

ARCH- EE 599: Acoustics of Real and Virtual Spaces

Course Information

Spring Semester, Units: 3
Tuesdays 10 am to 12:50 pm

Course Summary

Examination of the comprehensive synergy between acoustics, psychoacoustics (human perception of sound), and the architecture of real and virtual spaces.

Learning Objectives

After successfully completing this course, students will

1. Understand basic architectural acoustics and psychoacoustics principles.
2. Become more aware of the role of sound in real-world spaces.
3. Edit virtual spaces to include sound.
4. Understand how sound changes and influences our perception of space.

Instructor: Chris Kyriakakis (ECE)

Office: RTH 213

Office Hours: send email for appointment

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<https://viterbi.usc.edu/directory/faculty/Kyriakakis/Christos>

Instructor: Karen Kensek (ARCH)

Office: Watt 309

Office Hours: send email for appointment

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Class Assistant: to be announced

Office Hours: to be announced; additional hours available by email

Contact Info: to be announced

Prerequisite(s): None.

Co-Requisite(s): None.

Concurrent Enrollment: N/A

Recommended Preparation: None. Interdisciplinary course open to students from all disciplines.

Course Notes

Lecture Periods: Co-taught by the two professors in tandem to facilitate interdisciplinary discussions

Grading: Numeric for assignments and projects, letter for course grade

Demonstrations: Hands-on in-class demonstrations will be given using the advanced audio capabilities of the classroom (RTH 217)

Technological Proficiency and Hardware/Software Required

Free student software: ODEON (demo version), Enscape, Revit, and Audacity. Students are also welcome to use other software that they are familiar with in certain assignments.

Readings

Required Textbook (read the entire book)

Blessner, B. and Salter, L.R., *Spaces Speak, Are you Listening*, MIT Press (2007)

Reference Book (skim the entire book as use for reference and to clarify lecture material)

Ermann, M., *Architectural Acoustics Illustrated*, Wiley (2017)

<https://www.amazon.com/Architectural-Acoustics-Illustrated-Michael-Ermann/dp/1118568494>

OR

Jaramillo, Ana M. and Steel, Chris, *Architectural Acoustics*. Routledge (2015).

<https://www.routledge.com/Architectural-Acoustics/Jaramillo-Steel/p/book/9780415732147?source=igodigital>

OR

Egan, M.D., *Architectural Acoustics*, J Ross Publishing (2007)

<https://www.amazon.com/Architectural-Acoustics-Ross-Publishing-Classics/dp/1932159789>

Other Non-Required Additional Resources

Armstrong Ceilings' free Sound Level Meter app for your smart phone or iPad

<https://apps.apple.com/us/app/armstrong-sound-level-meter/id953513885>

SoundScape, a freeware program developed by Rob Bullen an experienced acoustics consultant and acoustics instructor in Sydney, Australia. You can download the Windows program from

<http://www.soundscience.com.au/products/soundscape.htm>

Erwin, B., *Creating Sensory Spaces: The Architecture of the Invisible*, Routledge (2017) – Chapter 6. The Routledge Student Discount code SS213 should provide a 30% discount for students. If by any chance that doesn't work, the general 20% discount code FLR40 should provide a 20% discount.

Sewart, T.J., "The sounds of the past," *American Archaeology*, Winter 2020-21

Visualizing the Invisible: the sound of real and virtual worlds, <https://www.unrealengine.com/en-US/spotlights/visualizing-the-invisible-the-sound-of-real-and-virtual-worlds>

Novitski, B.J., *Real and Imagined Buildings*, Rockport Pub (1998)

Toyota, Y., Komoda, M., Beckmann, D., Quiquerez, M., Bergal, E., *Concert Halls by Nagata Acoustics: Thirty Years of Acoustical Design for Music Venues and Vineyard-Style Auditoria*, Springer (February 26, 2021)

Description and Assessment of Assignments

Homework assignments are usually one or two weeks in length. If an assignment is two weeks in length, it is because it is a longer assignment, and you need the additional time to complete it. Late assignments will not be accepted; turn in what you have on the due date at the beginning of class. You will receive partial credit. Successful students read the entire homework assignment before starting, read it again as they are working on it to refresh their memory, and read it yet again to verify that they have the correct elements to turn in. There is also a final project and required questions on the readings. Grades will be posted on Blackboard.

LATE ASSIGNMENTS WILL NOT BE ACCEPTED; TURN IN WHAT YOU HAVE ON THE DUE DATE AT THE BEGINNING OF CLASS ON BLACKBOARD. There are no "make-up" assignments or extra credit. Do the absolute best that you can on each assignment and turn it in on time.

PLEASE NOTE THAT YOU ARE EXPECTED TO COMPLETE ALL HOMEWORK ASSIGNMENTS BY YOURSELF USING THE SOFTWARE THAT HAS BEEN ASSIGNED. COPYING OTHER PEOPLE'S FILES OR TURNING IN WORK THAT YOU DID NOT COMPLETE YOURSELF WILL RESULT IN A FAILING GRADE.

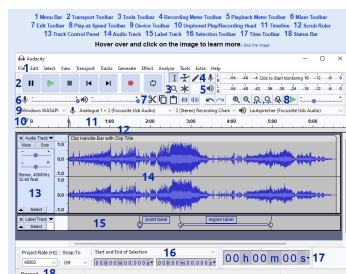
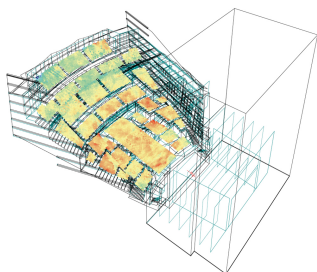
Make backups of everything!!! These should be in different locations (e.g. multiple flash drives, hard drive, portable hard drive, the cloud) and under different names. Keep older files in case the newest version somehow becomes corrupted. Losing your files will not be an excuse for late or missing assignments.

Grading Breakdown

	Percentage of Grade		Number of points
Homework Assignments	60%	Homework 1 – Auditory Characteristics of an Interior Space	10
		Homework 2 – Acoustical Characterization of a Classroom	10
		Homework 3 – Sound in Computer Games and Digital Models (team)	10
		Homework 4 – Quantitative Audio Metrics	10
		Homework 5 – Auditory Spatial Awareness (team)	10
		Homework 6 – Soundscape (team)	10
Final Project	25%	Final Project - Aural Synthesis (team)	100
Other Assessment	15% This might be re-distributed as necessary.	Quizzes	varies
		Questions on readings	varies
		Participation	varies
		Other	varies

Assignment Submission Policy

Assignments will usually be turned in both on Blackboard as print-outs and application specific file formats. They are due **before the beginning** of class. There are **no make-ups** on assignments, quizzes, or participation responses. Turn in what you have done for partial credit.



<https://audioxpress.com/article/predictive-acoustics-and-acoustical-modeling-software-odeon-room-acoustics-software>, (left)
<https://manual.audacityteam.org/> (middle), <https://www.laphil.com/about/our-venues/about-the-walt-disney-concert-hall> (right)

Course Schedule: A Weekly Breakdown

Tuesdays 10 am – 12:50 pm	Topics/Daily Activities You have both a textbook and a reference manual for this course. They will help you a lot if you keep up with the required readings and use the reference book to help clarify ideas presented in class.	Readings/Preparation
Week 1 Jan. 10	Course overview What is sound – overview of key ideas and terms Characteristics of sound in rooms including reverberation Reverberation	
Week 2 Jan. 17	Characteristics of sound in rooms Impulse response, frequency and time, acoustic power Criteria for good acoustic performance. Design of auditoria.	Textbook, Ch. 1
Week 3 Jan. 24	Auditory spatial awareness and soundscapes Discuss homework 2.	HWK 1 due Textbook, Ch. 2 (start)
Week 4 Jan. 31	Auditory spatial awareness and hearing spatial attributes	Textbook, Ch. 2 (finish)
Week 5 Feb. 7	Sound in VR and game design Discuss homework 3.	HWK 2 due
Week 6 Feb. 14	Virtual Space Acoustics; design principles using ODEON	
Week 7 Feb. 21	Virtual Space Acoustics; case study using ODEON Discuss homework 4.	HWK 3 due Textbook, Ch. 4
Week 8 Feb. 28	Site visit: ARUP Sound Lab, Los Angeles Architectural acoustics in the real world	
Week 9 March 7	Hearing and Psychoacoustics Anatomy of the ear, loudness, pitch, timbre Discuss homework 5.	HWK 4 due
Week 10 March 14	Spring Break	
Week 11 March 21	Hearing and Psychoacoustics Spectral cues; head-related transfer function; subjective listening evaluations	

Week 12 March 28	Spatial audio: theory and applications Capturing sound: microphones, headphones, and loudspeakers Discuss homework 6.	HWK 5 due Textbook, Ch. 6
Week 13 Apr. 4	Binaural audio In-ear measurements; head-related transfer functions	Textbook, Ch. 7
Week 14 Apr. 11	Archaeoacoustics: culture and aural architecture Acoustics of ancient spaces Examples from Byzantium	HWK 6 due Textbook, Ch. 3
Week 15 Apr. 18	Discuss final project ideas during class time with instructors.	Final project, part 1 due Textbook, Ch. 3
Week 16 Apr. 25	Current state-of-the-art Ambisonics New research areas Discussion of class	
FINAL	Final Project Presentation – Tuesday, May 9, 8 – 10 am	Final Project due

Statement on Academic Conduct and Support Systems

Academic Conduct

Plagiarism – presenting someone else’s ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in *SCampus* in Part B, Section 11, “Behavior Violating University Standards” <https://policy.usc.edu/scampus-part-b/>. Other forms of academic dishonesty are equally unacceptable. See additional information in *SCampus* and university policies on scientific misconduct, <http://policy.usc.edu/scientific-misconduct>.

Support Systems

Student Counseling Services (SCS) - (213) 740-7711 – 24/7 on call

Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention. <https://engemannshc.usc.edu/counseling/>

National Suicide Prevention Lifeline - 1-800-273-8255

Provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week. <http://www.suicidepreventionlifeline.org>

Relationship and Sexual Violence Prevention Services (RSVP) - (213) 740-4900 - 24/7 on call

Free and confidential therapy services, workshops, and training for situations related to gender-based harm. <https://engemannshc.usc.edu/rsvp/>

Sexual Assault Resource Center

For more information about how to get help or help a survivor, rights, reporting options, and additional resources, visit the website: <http://sarc.usc.edu/>

Office of Equity and Diversity (OED)/Title IX Compliance – (213) 740-5086

Works with faculty, staff, visitors, applicants, and students around issues of protected class. <https://equity.usc.edu/>

Bias Assessment Response and Support

Incidents of bias, hate crimes and microaggressions need to be reported allowing for appropriate investigation and response. <https://studentaffairs.usc.edu/bias-assessment-response-support/>

The Office of Disability Services and Programs

Provides certification for students with disabilities and helps arrange relevant accommodations. <http://dsp.usc.edu>

Student Support and Advocacy – (213) 821-4710

Assists students and families in resolving complex issues adversely affecting their success as a student EX: personal, financial, and academic. <https://studentaffairs.usc.edu/ssa/>

Diversity at USC

Information on events, programs and training, the Diversity Task Force (including representatives for each school), chronology, participation, and various resources for students. <https://diversity.usc.edu/>

USC Emergency Information

Provides safety and other updates, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible, <http://emergency.usc.edu>

USC Department of Public Safety – 213-740-4321 (UPC) and 323-442-1000 (HSC) for 24-hour emergency assistance or to report a crime. Provides overall safety to USC community. <http://dps.usc.edu>