Architectural Acoustics

Study Guide

7LS8M0, year 2021-22
Version 2022-03-21

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1. Educational Structure of the Course

1.1. General Information

During this course, topics relevant to Architectural Acoustics will be lectured: sound and vibration quantities, equations and mechanisms, room acoustics and sound transmission in buildings. The course consists of lectures, tutorials on exercises as well as assignments that mainly consist of analyses of impulse responses and transfer functions of sound and vibration in the built environment using MATLAB. In the elective course 7LY7M0: Techniques in Architectural Acoustics (Q4), the knowledge in this course is needed to work with experimental and computational techniques in Architectural Acoustics.

Year	2021/2022
Lecture planning	Year 1, semester B, quartile 3
Target group	Master, Building Physics and Services Master, Architecture, Building and Planning
Credits	5 ECTS
Coordinating department	BE
Coordinating lecturers	prof.dr.ir. M.C.J. Hornikx (responsible lecturer) dr. J. Yang C.C.J.M. Hak, M.Sc. M.E. Terzakis M.Sc.
Type of education	Lectures, tutorials, and exercises.
Examination	Hand-in assignments Written exam
Prior Knowledge	-
Study Material	Compulsory Kuttruff. Acoustics: An Introduction. (Taylor and Francis, 2007), digital available at TU/e library or order at e.g. www.bol.com www.amazon.com Additional course material will be posted at Canvas Suggested further reading: Kuttruff. Room Acoustics, Vigran. Building Acoustics

1.2 Learning Outcomes

For this course, the following learning objectives have been defined:

- Completeness and correctness in explaining the physical mechanisms of the sound and, acoustic related, vibration phenomena that occur in the built environment, in terms of physical mechanisms, equations and quantities.
- Correct numerical analysis of a transfer function and impulse response, and a translation into an acoustic quantity relevant for architectural acoustics.

1.3 Examination

The final grade for this course is based on the following components:

Type of examination	**Weight**	**Threshold**
a) Hand-in assignments	40 %	No minimum
b) Written exam	60 %	Minimum grade 5

The **hand-in assignments** consist of the following components: Three (3) MATLAB assignments, and one (1) presentation of a concept in acoustics and vibration. For the first type of assignments, a maximum of 8 credits can be obtained for each assignment, and a maximum of 16 credits can be obtained for the second type of assignment. This means that a total of 40 credits can be received.

The 3-hour **written exam** is scheduled in the exam period of Quartile 3. A total of 60 credits can be earned by this exam, and a minimum of 30 credits is required to pass the course. The exam consists of two parts: a part where no course material is allowed (multiple choice questions) and a part where course material is allowed. In the latter part, a formula sheet will be provided along with the exam questions. The formula sheet will be posted at Canvas as well.

1.4 Educational Forms & Teaching Models

1.4.1 Quartile 3

Lectures

The course content is mostly conveyed by lecture time, 2 hours per week. The teaching level is based on the expectation that the students have prepared the content of the course prior to the lecture. The content of the respective week will be clarified.

Tutorials

A second part of the course consists of Tutorials. **Exercises** are handed out that consist of short questions related to the contents of the course, and students work with these exercises during this hour. In the beginning of each exercise tutorial, a short introduction is given with respect to the tasks. The exercises contain questions similar to exam questions.

In course Week 3, 5 and 7, students have time to work on the hand-in **assignments**. Some guidance will be provided on the MATLAB tasks in these occasions. The deadlines of the hand-in assignments can be found in Section 2.3 of this study guide. These assignments are meant to be completed by groups of 2 students. If possible, we ask you to form groups in which at least one of the students has experience with MATLAB. **Don't forget to bring your laptop to the tutorials**.

The last assignment is a presentation of a concept in acoustics and vibration. With a group of 2 students, you select a concept from a list of that is provided. Examples of concepts are sound intensity, acoustic impedance or resonance. On top of the material provided in the lectures and course book, you are supposed to find more information on the concept to clarify your presentation. We will provide more information on Canvas on what is expected from the presentation. In week 8, 3 hours are reserved for 15-minute presentations in total (i.e., 10 minutes presentation and 5 minutes questions) per group.

Study Hub Hours (SHHs)

During the study hub hours, students have the opportunity to work in the reserved location, strengthening discussions, collaboration and the group work (see Section 2.2). On Wednesday's SHHs, students can work by themselves, whereas on Friday's SHHs, students can also ask questions to the responsible lecturer of the assignments related to their activities (see Section 3).

Self-Study

For a successful completion of this course, self-study is important. The weekly lectures and tutorials are based on the course content of that specific week, and preparation of the course material is important for a high learning outcome.

1.5 Course programme

The schedule of Architectural Acoustics course can be found below. In Section 3, the detailed weekly programme can be retrieved.

Quartile 3	Contents	Type of education	Dates	Assignment deadlines & Examination
Week 1	Course introduction	Introduction (1h)	9 February	
	Introduction to Tutorials & StudyHub Hours	Introduction (1h)		
	Fundamentals of Acoustics	Lecture (2h)	11 February	
Week 2	Fundamentals of Acoustics	Tutorial (3h)	16 February	
	Fundamentals of Acoustics	Lecture (2h)	18 February	
Week 3	Fundamentals of Acoustics	Tutorial (2h)	23 February	
	Fundamentals of Acoustics	Lecture (2h)	25 February	
	Carnival holiday February 28 to March 4 No education		2 March 4 March	
Week 4	No education	Lecture (2h)	9 March	HA1
	Fundamentals of Acoustics	Lecture (1h)	11 March	
Week 5	Fundamentals of Acoustics	Tutorial (2h)	16 March	
	Room Acoustics	~~Lecture (2h)~~	18 March	
Week 6	Room Acoustics	Lecture (2h) Tutorial (1h)	23 March	
	Building Acoustics	Lecture (2h)	25 March	
Week 7	Building Acoustics	Lecture (2h)	30 March	HA2
	Building Acoustics	Tutorial (2h)	1 April	
Week 8	Concept presentations	Presentations	8 April	HA 4
Exam weeks			13 April	HA 3
		Exam (3h)	**22 April**	WE

Abbreviations
HA: Hand-in Assignment
WE: Written Exam

2. Organizational Structure of the Course

2.1 Instructor Information & Availability

Below, you will find the week numbers of the involvement of the lecturers/instructors in this course

Lecturer/instructor	Quartile 3, Week
M.C.J. (Maarten) Hornikx	1-4,8
C. (Constant) Hak	5,6,8
J. (Jieun) Yang	6,7,8
M.E. (Michalis) Terzakis	2-8

2.2 Course Schedule

The course has the following time slots. The exact dates are included in the detailed weekly programme in section 3. Note: The hours that are not used for activities, they can be used by student groups to work on assignments and exercises at the specific location.

Week 1-8		
Day	**Hour**	**Location**
Wednesday	5-8	Atlas 6.208
Friday	1-4	Atlas 6.208

2.3 Landmark Events, Assessments & Due Dates

Quartile 3	Group size	Starting Date	Deadlines	Submission
HA 1	2 students	Wednesday 16 February	Wednesday 9 March, 11:59 pm	Canvas
HA 2	2 students	Wednesday 16 March	Wednesday 30 March, 11:59 pm	Canvas
HA 3	2 students	Friday 1 April	Wednesday 13 April, 11:59 pm	Canvas
HA 4	2 students	Wednesday 16 February	Friday 8 April, 11:59 pm (ppt) Friday 8 April (presentation)	Canvas
WE	1 student		Friday April 22, 09:00-12:00	

Abbreviations
HA: Hand-in Assignment
WE: Written Exam

3. Programme by Week (In Detail)

Week 1: Course Introduction, Fundamentals of Acoustics	
- Course Material: Chapter 2 with the exception of sections 2.7, 2.9.4, and 2.11 - Additional material will be posted at Canvas (if any)	
Wednesday 9 February, Atlas 6.208	
Hour 5	Course Introduction (Maarten Hornikx), including entry quiz
Hour 6	Introduction to Tutorials and StudyHub Hours (Michalis Terzakis)
Hour 7-8	Study Hub Hours
Friday 11 February, Atlas 6.208	
Hour 1	**Fundamentals of Acoustics Lecture (Maarten Hornikx)** Contents: Complex numbers, vibrations, impedance, resonance.
Hour 2	**Fundamentals of Acoustics Lecture (Maarten Hornikx)** Contents: Power, Fourier Transform, Impulse response, and Transfer function.
Hour 3-4	Study Hub Hours

Week 2: Fundamentals of Acoustics	
- Course Material: Chapter 3, Chapter 4.1 and 4.2 - Google docs document available for choice of acoustic concept - New information posted at Canvas: Additional Material (if any) List of concepts to select from, as well as guidelines for presentation (for HA 4)	
Wednesday 16 February, Atlas 6.208	
Hour 5	**Tutorial (Michalis Terzakis)** Introduction to MATLAB
Hour 6	**Tutorial (Michalis Terzakis)** Signal Processing
Hour 7	**Tutorial (Michalis Terzakis)** Explanation concept presentation assignment (HA 4).
Hour 8	Study Hub Hour
Friday 18 February, Atlas 6.208	
Hour 1	**Fundamentals of Acoustics Lecture (Maarten Hornikx)** Contents: Wave equation in fluids, plane waves, harmonic waves, speed of sound, sound pressure level.
Hour 2	**Fundamentals of Acoustics Lecture (Maarten Hornikx)** Contents: Intensity, sound pressure level, wave equation in solids.
Hour 3-4	Study Hub Hours (Michalis Terzakis)

Week 3: Fundamentals of Acoustics	
- Course Material: Chapter 4 with the exception of sections 4.4.2 and 4.5 Chapter 5, with the exception of sections 5.3 and 5.8.3 - New information posted at Canvas: Additional Material (if any) Description Hand-in Assignment 1	
Wednesday 23 February, Atlas 6.208	
Hour 5	**Tutorial (Michalis Terzakis)** Assignment HA1
Hour 6	**Tutorial (Michalis Terzakis)** Exercise on contents of Weeks 1 and 2.
Hour 7-8	Study Hub Hours

Friday 25 February, Atlas 6.208	
Hour 1	**Fundamentals of Acoustics Lecture (Maarten Hornikx)** Contents: Air attenuation, spherical waves.
Hour 2	**Fundamentals of Acoustics Lecture (Maarten Hornikx)** Contents: Sound radiation.
Hour 3-4	Study Hub Hours (Michalis Terzakis)

Week 4: Fundamentals of Acoustics	
- Course Material: Chapter 6 - New information posted at Canvas: Additional Material (if any)	
Wednesday 9 March, Atlas 6.208	
Hour 5	No education
Hour 6	No education
Hour 7-8	Study Hub Hours
Friday 11 March, Atlas 6.208	
Hour 1	**Fundamentals of Acoustics Lecture (Maarten Hornikx)** Contents: Reflection.
Hour 2	Study Hub Hour
Hour 3-4	Study Hub Hours (Michalis Terzakis)

Week 5: Fundamentals of Acoustics / Room Acoustics	
- Course Material: Chapter 9, Chapter 13 - New information posted at Canvas: Additional Material (if any) Description Hand-in Assignment 2	
Wednesday 16 March, Atlas 6.208	
Hour 5	**Tutorial (Michalis Terzakis)** Assignment HA2.
Hour 6	**Tutorial (Michalis Terzakis)** Exercises on contents of week 3 and 4.
Hour 7-8	Study Hub Hours
Friday 18 March, Atlas 6.208	
Hour 1	~~**Room Acoustics Lecture (Constant Hak)**~~ ~~Contents: Sound in closed spaces.~~
Hour 2	~~**Room Acoustics Lecture (Constant Hak)**~~ ~~Contents: Room Acoustics.~~
Hour 3-4	Study Hub Hours (Michalis Terzakis)

Week 6: Room Acoustics / Building Acoustics	
- Course Material: Chapter 13 (Room Acoustics), Chapter 10 and 14 (Building Acoustics) - New information posted at Canvas: Additional Material (if any)	
Wednesday 23 March, Atlas 6.208	
Hour 5	**Room Acoustics Lecture (Constant Hak)** Contents: Sound in closed spaces
Hour 6	**Room Acoustics Lecture (Constant Hak)** Contents: Room Acoustics.
Hour 7	**Tutorial (Michalis Terzakis)** Exercises on Room Acoustics.
Hour 8	Study Hub Hours

Friday 25 March, Atlas 6.208	
Hour 1	**Building Acoustics Lecture (Jieun Yang)** Contents: Waves in unbounded solids, waves in plates and bars, wave types.
Hour 2	**Building Acoustics Lecture (Jieun Yang)** Contents: Airborne sound insulation (single leaf and double leaf walls).
Hour 3-4	Study Hub Hours (Michalis Terzakis)

Week 7: Building Acoustics	
- Course Material: Vigran Chapter 9 - New information posted at Canvas: Additional Material (if any) Description Hand-in Assignment 3	
Wednesday 30 March, Atlas 6.208	
Hour 5-6	**Building Acoustics Lecture (Jieun Yang)** Contents: Flanking sound transmission.
Hour 7-8	Study Hub Hour
Friday 1 April, Atlas 6.208	
Hour 1	**Tutorial (Michalis Terzakis)** Assignment HA 3.
Hour 2	**Tutorial (Michalis Terzakis)** Exercises on Building Acoustics.
Hour 3-4	Study Hub Hours (Michalis Terzakis)

Week 8: Concepts Presentations	
Wednesday 6 April, Atlas 6.208	
Hour 5-8	Study Hub Hours
Friday 8 April, Atlas 6.208	
Hour 1-2	**Concepts Presentations (HA 4)** Presentations of student groups on concepts.
Hour 3-4	Study Hub Hours (Michalis Terzakis)