ELEG 305 Signals and Systems

Credits: 3, Semester: Spring, Year: 2022
Lecture (-10 and -80): Tuesday and Thursday 12:30–1:45 p.m.
Discussion (-20D and -80D): Monday 12:20–1:10 p.m.
Add-on Honors Discussion (-80D): Wednesday 12:20–1:10 p.m.

		Campus Location
Monday 12:20	Discussion	Memorial 108
Tuesday 12:30	Lecture	Smith 120
Wednesday 12:20	Honors Discussion	Colburn 109
Thursday 12:30	Lecture	Smith 120
M-F 2–3:15	Office Hours	Location varies

	M	Tues.	W	Thurs.	F
12:20					
12:30			Add-on Honors Discussion		
1:10	Discussion				
1:45		Lecture		Lecture	
2		Dr. B Office Hours		Dr. B Office Hours	
2:30					
3:15	Mohammad Zoom Hours	Zahra Office Hours	Prof. Cimini Office Hours	Mohammad Zoom Hours	Zahra Office Hours

Table of Contents

1. Instructor Information

Instructor Contact Information

Instructor: Austin J. Brockmeier, Ph.D.
(prefers Dr. Brockmeier/Prof. Brockmeier; he/him)

Email address: ajbrock@udel.edu
Office hours: Tues./Thurs. 2–2:30
Office: Evans Hall, 3rd floor, Room 306

Instructor: Leonard J. Cimini, Jr., Ph.D.
(prefers Prof. Cimini; he/him)

Email address: cimini@udel.edu
Office hours: W 2–3:15 p.m.
Office: Evans Hall, 2nd floor, Room 217A
Available remotely at other times, please email.

Teaching Assistant(s) Contact Information

Teaching Assistant: Mohammad Towliat (prefers Mohammad; he/him)

Email address: mtowliat@udel.edu
Zoom hours: M 2–3:15, Thurs. 2:30–3:15

Teaching Assistant: Zahra Vahdat (prefers Zahra; she/her)

Email address: zahravd@udel.edu
Office hours: Tues. 2:30–3:15, F 2–3:15
Office: Evans Hall, 3rd floor, Room 310

	M	Tues.	W	Thurs.	F
2:00 2:30		Dr. B Office Hours - Evans 306		Dr. B Office Hours - Evans 306	
3:15	Mohammad Office Hours @ Zoom	Zahra Office Hours - Evans 310	Prof. Cimini Office Hours - Evans 217A	Mohammad Hours Office Hours @ Zoom	Zahra Office Hours - Evans 310

2. Course Description

Description

Introduction to signals and systems, with an emphasis on time and frequency characterization of linear, time-invariant systems. Covers discrete and continuous time systems, sampling, and Fourier, Laplace, and Z transforms. Topics include:

- Operations on and properties of signals
- Basic characteristics of systems
- Impulse response
- Convolution
- Difference and differential equations
- Laplace transform
- Fourier series and transform
- Frequency response of systems
- Modulation
- Sampling
- Discrete-time Fourier transform
- Z transforms

The course relies heavily on mathematical techniques but emphasizes the engineering aspects of the design and analysis of physical—electrical, acoustic, and mechanical—and digital systems and signals. Key skills include graphing signals and system transfer functions in different domains, drawing and interpreting block diagrams and analytic expressions of systems, and implementing numerical representations of signals and systems using MATLAB.

Learning outcomes can be succinctly stated as the mathematical and numerical analysis and visualization of signals and systems, for both discrete and continuous time, in frequency and transform domains, and the role and design of sampling.

"Signals and Systems" is a required course for computer and electrical engineering majors. The content assumes a previous introduction to programming and familiarity of electrical circuits with resistors, capacitors, and inductors introduced in the study of electrical circuits seen in "Fundamentals of Physics II" or "Analog Circuits I". Equivalent experience with mechanical systems and biological processes should suffice.

"Signals and Systems" is a prerequisite for "Digital Signal Processing", "Digital Control", "Digital Imaging and Photography", "Communication Systems Engineering", and "Radar Systems". These courses cover the engineering principles and techniques for communication, sensing and processing, and control of dynamical systems. There is a related vertically integrated project "Acoustics & Signal Processing".

The concepts introduced in "Signals and Systems" are fundamental to machine learning, computer vision, speech recognition, autonomous robotics, and artificial intelligence, emerging topics such as quantum communication and computing, and computer and network design including physical security.

The course content is applicable to various contexts of sensors and systems, including biomedical equipment; climate and environmental monitoring; remote sensing of weather, oceans, agriculture, transportation, infrastructure, and urban activity; acoustic, audio, and sound engineering for music and fine arts. Additionally, the concepts are useful for understanding human and animal senses, perception, and communication.

Grasping the mathematical concepts and intuition in "Signals and Systems" may be challenging, but the benefit is that once learned these concepts can be applied throughout computing, engineering, and science fields.

Prerequisites

MATH 242 Analytic Geometry and Calculus B: functions and their inverses (especially logarithm/exponential), derivatives and integrals of univariate functions on the real line, conversion between rectangular and polar coordinates, sequences and series, convergent series, elementary differential equations
ELEG 205 *{for ELEG or CPEG Majors}:* complex numbers, alternating current, power analysis, transfer functions

Course Delivery

1st Week: Online synchronous. (Zoom Links)
- Discussions and lectures may involve active participation (polls, quizzes and/or breakout rooms).
- Recorded lectures and discussions will be posted to Canvas within a few days.

Rest of semester: In-person.
- In-person discussions and lectures involve active participation (polls, quizzes and/or team work).
- Typically, recorded lectures and discussions will be posted to Canvas within a few days.

	M	Tues.	W	Thurs.	F

Time					
12:20	Discussion - Memorial 108		Add-on Honors Discussion - Colburn 109		
12:30		Lecture - Smith 120		Lecture - Smith 120	
2:00		Dr. B Office Hours - Evans 306		Dr. B Office Hours - Evans 306	
2:30					
	Mohammad Office Hours @ Zoom	Zahra Office Hours - Evans 310	Prof. Cimini Office Hours - Evans 217A	Mohammad Hours Office Hours @ Zoom	Zahra Office Hours - Evans 310

Student Engagement and Effort

- Students are encouraged to take their own hand-written notes during lectures to maintain attention.
- Students are expected to spend sufficient class time to read the textbook, review the notes, and perform homework exercises for submission.
- Group work will be required for certain assignments (this will require coordination outside of class time) and not permitted in other situations (take-home exams).
- MATLAB will be used as a numerical programming language for signal processing and analysis. There will be additional assignments that require computer programming and plotting, and digital submission of legible code, scripts, and results in reports.
- Plan to spend on average 9+ hours per week for competency.

3. Learning Outcomes

ABET Outcomes:
(1)   An ability to identify, **formulate**, and **solve** complex engineering problems by applying principles of **engineering**, **science**, and **mathematics**.
   (1.5)   Apply knowledge of science and math towards problems in **signal processing** and **communications**

Learning Outcomes:
1. Analyze, relate, and visualize signals—Recognize properties of signals and convert between their mathematical, graphical, and numerical representations.
2. Characterize and represent systems—Analyze systems (and their effect on idealized inputs) whether they are expressed analytically through formula, code, or depicted as block diagrams, and convert between equivalent representations.
3. Compute system responses—Describe the effect of various transformations in different domains (time, frequency, etc.) on signals, especially computing the output of linear time-invariant systems.
4. Determine sampling and analog-to-digital conversion parameters—Choose an appropriate sampling rate and filtering in order to uniquely preserve the information of bandlimited signals and describe the consequences of undersampling (aliasing).
5. Analyze filters—Calculate the magnitude and phase response and analyze the properties of basic filters in continuous and discrete-time using appropriate transforms.
6. Numerical programming for signal processing—Use modern programming languages to describe signals and systems for computer-based analysis, processing, and visualization.

4. Learning Resources

Required Learning Materials

OWN: *Signals and Systems*, 2nd Ed., A. V. **O**ppenheim and A. S. **W**illsky, with S. H. **N**awab, Pearson Education, Upper Saddle River, NJ, 1997, ISBN: 978-0138147570.

Schaum's: *Schaum's Outlines Signals and Systems*, 4th Ed., Hwei P. Hsu, McGraw-Hill Education, New York, NY, 2017, ISBN: 978-1260454246.
(3rd edition is equivalent)

Suggested Learning Materials

Paper: Engineering or computation paper (UD bookstore or Amazon)
Pencil: Much better for hand drawn plots. Engineers revise and improve.

Technology

Canvas: In this class, Canvas, UD's online learning management system, will be used for most course activities and communication channels. All assignments will be posted through the Canvas course site unless otherwise directed.

Information on how to use Canvas is available through the Canvas Student Guide.

Canvas can also be accessed via MyUD.

Computer access for programming assignments. MATLAB/Octave (MATLAB is on College of Engineering eCALC machines available streaming; via AppsAnywhere for Windows based machines; via AppsAnywhere using virtual machine application or browser-based access); Octave is an open-source clone of MATLAB that can be run on various platforms;
Later assignments can be completed in NumPy is Python library for numerical computation that based a large part of their syntax on MATLAB

A scanner or digital camera (on a mobile phone possibly) to capture handwritten work from homework in digital form, and software or applications to convert them to readable PDFs.

Additional Tutoring Resource

HKN (Eta Kappa Nu) is an IEEE associated honor society for ECE majors: they typically offer group tutoring one night a week with pizza. Please reach out to HKN leaders Susie sarno@udel.edu or Prof. Cimini cimini@udel.edu There is also central tutoring resources (Office of Academic Enrichment) for paired and paid tutoring

Asynchronous Learning Resources

"Signals and Systems" from MIT Open Courseware high degree of overlap and uses the same book
"Signals and Systems - Flipped" from Prof. Mark Fowler at Binghamton University

5. Learning Assessment

Final Grade Breakdown

The final course grade will be calculated using the following components:

Course Component	Percentage of Total
Homework Assignments	10
Quizzes/Participation (bonus from in-class polls and group cooperation)	10
Computer Assignments	20
Out-of-class Exams: exam 1 (10%), exam 3 (10%)	20
In-Class Exams: exam 2 (10%) and Final (30%)	40

Homework Assignments

Homework assignments assessed for completion, competency, and mastery. Assigned weekly, one compiled set of solutions for each group (one solution per problem) should be clearly handwritten on engineering paper or a tablet (perhaps using engineering rule: digital template PDF) or typed when appropriate, each page labeled, and uploaded as PDF with a cover sheet to Canvas. Please see the TAs' homework guidelines on Canvas.

The goal is practice the skills and techniques involving the concepts discussed in lecture. Doing, rather than simply watching, is the best way to learn, and there are no shortcuts to practice.

If students are not satisfied with their homework grades, they will have a chance to improve their grades by submitting a revised version to the teaching assistants.

Participation

There will be a quiz following each homework assignment due date. Additionally there will be participation bonus points for in-class polls that are multiple choice judged by participation only.

Computer Assignments

Completion of MATLAB Grader Assignments, and at least two problem-based assignments assessed for correctness, completeness, and clarity.

Exams

- Exam 1, take-home, (10%)
- Exam 2, in-class, (10%)
- Exam 3, take-home, (10%)
- Final Exam, in-classroom during finals week, (30%)

Out-of-class exams to assess and deepen the understanding of key concepts and demonstrated key skills. In-class exams to assess mastery of learning outcomes.

Grading Scale

Important Note: UD does not have a required grading scale to relate your grade in Canvas with your final letter grade. The final scale for this course in this semester will be posted before the final exam. A **tentative grading scale** will award an A to those who earn 95% or more of the possible points, A- to those who earn 90% or more, and so on until a C- for the interval [60,65). The range for Ds will be constricted as a C- in minimum grade for ECE majors to count toward the major requirements.There may be opportunities for extra credit at times during the semester. Typically these include the submission of essays covering science or engineering topics, including those covered in seminars and articles related to signals and systems or previews of technical electives related to the course content.

6. Course Calendar

Date	Event
Mon. 2/7	1st remote (Zoom) discussion 12:20–1:10
Tues. 2/8	1st remote (Zoom) lecture 12:30–1:45
Mon. 2/14	1st in-person discussion 12:20–1:10
Tues. 2/15	1st in-person lecture 12:30–1:45
Fri. 2/18	Last day for drop/add without financial implications and without receiving a "W" on permanent record
Tues. 3/15	Exam 1 (out of class) assigned at end of lecture
Fri. 3/25	Midterm grades due; Spring break starts
Mon. 4/4	Week after spring break
Thurs. 4/7	Exam 2 (in class)
Mon. 5/2	Deadline to withdraw from course without academic penalty
Tues. 5/10	Exam 3 (out of class) assigned at end of lecture
Tues. 5/17	Last lecture
Mon. 5/23	Final exam 1–3pm (same room as lecture: Smith 120)
Tue. 5/31	Spring semester grades due

7. Course Policy Document

Course Specific Policies

The Safety of Our Learning Environment

Student learning can only occur when students and their instructors feel safe, respected, and supported by each other. To ensure that our learning environment is as safe as possible, and In keeping with CDC guidelines to slow the transmission of COVID-19 and the University of Delaware's Return to Campus Guidelines (Health and Safety Section), we will adhere to the practice of wearing face masks and cleaning your seat and desk area at the beginning of class.

This means that you:
● Must wear a cloth mask that covers your nose and mouth
● Must not eat or drink in class
● Upon entering the classroom, wipe down your seat and desk area
As necessary, the University may announce modifications to these practices. In that event, these guidelines will be updated to reflect those modifications.

Attendance

Absences on religious holidays listed in university calendars are recognized as an excused absence. Nevertheless, students are urged to remind the instructor of their intention to be absent on a particular upcoming holiday. Absences on religious holidays not listed in university calendars, as well as absences due to athletic participation or other extracurricular activities in which students are official representatives of the university, shall be recognized as excused absences when the student informs the instructor in writing during the first two weeks of the semester of these planned absences for the semester.

Communication

Preference for course related questions is discussion and office hours. Otherwise please email the instructor and/or the teaching assistants at your discretion. This could include scheduling additional office hours if you have conflicts.

Student Mental Health & Wellbeing

In addition to impacting your overall well being, diminished mental health can interfere with optimal academic performance. If this course is causing or contributing significant mental or emotional stress, then please reach out to me directly. However, problems with other parts of your life can also contribute to decreased academic performance. UD's Center for Counseling & Student Development (CCSD) provides cost-free and confidential mental health services to help you manage personal challenges that threaten your emotional or academic well-being. Remember, getting help is a smart and courageous thing to do -- for yourself and for those who care about you.
● Contact me
  ○ If you are struggling with this class, please check-in during office hours or contact me by email at ajbrock@udel.edu
● Check-in with your academic advisor
  ○ If you are struggling in multiple classes, unsure whether you are making the most of your time at UD, or unsure what academic resources are available at UD.
● UD's Center for Counseling & Student Development and UD Helpline
  ○ CCSD is open and available remotely, and 24/7 mental health support remains available on the UD Helpline at 302-831-1001 for any student in need of someone to talk to. Visit CCSD's website for additional information and resources.
● UD's Crisis Text Line
  ○ Text "UDTEXT" or "STEVE" at 741741 for students of color to connect with confidential text message support.
● Division of Student Life
  ○ Explore the Student Life's Wellbeing webpage for a comprehensive listing of well-being resources, activities and services available to all students.

UD Policies

UD Student Code of Conduct has a provision (A.1.d.vii) which states: "Academic misconduct includes, but is not limited to:…**Posting of notes or other materials from a class (whether the student is enrolled in the class or not) on the Internet, whether or not for a fee, without express permission from the faculty member.**"

Academic Integrity

Please familiarize yourself with UD policies regarding academic dishonesty. To falsify the results of one's research, to steal the words or ideas of another, to cheat on an assignment, to re-submit the same assignment for different classes, or to allow or assist another to commit these acts corrupts the educational process. Students are expected to do their own work and neither give nor receive unauthorized assistance. Complete details of the university's academic integrity policies and procedures can be found at sites.udel.edu/studentconduct/sgup/ Office of Student Conduct, 218 Hullihen Hall, (302) 831-2117. E-mail: student-conduct@udel.edu

Harassment and Discrimination

The University of Delaware works to promote an academic and work environment that is free from all forms of discrimination, including harassment. As a member of the community, your rights, resource and responsibilities are reflected in the non-discrimination and sexual misconduct policies. Please familiarize yourself with these policies at www.udel.edu/oei . You can report any concerns to the University's Office of Equity & Inclusion, at 305 Hullihen Hall, (302) 831-8063 or you can report anonymously through UD Police (302) 831-2222 or the EthicsPoint Compliance Hotline at www1.udel.edu/compliance. You can also report any violation of UD policy on harassment, discrimination, or abuse of any person at this site: sites.udel.edu/sexualmisconduct/how-to-report/

Faculty Statement on Disclosures of Instances of Sexual Misconduct

If, at any time during this course, I happen to be made aware that a student may have been the victim of sexual misconduct (including sexual harassment, sexual violence, domestic/dating violence, or stalking), I am obligated by federal law to inform the university's Title IX Coordinator. The university needs to know information about such incidents to, not only offer resources, but to ensure a safe campus environment. The Title IX Coordinator will decide if the incident should be examined further. If such a situation is disclosed to me in class, in a paper assignment, or in office hours, I promise to protect your privacy--I will not disclose the incident to anyone but the Title IX Coordinator.

For more information on Sexual Misconduct policies, where to get help, and reporting information, please refer to www.udel.edu/sexualmisconduct. At UD, we provide 24/7/365 crisis assistance and victim advocacy and counseling. Contact 302-831-1001 to get in touch with a sexual offense support advocate, as well as confidential and anonymous counseling services for other concerns.

Accommodations for Students with Disabilities

Any student who thinks he/she/they may need an accommodation based on a disability should contact the Office of Disability Support Services (DSS) office as soon as possible. Students who have documentation of their need for accommodation should register via the SAM platform: andes.accessiblelearning.com/UDEL/. Reach DSS in the following ways: Phone: 302-831-4643, fax: 302-831-3261, DSS website. Email: dssoffice@udel.edu or visit at 240 Academy Street, Alison Hall Suite 130.
During COVID-19, Disability Support Services staff are available remotely. Please call 302-831-4643 during business hours (8-5 M-F) or email dssoffice@udel.edu for assistance.

Non-Discrimination

The University of Delaware does not discriminate against any person on the basis of race, color, national origin, sex, gender identity or expression, sexual orientation, genetic information, marital status, disability, religion, age, veteran status or any other characteristic protected by applicable law in its employment, educational programs and activities, admissions policies, and scholarship and loan programs as required by Title IX of the Educational Amendments of 1972, the Americans with Disabilities Act of 1990, Section 504 of the Rehabilitation Act of 1973, Title VII of the Civil Rights Act of 1964, and other applicable statutes and University policies. The University of Delaware also prohibits unlawful harassment including sexual harassment and sexual violence.