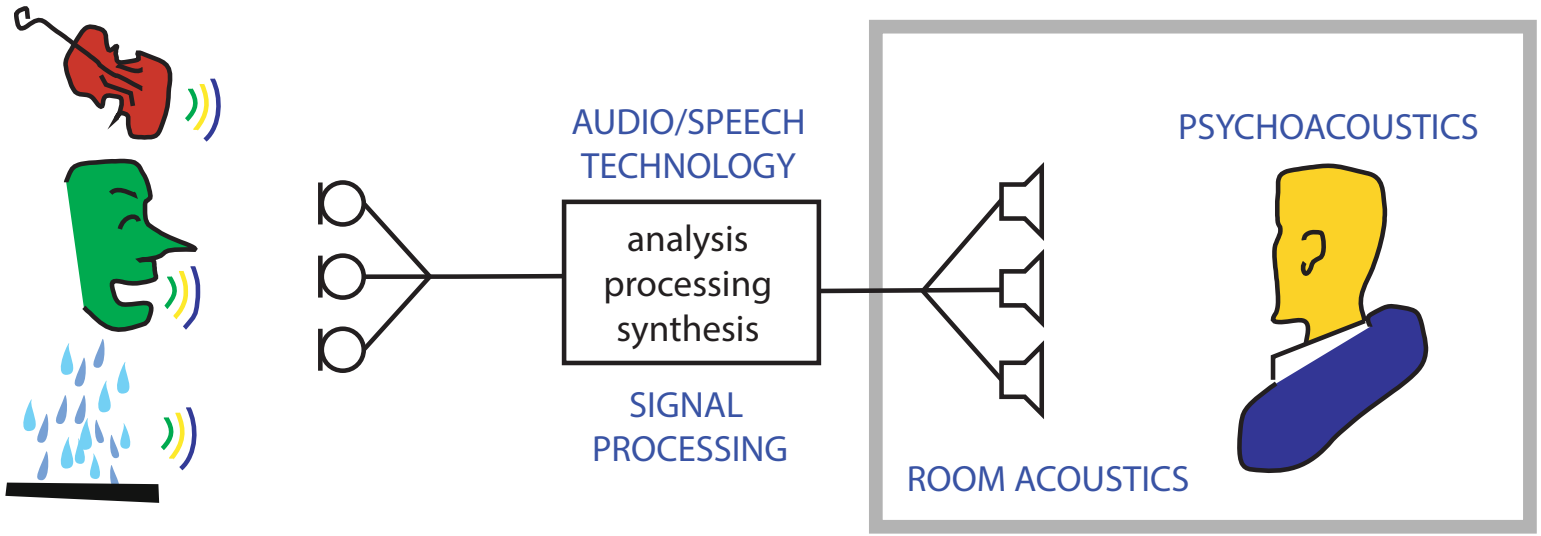


- Wider and translated version of Matti Karjalainen's "Kommunikaatioakustiikka"
  - Link to ebrary book with Aalto account
- E-books and hardcovers available in the Internet
- Chapters relevant to the course will come to mycourses
- ELEC library has about 8 books to borrow
- Printed paper copy available for copying
- 19 chapters, 456 pages, 250 figures

Chapters covered on this course

- Human voice
- Music instruments
- Anatomy and physiology of hearing
- Psychoacoustic testing
- Basic function of hearing
- Basic psychoacoustic quantities
- Further analysis in hearing
- Spatial hearing
- Auditory modelling
- Speech technologies
- Sound quality
- Technical audiology

Overall view



Hearing / Psychoacoustics / Speech / Music /
Perception and evaluation of sound quality

Completing the course

- **Home work**
  - Basic Matlab exercise
  - mandatory to pass the course

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  - Subjective testing + Computational modeling of human hearing
- **Examination**

Home work

- Simple Matlab exercise
- Record your own sound
- Read audio file in
- Plot different versions of spectrograms
- Submit Matlab script + some plottings

Has to be passed to complete the course!

Group work

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- Groups of a few students

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- Collect six few-second sounds from your surroundings
- Run a multiple-stimulus psychoacoustic test with given web-based software ▸ Link to existing test
- Take the test of other students

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Not mandatory, but makes your life easier in the examination

Examination

Q1 Explain 9 concepts (total 36 points)

Q2 Essay 1 (24 or 16 pts)

Q3 Essay 2 (24 or 16 pts)

Q4 Essay 3 (24 or 16 pts)

Answer to Q1, AND

- if you have passed group work: TWO essays (max 24 points each)

  OR

- if you have NOT passed group work: THREE essays (max 16 points each)

In both cases max points for exam is 84

Examination / bank of questions

List of concepts that can be asked in question 1:

A-weighted sound level, Absolute threshold, Acoustic horizon, Allophone, Approximant, Auditory event, Auditory filter, Auditory nerve, Auditory stream, Bark, Binaural cues, Cochlear amplifier, Cochlear implant, Concatenation cost, Contralateral, Critical band, Dichotic, DMOS, Equal loudness curves, ERB, Fricative, Gammatone filter bank, Glottis, Hearing level, Hearing threshold, Idiophone, Just intonation, Localization cue, Loudness, Median plane, Method of adjustment, Missing fundamental, Modulation transfer function, Nasal tract, Octave, Ossicles, Otoacoustic emission, Outer hair cell, PEAQ, Phoneme, Pitch, Pink noise, Prosody, Roughness, Sound event, Source–filter model, Stapes, STIPA, Timbre, Travelling wave, Vacil, Voiced sound.

Total 9 concepts will be asked resulting in max 36 points

Examination / bank of questions

List of questions for Q2, Q3 and Q4.

- Explain parts A–F of human speech production organs in attached figure. Basic classes of phonemes, and their production and acoustic properties. Explain concepts A–G in attached figure of ideal magnitude spectrum of a vowel. What causes the fluctuations on the curve?
- Sensory consonance and dissonance. Explain why the roughness produced by interference of harmonics of different notes. Consider an interval produced by two instruments with all harmonics compared to an interval produced by two instruments with only odd harmonics. Which one can be assumed to have lower dissonance in case of diminished fifth interval, and why?
- Modulation transfer function and STI in estimation of speech intelligibility. Explain how speech intelligibility [%] changes as function of STI for digits, short sentences, and logatomes.
- Explain the roles of inner and outer hair cells. Active function of cochlea. Explain how the velocity of the basilar membrane recorded at a single point changes when excited with sinusoids of different frequencies and levels. Explain why the amplification of the velocity is different at different levels of excitation.
- Hearing impairments. Hearing threshold shift and recruitment. Explain the stages of hair cell damage and the corresponding effect on neural tuning curves using the figure attached
- Roughness, fluctuation strength and sharpness. Definitions, units and modeling
- Definitions and measurement of HRIR and HRTF. Sketch the HRIR and HRTF responses for each ear for a sound source in the direction of 30 degrees of azimuth on right side. Which properties of HRIRs and HRTFs compose directional cues?
- Text-to-speech synthesis. Explain the basic principles of knowledge-based, unit-selection, and statistical parametric synthesis methods. Discuss the pros and cons of the methods.
- Perceptual measures and models for monaural audio quality. How are perceptual models utilised in estimation of degradation of sound quality?
- Describe detection, discrimination, forced choice and scaling tasks used in subjective testing. Which source of error does forced choice task mitigate, and how, when compared to detection tasks?

Tentative schedule

- **5.9** Lecture: Practicalities (Ville), Physiology of hearing CH 7 (Pedro)
- **7.9** Lecture: CH 8,9 (psychoacoustic testing, masking, frequency scales) (Pedro)
- **12.9** Lecture: CH 10 (perceived quantities)
- **14.9** Lecture: CH 11 (more qs)
- **19.9** Lecture: CH 12 (spatial hearing)
- **21.9** Lecture: CH 13 (auditory modeling) (Pedro Llado)
- **26.9** Lecture: CH (2),6 (vibration, music instr)
- **28.9** Lecture: CH 5, 16 (speech)
- **3.10** Lecture: CH 17 (sound Q)
- **5.10** Lecture: CH 18 (other)
- **10.10** Lecture: CH 19. (technical audiology) (Petteri Hyvärinen)
- **12.10** Demos at Acoustics lab
- **17.10** Workshop and Oral exam: **(Group work pass/fail)** (Ville, Pedro)
- **25.10?** Examination period of about 2 weeks starts in EXAM digital examination system space

Schedule for project

5.9 Homework given

12.9 Homework deadline

14.9 Division to groups, project work start

21.9 Delivery of sound files

26.9 Listening tests start

4.10 Listening tests deadline

4.10 Auditory modeling start

10.10 Test result boxplots deadline

17.10 Workshop: Final report as powerpoint show

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- Student feedback, too much content on lectures

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- Slides will be available, possibly also with audio recording from the lecture

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- Project work groups will be formed there

Communication with lecturers

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- It helps everybody when they see the question and the answer