ECE 45 Syllabus – Winter 2025

Course introduction

Signal processing is rich with tools that have applications in a broad class of problems including communications, controls, image compression, sonar, radar, array processing, and digital video. The theory is both elegant and beautiful. This course servers a first step in the transition from circuits to the theory of signal processing. It provides the mathematical foundations of continuous-time signal processing including the Fourier Series, Fourier Transform, and Convolution. The mathematical concepts that you will learn in this course will serve as a platform for more advanced courses in signal processing and machine learning.

Key topics for the course include the following
- Signals, systems, circuits and phasors
    - Signal transformations, periodic, even and odd, rectangle, step
    - Exponential, sinusoids, complex exponentials, phasors
    - Dirac delta, Kronecker delta, Sha function
- Linear and time-invariant systems
    - Convolution
    - Sinusoids as eigenfunctions, connection to phasors
    - Convolution properties
- Fourier series
    - Convergence
    - Transform pairs
    - Properties
- Fourier transform
    - Transform pairs
    - Properties
    - Frequency response of LTI systems
    - Multiplication and windowing
- Sampling theorem

Instructional team

Instructor: Robert W. Heath Jr.
Instructional Assistants (IAs):   Amirhosein Javad (TA), Yun Chen (TA), Zihan Ling (grader)

Brief biography of your instructor

Robert W. Heath Jr. is the Charles Lee Powell Chair in the Dept. of Electrical and Computer Engineering at the University of California, San Diego. Previously he was the Cockrell Family Regents Chair in Engineering #7 at The University of Texas at Austin and the Lampe

Distinguished Professor at the North Carolina State University. In 2011, he was elevated to IEEE Fellow for "contributions to multiple antenna wireless communications", their highest level of membership. In 2017, he was elected as a Fellow of the National Academy of Inventors, which recognizes academic inventors who have demonstrated a prolific spirit of innovation in creating or facilitating outstanding inventions that have made a tangible impact on quality of life, economic development, and the welfare of society. In 2023, he was elected as a Fellow of the American Association for the Advancement of Science, which recognizes achievements across disciplines from research, teaching and technology. He was an elected Distinguished Lecturer in the IEEE Signal Processing Society and the IEEE Vehicular Technology Society. He is also an amateur radio operator and a registered Professional Engineer in Texas.

He has considerable real-world engineering experience, including working at a wireless startup in Silicon Valley, running a consulting company MIMO Wireless Inc, and co-founding a local startup Kuma Signals LLC. He has consulting with many companies around the world and is on the technical advisory board of two startup companies.

His published approximately 800 papers including some that are among the most cited in wireless communications and signal processing. He has published four books: *Millimeter Wave Wireless Communications* (a book on the theory and practice of wireless communications at high frequencies), *Digital Wireless Communication: Physical Layer Exploration Lab Using the NI USRP* (a laboratory book on signal processing for wireless communications), *Introduction to Wireless Communications: A Signal Processing Perspective* (an undergraduate text targeted towards teaching wireless communications to undergraduates), and *Foundations of MIMO Communication* (a textbook that presents an information theoretic view of multiple antenna wireless systems).

He is among the most highly cited researchers in Electronics and Electrical Engineering, with a rank of 19 worldwide and 9 in the USA https://research.com/scientists-rankings/electronics-and-electrical-engineering. He is among the top cited research in wireless communications and signal processing. His papers have received numerous awards including the 2010 and 2013 EURASIP Journal on Wireless Communications and Networking best paper awards, the 2012 Signal Processing Magazine best paper award, a 2013 Signal Processing Society best paper award, the 2014 EURASIP Journal on Advances in Signal Processing best paper award, the 2014 Journal of Communications and Networks best paper award, the 2016 IEEE Communications Society Fred W. Ellersick Prize, the 2016 IEEE Communications Society and Information Theory Society Joint Paper Award, the 2019 IEEE Communications Society Stephen O. Rice Prize, the 2019 IEEE Kiyo Tomiyasu Award, the 2020 IEEE Signal Processing Society Donald G. Fink Overview Paper Award, the 2021 IEEE Vehicular Technology Society Neal Shepherd Memorial Best Propagation Paper Award and the 2022 IEEE Vehicular Technology Society Best Vehicular Electronics Paper Award. He was an elected member-at-large of the IEEE Signal Processing Society Board of Governors and the IEEE Communications Society Board of Governors. He will receive the 2025 IEEE / RSE James Clerk Maxwell Medal from the IEEE "for groundbreaking contributions that have had an exceptional impact on the development of electronics and electrical engineering, or related fields." Outside of teaching, Prof. Heath is interested in stand up jetskis

(where he has built two custom carbon fiber skis), snorkeling (especially in La Jolla) scuba diving, and exploring Galicia in Spain. He is also a Private Pilot, though has not been flying recently.

Course structure and modalities

Course schedule

Lectures	TuTh 3:30pm-4:50pm	LEDDN AUD
Discussions	M 10:00am-10:50am	CENTR 214
	F 12:00pm – 12:50pm	CSB 001
Office and tutoring hours	TBD	

Course communications - Piazza

We will use Piazza for all course related (non-realtime) communications. You can post questions to the entire class or to the instructional team.

Make messages private if they include (part of) your solutions or would otherwise violate the academic integrity policy. When in doubt, make your post private; we always have the option to change it to public if we feel everyone could benefit from the question. If you select "Instructors" in the 'Post to' field (rather than the entire class), only the instructor and the IAs can read these messages.

You can also send private messages on piazza by selecting specific people in the 'Post to' field. Use this to contact the individual IAs or the instructor. In that case, start the 'summary line' of the message with "Private: ". That said, unless there are unusual circumstances you should address your correspondence to "Instructors."

Do NOT use the Canvas mailing feature to contact us. We will NOT respond to those messages.

Course resources - Piazza

We will use Piazza to deliver all course-related materials in the Resources section.

Here you will find the following sections and contents.

Chapter notes – This section contains the PDFs of all the relevant chapters of the Signals & Systems book. Note that these PDFs may contain more material than we cover in the course. The lectures every week are extracted from these chapters.

Lecture notes – This section contains the PDFs of the lecture notes for each week. The notes will be posted before each lecture so you can download and annotate on your own computer or tablet.

Annotated notes – This section contains the PDFs of the lecture notes after the lecture. They will include highlights, annotations, and handwritten example problems. They will be posted after the lectures.

Discussion notes – This section contains the notes from the discussion sections. They consist mainly of some review material and solved problems.

Homework – This section contains the PDFs for the weekly homework. Aside from the first week, the homeworks will generally be due at 11:59pm on Thursdays.

Homework solutions – This section contains solutions to the homework.

General resources – Here you will find the lecture schedule for the course including the topic of the lecture and indications of the relevant material from the textbook. You will also find a version of the syllabus.

Calendar

Check the lecture schedule for the course as found in the Resources section. <u>It is your responsibility to be aware of all the deadlines and deliverables</u>.

Lectures

This course is scheduled to be in-person, in the lecture room listed on the schedule. Lectures will also be recorded via the UCSD podcast system and made accessible through a link on Canvas for asynchronous viewing.

The ECE 45 course material can be challenging. It requires the use of mathematics and developing levels of abstraction beyond circuits from ECE 35. While there is no in-class attendance requirement, I cannot urge more strongly that you attend the lectures in person. Studies consistently show that attending class in person matters.

Textbook

This course is developed to follow the textbook *Signals and Systems* by Alan Oppenheim, Alan Willsky, and S. Hamid Nawab, second edition, ISBN: 978-0138147570. The covered sections are indicated in the lecture outline. It is a great textbook that is also used in ECE 101 and is worth owning if you can afford the investment. Note that the textbook has substantial coverage of topics beyond this course – we will focus on the contents related to continuous time-signal processing from Chapters 1 to 4.

Discussions sections

There are two discussion sessions. They will have some common review material but may cover different problems. You may attend both on a space available basis. The sessions will focus on the material that is necessary for the homework for the following week (with Friday / Monday covering the material for the homework that is due on Thursday). Come prepared to solve problems and ask questions. We will endeavor to record the discussions, but the quality of podcasts is far from guaranteed as we may be using the blackboard.

Office hours

The Instructional Assistants (TAs) will also hold office hours to help you with the material. The detailed schedule is TBD and will be finalized the first week of class.

Grading

Breakdown

Homework = 10%
Midterm 1 = 25%
Midterm 2 = 25%
Final exam = 40%

One of your midterm scores will be replaced with the final if and only if it helps your grade. I grade this way so that you are afforded room for error: if you bomb a midterm, there is ample opportunity to make up for it on the final and with your other midterm scores.

Exams

Two midterm exams will be held in class as indicated in the lecture outline. The final exam will occur during the timeslot indicated based on information from the UC San Diego Registrar. **No notes are allowed**, but we will provide a formula sheet. For the exams, the grading rubrics focus on testing your mastery of the fundamental concepts and your ability to apply them.

Homework

Assignments will be handled via Gradescope. Go to Gradescope to find the PDF of questions. Except for the first week, your homework solutions are due Thursday night at 11:59 pm (23:59). We will release solutions and a new homework the day after homework is due. No late homework will be accepted without prior approval by the teaching staff.

Homework will be graded on effort only. These problems are for you to **practice** so you are ready for the exams.

To receive full credit on each assignment, please **submit to Gradescope one PDF that contains the following**. Note that you must mark the correct regions for each problem.
Your genuine attempt on all problems from this week's problem set. If you're stuck, at least write out what you're thinking. This is worth 75%.

Annotated corrections to your previous week's incorrect problems homework. For any correct answers, please simply put a check mark by the problem to indicate that you got it right. If you did not complete a problem or need more space, you can submit a new solution to the question. This is worth 25%.

Academic integrity

Integrity of scholarship is essential for an academic community. The University expects that both faculty and students will honor this principle and in so doing protect the validity of University intellectual work. For students, this means that all academic work will be done by the individual to whom it is assigned, without unauthorized aid of any kind.

Cheating, plagiarism and any other form of academic dishonesty **will not be tolerated**. This includes cheating on exams, using resources that are not allowed, copying assignments, lying to tutors/TAs or the instructor, aiding in plagiarism or cheating, or any form of dishonesty including impersonating someone else on the lab attendance sheet, impersonating someone else in student polling or voting remotely (i.e., misrepresenting yourself with respect to class attendance). Never claim work/ideas to be yours if they are not, and never assist others in cheating (e.g. by offering them your solutions). Do not post solutions, even after you have finished the course. Collaborating with other students to develop, complete or correct course work is limited to activities explicitly authorized by the Instructor. Use of other students' course work, in part or in total, to develop, complete or correct course work is unauthorized. If you are not sure of what is allowed, ask the instructor. Wrong assumptions are never an excuse.

Each student is responsible for knowing and abiding by UCSD's policies on Academic Dishonesty and on Student Conduct. Any student violating UCSD's Academic Dishonesty or UCSD's Student Conduct policies risks an F in the course and will be reported to their college Dean for administrative processing. Committing acts that violate Student Conduct policies that result in course disruption are cause for suspension or dismissal from UCSD. For more information, check out the UCSD Academic Integrity website.

Prerequisites
Make sure you satisfy the formal prerequisites for this course. It is extremely important that you are proficient in the material from ECE 35, including the relevant mathematical foundations in calculations, trigonometry, and complex numbers. One of the main reasons students fail in the major is the lack of sufficient mastery of math.

Getting additional help

ECE tutoring
The ECE tutoring center has a number of tutors to help you with a variety of core ECE classes. For more information, check out the ECE tutoring website.

IDEA center

The IDEA Engineering Student Center is a hub for student engagement, academic enrichment, personal/professional development, leadership, community involvement, and a respectful learning environment for all. It offers a variety of programs: http://idea.ucsd.edu/.

CAPS

Counseling and Psychological Services offers confidential counseling to students free of charge and has a 24-hour crisis line available at 858-534-3755.

Course policies

Regrade policy

For all regrade requests for ECE 45, the deadline is exactly one week from the moment the grades are posted. Regrade requests result in us looking at the entire assignment (so it is possible you gain points but you might also lose points). Regrade requests are for situations where we made an error in the grading. Since homework grading is effort-based, it is expected that regrade requests will be primarily used for exams. All requests will be made through Gradescope.

Recordings

This course uses video and audio recording or other personal information for the purpose of facilitating the course/class/meeting. The lectures and discussions are recorded. UC San Diego does not allow vendors to use this information for other purposes. If cheating is suspected, the recording may become part of the student's administrative disciplinary record.

Attendance policy

Attendance in the lectures is highly encouraged. We are creating an active learning environment, and 'attendance' does not simply mean being physically present; it involves being mentally present and having an active participation. Being engaged in class is crucial for your own learning, but also for that of your fellow classmates. It only works if everyone is committed to be truly present and to actively participate.

Late work policy and missing exams

There are no make-ups for exams. No late work will be accepted. Homework assignments will have strict deadlines. Since the assignments are effort based, it should not be a problem to meet the deadlines.

Professionalism policy

Please attend to all university policy and class etiquette procedures. Please be attentive, and respectful. Do not disrupt the lectures, act inappropriately, or exhibit other unprofessional behavior. Those not heeding the policies will be removed from the lecture, discussion or lab, so

as to not disrupt the learning environment. Habitually engaging in this behavior may result in a reduction in the final class grade (at the complete discretion of the instructor). Harassment or abuse of any kind will not be tolerated, and could lead to expulsion from the class, as well as official reporting (see also Title IX Compliance).

Title IX compliance

Title IX of the Education Amendments of 1972 is the federal law that prohibits sex discrimination in educational institutions that are recipients of federal funds. The University recognizes the inherent dignity of all individuals and promotes respect for all people. Sexual misconduct, physical and/or psychological abuse will NOT be tolerated. If you have been the victim of sexual misconduct, physical and/or psychological abuse, we encourage you to report this matter promptly. As a faculty member, I am interested in promoting a safe and healthy environment, and should I learn of any sexual misconduct, physical and/or psychological abuse, I must report the matter to the Title IX Coordinator. This does not necessarily mean that a formal complaint will be filed.

If you find yourself in an uncomfortable situation, ask for help. Should you want to speak to a confidential source you may contact the Counseling Center. The Office for the Prevention of Harassment & Discrimination (OPHD) provides assistance to students, faculty, and staff regarding reports of bias, harassment, and discrimination. Students have options for reporting incidents of sexual violence and sexual harassment. Sexual violence includes sexual assault, dating violence, domestic violence, and stalking. Information about reporting options may be obtained at OPHD at (858) 534-8298, ophd@ucsd.edu or http://ophd.ucsd.edu. Students may receive confidential assistance at CARE at the Sexual Assault Resource Center at (858) 534-5793, sarc@ucsd.edu or http://care.ucsd.edu or Counseling and Psychological Services (CAPS) at (858) 534-3755 or http://caps.ucsd.edu.

Disability access

Students requesting accommodations for this course due to a disability must provide a current Authorization for Accommodation (AFA) letter issued by the Office for Students with Disabilities (OSD). You need to contact me at least one week before a test or exam so that accommodations may be arranged.

Contact the OSD for further information:
858.534.4382 (phone)
osd@ucsd.edu(email)
http://disabilities.ucsd.edu(website)

Grades of "Incomplete"

The current university policy concerning incomplete grades will be followed in this course. Incomplete grades are given only in situations where someone currently has a passing grade (based on the completed work, which assumes the final will not replace any of the other grade components) and unexpected emergencies prevent them from completing the course and the

remaining work can be completed the next quarter. The instructor is the final authority on whether you qualify for an incomplete.

Satisfactory academic progress

Satisfactory Academic Progress (SAP) refers to the academic standards students must maintain to remain eligible for federal, state, and institutional financial aid. If you are receiving financial aid, please ensure you review the SAP requirements and the appeals process.

Religious observances

Students are expected to notify their instructor at least a week in advance if they intend to miss class to observe a holy day of their religious faith.

Acknowledgements

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