EE 499 (30447): Acoustics of Real and Virtual Spaces
Units: 3
Fall 2022
2-4:50 Tuesdays

Instructors:
Chris Kyriakakis

Location: RTH217

Instructor: Chris Kyriakakis
Office: RTH213
Office Hours: Friday 1–3 pm
Contact Info: ckyriak@usc.edu, (213)740-8600, replies to emails/calls within 12 hours.
Course Description
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. Analyze the role of sound in real-world spaces;
3. Create virtual spaces and experience virtual sound in them;
4. Deliver a project tailored for their individual major

Prerequisite(s): None
Co-Requisite(s): None
Concurrent Enrollment: N/A
Recommended Preparation: None. This is intended as an interdisciplinary course open to students from all disciplines

Course Notes
Grading: Numeric for assignments and projects, Letter for course grade
Hands-on in-class demonstrations will be given using the advanced audio capabilities of the classroom (RTH217)

Technological Proficiency and Hardware/Software Required
Access to the room acoustics software, ODEON, will be provided. Examples will be covered in class. 3D modeling software and Enscape is available to the students for free through students.autodesk.com, sketchup.com, and through USC Cloudapps.

Required Readings and Supplementary Materials

Required Textbook

Supplementary Materials


Additional readings and reference materials will be posted on Blackboard
Grading Breakdown

<table>
<thead>
<tr>
<th>Percentage of Grade</th>
<th>Assignments</th>
<th>Number of points</th>
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<tbody>
<tr>
<td>Homework</td>
<td>70%</td>
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<tr>
<td></td>
<td>Homework 1 – characteristics of sound</td>
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<td>Homework 2 – auditory spatial awareness</td>
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<td>Homework 3 – digital sound</td>
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<td>Homework 5 – sound localization</td>
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<td>Homework 6 – adding sound to 3D models</td>
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<td>Homework 7 – acoustic montage</td>
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<td>Final Project</td>
<td>25%</td>
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<td>Participation</td>
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<td>Pop-quizzes</td>
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<td>Questions on readings</td>
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<td></td>
<td>Other</td>
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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.

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.

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.

Grading Timeline
Assignments will be graded within 1 week of submission

Additional Policies
Late assignments will not be accepted; turn in what you have on the due date. 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.

This is a hands-on course so it is expected that you attend every class.
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<th>Week</th>
<th>Topics/Daily Activities</th>
<th>Readings/Preparation</th>
<th>Deliverables</th>
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<td>1</td>
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<td>Characteristics of sound in rooms</td>
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<td>Criteria for good acoustic performance</td>
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<td>Auditory spatial awareness</td>
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<td>Case study using ODEON</td>
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<td>Site visit: ARUP Sound Lab, Los Angeles</td>
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<td>HWK 4 due</td>
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<td>Architectural acoustics in the real world</td>
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<td>Hearing and Psychoacoustics</td>
<td>Lecture slides</td>
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<td>Anatomy of the ear</td>
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<td>Loudness</td>
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<td>Pitch, timbre</td>
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Summary of homework assignments

Homework 1: Characteristics of sound in rooms, reverberation, criteria for good acoustic performance. Pick an interesting space (concert hall, stadium, religious space, parking garage, large lecture hall, jazz club, etc.) You are going to have to visit it twice, once when it is mainly empty so that you can walk around, photograph the geometry of the space, document acoustic treatments, clap your hands to get a sense of the reverberation time, and try to decide it theoretically fulfills the criteria for a good acoustic performance. How did the architect/engineer do this? Then return to it when it is in use. Record audibly what the space is like. Try to go to different locations. Is the space different depending on where you are and how you are (for example, audience member versus performer). Capture what it is like to be in that space. From a sound point of view, is it successful?

Homework 2: Auditory spatial awareness. Consider the lecture/readings you had on the challenges of being blind and deaf. In teams of two, taking turns being blind folded, carefully walk around campus and actually standing still to really listen to the soundscape of campus. What auditory clues exist as to where you might be or where an entrance is or how to avoid danger? A few places you might try standing (discover your own places too): by a fountain, under the arches
of Bovard Hall, near the Music School practice rooms. Research online (remember your citations!) what techniques have designers (art, architecture, musicians, house owners, urban planners, etc. – be open in your interpretation of the term “designer”) in other places to assist blind people and to enhance the soundscape of a place. Then consider these issues from the perspective of a deaf person. What challenges exist in everyday life due to lack of auditory clues?

**Homework 3**: explore digital sound through computer games. Through images and capture sound snippets, explain how the designer uses sound to enhance or fail to enhance sound in a virtual world. Understand and explain what the designer was trying to do in different circumstances (walking around, being in battle, solving a puzzle). Then try to discover how “real” the simulation is. Does sound become quieter as you walk away from the source? Do surfaces that look hard seem to bounce sound more? Closing your eyes and concentrating might help with this. Then do some research – look at Unity or Unreal Engine documentation. How is sound actually simulated in one of these two software programs? What models and assumptions do they use?

**Homework 4**: most of the assignments so far have been about “subjective” acoustics. We went through a case study in class using ODEON for an interior space. It produced ray traced graphs and numeric evaluations of spaces. First explain how the simulation match or do not match what you think that the space should sound like. Then change the materials on the walls, ceilings, floor. Change the angles of surfaces. How were you able to create a reverberant space? A really lousy space for lectures? A quiet, contemplative space? The intent is for you to learn how the numbers relate to actual experience.

**Homework 5**: To examine the role of the pinnae in sound localization conduct the following experiment with 2-3 friends/classmates:

Use a blindfold on the test subject. Generate sound (of your choice) at a number of points in the imaginary sphere around the person. Ask the subject to identify the exact direction using a method of your choice (pointing, verbal, etc.). Create a representation that shows the actual location of the sound source in 3D space and the one selected by the subject. Show any errors that may occur. Now repeat the experiment by first filling the folds in the ears with “Play-Doh” putty. Make sure that the pinnae surface is completely flat, but that the entrance to the ear canal is not blocked. Show a representation of the errors in this case and compare to the previous case. Be careful not to place anything in the ear canal.

Based on our in-class discussion, take appropriate measures to ensure that the presentation and location of the stimuli is not known in advance to the test subject.

**Homework 6**: create a simple 3D building model in Revit or Rhino. If you don’t know either of those software programs, we will help you create find a 3D model you can use. Enscape will allow you to add short snippets of sound to the 3D model. Enhance the soundscape of the building through your selection of six sound snippets. Set up an animation walking around the space and record it to turn in. Borrow the VR headset and walk through and around the building. What was your intent for each of the six sound snippets? Did you succeed and how or why not?

**Homework 7**: create a 10 second acoustic montage (no words) that explains who you are at a specific moment in time. Use reverberation, pitch, timber, loudness, rhythm, etc. It might help for you to concentrate on a specific emotion, a place you visited, or anything that can describe your sonic identity.
Final Project (you will be presenting this in class to your colleagues). Depending on enrollment and background, this will be a team project with students from different disciplines to encourage interdisciplinary collaboration and thinking.

How does your major or strong background relate to acoustics? Each student (or group), with the help of the instructors, will design their own final project tailored to their interest. For example,

- Room acoustics (architecture / theater)
- The ear (pre-med / biology)
- Post processing (cinema / animation)
- Emotion and motion (dance / art)
- Podcast (literature / astronomy)
- Theremin (engineering / music)
- Ancient spaces (history / religion)

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” policy.usc.edu/scampus-part-b. Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on Research and Scholarship Misconduct.

Students and Disability Accommodations:

USC welcomes students with disabilities into all of the University’s educational programs. The Office of Student Accessibility Services (OSAS) is responsible for the determination of appropriate accommodations for students who encounter disability-related barriers. Once a student has completed the OSAS process (registration, initial appointment, and submitted documentation) and accommodations are determined to be reasonable and appropriate, a Letter of Accommodation (LOA) will be available to generate for each course. The LOA must be given to each course instructor by the student and followed up with a discussion. This should be done as early in the semester as possible as accommodations are not retroactive. More information can be found at osas.usc.edu. You may contact OSAS at (213) 740-0776 or via email at osasfrontdesk@usc.edu.

Support Systems:

Counseling and Mental Health - (213) 740-9355 – 24/7 on call studenthealth.usc.edu/counseling
Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

National Suicide Prevention Lifeline - 1 (800) 273-8255 – 24/7 on call suicidepreventionlifeline.org
Free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week.

Relationship and Sexual Violence Prevention Services (RSVP) - (213) 740-9355(WELL), press “0” after hours – 24/7 on call studenthealth.usc.edu/sexual-assault
Free and confidential therapy services, workshops, and training for situations related to gender-based harm.

Office for Equity, Equal Opportunity, and Title IX (EEO-TIX) - (213) 740-5086
eeo@usc.edu
Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants.

Reporting Incidents of Bias or Harassment - (213) 740-5086 or (213) 821-8298
usc-advocate.symplicity.com/care_report
Avenue to report incidents of bias, hate crimes, and microaggressions to the Office for Equity, Equal Opportunity, and Title for appropriate investigation, supportive measures, and response.

The Office of Student Accessibility Services (OSAS) - (213) 740-0776
osas@usc.edu
OSAS ensures equal access for students with disabilities through providing academic accommodations and auxiliary aids in accordance with federal laws and university policy.

USC Campus Support and Intervention - (213) 821-4710
campussupport@usc.edu
Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

Diversity, Equity and Inclusion - (213) 740-2101
diversity@usc.edu
Information on events, programs and training, the Provost’s Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

USC Emergency - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call
dps@usc.edu, emergency@usc.edu
Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

USC Department of Public Safety - UPC: (213) 740-6000, HSC: (323) 442-120 – 24/7 on call
dps@usc.edu
Non-emergency assistance or information.

Office of the Ombuds - (213) 821-9556 (UPC) / (323-442-0382 (HSC)
ombuds@usc.edu
A safe and confidential place to share your USC-related issues with a University Ombuds who will work with you to explore options or paths to manage your concern.

Occupational Therapy Faculty Practice - (323) 442-3340 or otfp@med.usc.edu
chan.usc.edu/otfp
Confidential Lifestyle Redesign services for USC students to support health promoting habits and routines that enhance quality of life and academic performance.