UC San Diego | SCRIPPS INSTITUTION OF OCEANOGRAPHY

Syllabus for SIOC 200A
Computational Ocean Acoustics and Signal Processing I

Fall 2023, 09:00-10:20am Tuesdays and Thursdays between 09/28 and 12/07 (total 20 lectures)
Classroom: Eckart 127
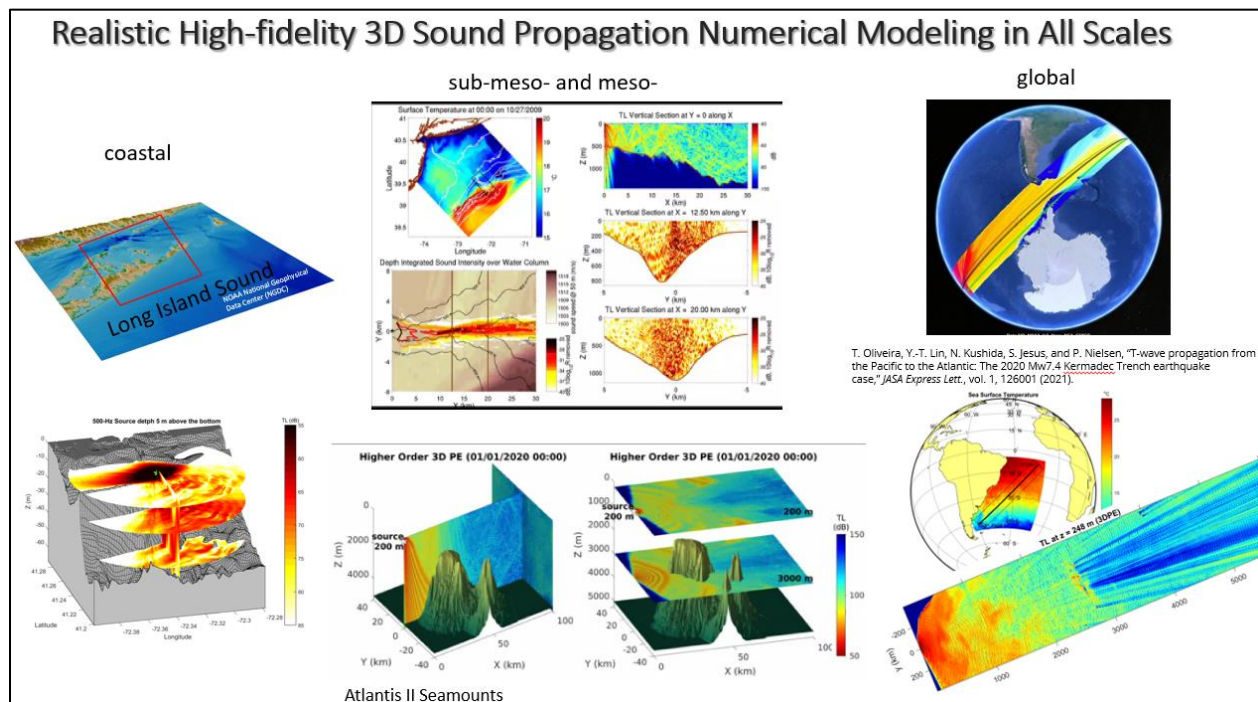Instructor: Prof. Ying-Tsong (YT) Lin
Office hours: Tuesdays 11am-2pm; Wednesdays: 9am-12pm; Thursdays 11am-2pm
Office hours can be either in person or remote, but by appointment only through the Google
Calendar: https://calendar.app.google/s4MrCghvqFtCzg1z5.

Course Description
Acoustics is one of the most effective tools to explore the ocean from the surface to the depths.
In this series of courses (Computational Ocean Acoustics and Signal Processing I-III), students
will learn useful computational ocean acoustic models and signal processing techniques for
processing and analyzing acoustic data to investigate ocean environmental variability, enhance
underwater communication, and boost target detection and localization.

Realistic High-fidelity 3D Sound Propagation Numerical Modeling in All Scales

T. Oliveira, Y.-T. Lin, N. Kushida, S. Jesus, and P. Nielsen, "T-wave propagation from the Pacific to the Atlantic: The 2020 Mw7.4 Kermadec Trench earthquake case," *JASA Express Lett.*, vol. 1, 126001 (2021).

Course Learning Outcomes
Upon completion of this course, students will be able to:
1. understand the fundamentals of ocean acoustics
2. establish solid physical concepts of sound propagation and scattering
3. develop numerical models for underwater sound propagation and scattering
4. master essential signal processing techniques for analyzing acoustic data

Last Updated September 10, 2023

Teaching and Learning Philosophy
Education is the foundation of a successful society.
To inspire students conceptualizing complex ideas
To encourage students thinking beyond mathematical formulas and equations
To enable students connecting and solving real world problems

Lecture Topics
*** Students are expected to develop their own computer programs on all subjects covered.*
I. Introduction (Lectures 1-3)
    Fundamentals of ocean acoustics
    Sonar equations
    Examples of ocean acoustic experiments and computational ocean acoustic tools for data processing and analysis
    Useful numerical techniques for computational ocean acoustics and signal processing
II. Acoustics Wave Equation with Fundamental Analytic Solutions (Lectures 4-6)
    Free space solutions
    Plane wave reflections
    The method of images
III. Ray Methods (Lectures 7-11)
    Derivation of Eikonal and Transport Equations
    Ray tracing
    Gaussian Beam tracing
IV. Normal Modes (Lectures 12-16)
    Derivation of normal mode equations
    Modal eigenvalue/wavenumber solutions
    Mode function solutions
*Special topic: Ray/Mode Duality (Lecture 17)
V. Array Signal Processing (Lectures 18-20)
    Plane wave beamforming
    Matched Field Processing for source localization

Text/Readings/Other Material
Jensen, Kuperman, Porter and Schmidt, 2011. Computational Ocean Acoustics, 2nd Edition.
Frisk, 1994. Ocean and Seabed Acoustics: A Theory of Wave Propagation.
Ocean Acoustics Library. https://oalib-acoustics.org/

Technology Requirements
A computer and any scientific programming language.

Grading
Scale: A = 90-100 %,   B = 80-89 %,   C = 70-79 %,   D = 60-69 %,   F = 59 %-below
Weight: weekly homework 75%, final project 25%

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Attendance and Participation

Every student is expected to attend all the classes. If missing a class, students should do their best to study the lecture recording and materials. Students are also encouraged to use the instructor's office hours for discussions.

Class Calendar

Week #	Monday	Tuesday	Wednesday	Thursday	Friday
Week 1				9/28 9-10:20am Lecture 1 11am-2pm office hours	
Week 2		10/3 9-10:20am Lecture 2 11am-2pm office hours	10/4 9am-12pm office hours	10/5 9-10:20am Lecture 3 11am-2pm office hours	10/6 Homework #1 due
Week 3		10/10 9-10:20am Lecture 4 11am-2pm office hours	10/11 9am-12pm office hours	10/12 9-10:20am Lecture 5 11am-2pm office hours	10/13 Homework #2 due
Week 4		10/17 9-10:20am Lecture 6 11am-2pm office hours	10/18 9am-12pm office hours	10/19 9-10:20am Lecture 7 11am-2pm office hours	10/20 Homework #3 due
Week 5		10/24 9-10:20am Lecture 8 11am-2pm office hours	10/25 9am-12pm office hours	10/26 9-10:20am Lecture 9 11am-2pm office hours	10/27 Homework #4 due
Week 6		10/31 9-10:20am Lecture 10 11am-2pm office hours	11/1 9am-12pm office hours	11/2 9-10:20am Lecture 11 11am-2pm office hours	11/3 Homework #5 due
Week 7		11/7 9-10:20am Lecture 12 11am-2pm office hours	11/8 9am-12pm office hours	11/9 9-10:20am Lecture 13 11am-2pm office hours	11/10 Veterans Day Holiday

Week 8	11/13 Homework #6 due	11/14 9-10:20am Lecture 14 11am-2pm office hours	11/15 9am-12pm office hours	11/16 9-10:20am Lecture 15 11am-2pm office hours	11/13 Homework #7 due
Week 9		11/21 9-10:20am Lecture 16 11am-2pm office hours	11/22 9am-12pm office hours	11/23 Thanksgiving Holiday No class	11/24 Thanksgiving Holiday
Week 10	11/27 Homework #8 due	11/28 9-10:20am Lecture 17 11am-2pm office hours	11/29 9am-12pm office hours	11/30 9-10:20am Lecture 18 11am-2pm office hours	12/1 Homework #9 due
Week 11		12/5 9-10:20am Lecture 19 11am-2pm office hours	12/6 9am-12pm office hours	12/7 9-10:20am Lecture 20 11am-2pm office hours	12/8 Homework #10 due
Final Week					12/15 Final project due

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Overall Course Expectations

What you can do to support your success in the course:	What I will do to support your success in the course:
stay current with the course progress	Be prepared and bring my enthusiasm to each lecture and office-hour session
Keep up with readings and homework assignments, as each one builds on the previous one.	Respond to emails within one working day, and provide timely feedback on assignments / submissions.
Contribute to the learning environment with fairness, cooperation, and professionalism	Establish a learning environment with fairness, cooperation and professionalism, and will take action if these principles are violated.

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Treat your classmates, instructional assistants and myself honestly and ethically	Treat you honestly and ethically, and will address any concerns you might have
Commit to excel with integrity[1]. Have the courage to act in ways that are honest, fair, responsible, respectful & trustworthy.	Uphold integrity standards and create an atmosphere that fosters active learning, creativity, critical thinking, and honest collaboration.
Manage your time, so you can stay on track with the course and complete tasks on time	Only assign work that is vital to the course, and will work to meet the standard credit hour allotment for the course.
Communicate with me if you determine that a deadline cannot be met due to extenuating circumstances	Consider requests for adjustments and will make reasonable exceptions available to all students when approved

1. Please read UC San Diego's Policy on Integrity of Scholarship and take the integrity pledge!

Diversity, Equality and Inclusion (DEI) Statement
Better science and technology development can be produced in a diversified environment where people with different backgrounds can inspire each other.

My pledge: I (YT Lin) will uphold my belief on DEI and be a role model on creating a welcome research and study environment providing services, partnership, mentorship, and education to underrepresented minority groups and everyone else.

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