

## ECE445S Real-Time Digital Signal Processing Lab (Spring 2024)

Lecture:	MW 10:30am–12:00pm in ECJ 1.312
Instructor:	Prof. Brian L. Evans, bevans@ece.utexas.edu (He/His/Him)
Office Hours:	MW 2:00–3:30pm in EER 6.882 and immediately after lecture
Lab Sections:	M 6:30–9:30pm (Barati) T 5:00–8:00pm (Barati)
(EER 1.810)	W 6:30–9:30pm (Eun) F 1:00–4:00pm (Eun)
TA Office Hours:	Mr. Faraz Barati (he/him), W 4:30–6:00pm, TH 3:00–4:30pm
	Mr. Yongjin Eun (he/him), TH 4:30–6:00pm, F 5:00–6:30pm
TA E-mail:	faraz.barati@utmail.utexas.edu and ye2259@utmail.utexas.edu
Course Web Page:	<a href="http://users.ece.utexas.edu/~bevans/courses/realtime">http://users.ece.utexas.edu/~bevans/courses/realtime</a>

This course covers discrete-time signal processing algorithms and translating them into system simulations and embedded real-time software. A goal is to understand design tradeoffs in signal quality vs. run-time implementation complexity. Applications include audio, communications, and image processing. Great way to build breadth and depth in signal processing.

### Prerequisites

ECE312/312H C Programming and 319K/319H Intro to Embedded Systems with a grade of at least C- in each; BME343 or ECE313 Signals and Systems with a grade of at least C-; credit with a grade of at least C- or registration for BME/ECE333T Engineering Communication; and credit with a grade of at least C- or registration for BME335/ECE351K Probability.

### Topical Outline

Digital signal processing algorithms; simulation and real-time implementation of audio and communication systems; filters; pulse shaping and matched filters; modulation and demodulation; adaptive filters; carrier recovery; symbol synchronization; equalization; quantization.

### Order of Lecture Topics

Sinusoidal Generation - Signals & Systems - Finite Impulse Response Filters - Infinite Impulse Response Filters - Sampling & Aliasing - Interpolation & Pulse Shaping - Digital Pulse Amplitude Modulation (PAM) - Channel Impairments - Matched Filtering - Digital Quadrature Amplitude Modulation (QAM) - Quantization - Data Conversion

### Order of Laboratory Topics

Simulation Tools - Sinusoidal Generation - Filters - Pseudonoise Sequences & Data Scramblers - Digital PAM Transceivers - Digital QAM Transceivers - Guitar Effects

### Required Textbooks

1. C. R. Johnson Jr., W. A. Sethares and A. G. Klein, *Software Receiver Design*, Oct. 2011, ISBN 978-0521189446. Paperback. Matlab code. Free Download from UT Libraries.
2. C. Unsalan, M. E. Yucel, and H. D. Gurhan, *Digital Signal Processing using Arm Cortex-M based Microcontrollers*, Arm Educational Media, Sep. 14, 2018, ISBN 978-1-911531-15-9, 354 pages. Request free download.
3. B. L. Evans, *ECE445S Real-Time DSP Lab Course Reader*. Free download.

### Supplemental Text

4. J. H. McClellan, R. W. Schafer, and M. A. Yoder, *Signal Processing First*, ISBN 978-0130909992, 2003. On-line demonstrations.

### Grading

14% Homework, 20% Midterm #1, 20% Midterm #2, 5% In-Lecture Work, 5% Pre-lab quizzes, 36% Lab reports. Lab work is performed in person; lab attendance and participation is required and comprises 25% of the lab report grade. In-class midterm exams are on Wednesday, Mar. 6th, and Monday, Apr. 29th. There is no final exam.

Assignment of letter grades is below; no rounding will be applied. Although there aren't any extra credit assignments, other options for flexibility are described next.

90.00–100.00	A	86.67–89.99	A-	83.34–86.66	B+
80.00–83.33	B	76.67–79.99	B-	73.34–76.66	C+
70.00–73.33	C	66.67–69.99	C-	etc.	

### Flexibility

Each student will be able to drop the lowest grade in each of the following categories: homeworks, in-lecture assignments, pre-lab quizzes, and lab reports. This will give flexibility when something unexpected happens not covered by these policies, and allow you to strategically use grade drops to balance your course workload and other commitments. Please let me know if you face difficulties this semester in accessing course resources or completing work.

### Critical Thinking

I am interested in the critical thinking process you use when solving a problem. Please provide rationale and justification. For homework and exams, I use the following rubric:

- 3/3 points. Correct rationale/justification and correct results
- 2/3 points. Correct rationale/justification but incorrect results.
- 1/3 points. Some progress; errors in rationale/justification even if results are correct.
- 0/3 points. Answer is blank, or only repeated/reworded the question, or gave an incorrect answer without justification, or never really “got going” towards a solution.

### Regrade Requests

Request for regrading an assignment must be made in writing within one (1) week of the graded assignment being made available to students in the class.

### Learning and Growth

Throughout the course, your learning and growth in theory and practice of the engineering profession are important to me. We all need accommodations because we all learn differently, and the current pandemic makes accommodations all the more important. If there are aspects of this course that prevent you from learning or exclude you, please let me know as soon as possible. Together we will develop strategies to meet your needs and course requirements. I also encourage you to reach out to the resources available through UT. Many are on this syllabus. I am happy to connect you with a person or Center if you would like.

### Use of AI Generated Content

This course encourages students to explore the use of generative artificial intelligence (GAI) tools such as ChatGPT for all assignments and assessments, except for the two midterm

exams. Any such use must be appropriately acknowledged and cited. It is each student's responsibility to assess the validity and applicability of any GAI output that is submitted; you bear the final responsibility. Violations of this policy will be considered violations of the campus academic integrity. We draw your attention to the fact that different classes at UT Austin could implement different AI policies, and it is the student's responsibility to conform to expectations for each course. The use of generative artificial intelligence tools on two midterm exams is prohibited.

Examples of Content Input-and Output AI Generation with Associated Tools:

<b>Content Input-Output</b>	<b>Tool</b>
Text In, Text Out	ChatGPT, GPT-3, GPT-4
Text In, Image Out	DALL-E, Midjourney, Stable Diffusion
Image In, Text Out	GPT-4, BLIP
Text In, Video Out	RunwayML, Decorum
Multimedia In, Image Out	Stable Diffusion, Midjourney, Deforum
Parameters In, Audio (Music) Out	Boomy, AIVA

### Academic Integrity

Discussion of homework questions is encouraged. Please submit your own independent homework solutions, lab 1 and 7 reports, pre-lab quizzes, and midterm exams. For labs 2–6, students work in teams of two, and each team would submit one report. Collaboration is allowed for in-lecture assignments, but each person must submit their own assignment. For all homework, in-lecture assignments, and lab reports, cite your sources of information. When providing answers on midterm exams, be sure to cite your sources of information as part of your justification for your answers.

Each student is expected to abide by the UT Honor Code: “As a student of The University of Texas at Austin, I shall abide by the core values of the University and uphold academic integrity.” If you use words or ideas that are not your own (or that you have used in a previous class), you must cite your sources. Otherwise, you might be in violation of the university's academic integrity policies. Please see Student Conduct and Academic Integrity.

### Texas Senate Bill 17

Texas Senate Bill 17, the recent law that outlaws diversity, equity, and inclusion programs at public colleges and universities in Texas, does not in any way affect content, instruction or discussion in a course at public colleges and universities in Texas. Expectations and academic freedom for teaching and class discussion have not been altered post-SB 17, and students should not feel the need to censor their speech pertaining to topics including race and racism, structural inequality, LGBTQ+ issues, or diversity, equity, and inclusion.

### Use of Electronics

Please focus the use of electronics on the content during lecture and lab sessions to maximize your own learning and support the learning environment for others.

### Video Recordings

Video recording of class activities are reserved for students and TAs in this class only for educational purposes and are protected by FERPA laws if any students are identifiable in

the video. Video recordings should not be shared outside the class in any form. Students violating this university policy could face misconduct proceedings.

### **Food Pantry and Career Clothes Closet**

UT Outpost (UA9 Building, 2609 University Avenue) is equipped with a food pantry, and a career clothing closet, to ensure every Longhorn has access to professional clothes for job and internship interviews. Emergencies and financial hardships can interfere with student success beyond the classroom, and this program will serve as an additional resource for students. This resource is from Student Emergency Services in the Office of the Dean of Students.

### **Disability and Access**

The university is committed to creating an accessible and inclusive learning environment consistent with university policy and federal and state law. Please let me know if you experience any barriers to learning so I can work with you to ensure you have equal opportunity to participate fully in this course. If you are a student with a disability, or think you may have a disability, and need accommodations please contact Disability & Access (formerly Services for Students with Disabilities). Here are some examples of the types of diagnoses and conditions that can be considered disabilities: Attention-Deficit/Hyperactivity Disorders (ADHD), Autism, Blind & Visually Impaired, Brain Injuries, Deaf & Hard of Hearing, Learning Disabilities, Medical Disabilities, Physical Disabilities, Psychological Disabilities and Temporary Disabilities. Please refer to the D&A website for contact and more information. If you are already registered with D&A, please deliver your Accommodation Letter to me as early as possible in the semester so we can discuss your approved accommodations and needs in this course.

### **Mental Health Counseling**

College can be stressful and sometimes we need a little help. Luckily, we have a wealth of resources and dedicated people ready to assist you, and treatment does work. The Counseling and Mental Health Center provides counseling, psychiatric, consultation, and prevention services that facilitate academic and life goals and enhance personal growth and well-being. Counselors are available Monday-Friday 8am-5pm by phone (512-471-3515) and Zoom.

Alternatively, you can talk to Ms. Alexandra Okeke, LPC, right here in the College of Engineering. Ms. Okeke is our CARE Counselor and she can be reached at 512-471-3741.

If you are experiencing a mental health crisis (e.g. depression or anxiety), please call the Mental Health Center Crisis line at 512-471-CALL(2255). Call even if you aren't sure you're in a full-blown crisis, but sincerely need help. Staff are there to help you.

### **Student Rights and Responsibilities**

- You have a right to a learning environment that supports mental and physical wellness.
- You have a right to respect.
- You have a right to be assessed and graded fairly.
- You have a right to freedom of opinion and expression.
- You have a right to privacy and confidentiality.
- You have a right to meaningful and equal participation, to self-organize groups to improve your learning environment.

- You have a right to learn in an environment that is welcoming to all people. No student shall be isolated, excluded or diminished in any way.

With these rights come responsibilities, you are responsible for

- taking care of yourself, managing your time, and communicating with the teaching team and others if things start to feel out of control or overwhelming.
- acting in a way worthy of respect and respectful of others.
- creating an inclusive environment and speaking up when someone is excluded.
- holding yourself accountable to these standards, holding each other to these standards, and holding the teaching team accountable as well.

Your experience with this course is directly related to the quality of the energy that you bring to it, and your energy shapes the quality of your peers' experiences.

### **Personal Pronoun Use**

Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with differences of race, culture, religion, politics, sexual orientation, gender, gender expression, gender variance, and nationalities. Class rosters are provided to the instructor with the student's legal name, unless they have added a "preferred name" with the Gender and Sexuality Center. Canvas provides an opportunity to select a pronoun preference. I will gladly honor your request to address you by a name that is different from what is on the roster, and by the gender pronouns you use (she/he/they/ze, etc).

### **Official Correspondence**

UT Austin considers e-mail as an official mode of university correspondence. You are responsible for following course-related information on the course Canvas site.

### **Q Drop Policy**

If you would like to drop a class after the 12th class day, you'll need to execute a Q drop before the Q-drop deadline, which is Monday, April 4th. Under Texas law, you are only allowed six Q drops while you are in college at any public Texas institution. More information.

### **Religious Holy Days**

In accordance with section 51.911 of the Texas Education code and University policies on class attendance, a student who misses classes or other required activities, including examinations, for the observance of a religious holy day should inform the instructor as far in advance of the absence as possible so that arrangements can be made to complete an assignment within a reasonable period after the absence. A reasonable accommodation does not include substantial modification to academic standards, or adjustments of requirements essential to any program of instruction. Students and instructors who have questions or concerns about academic accommodations for religious observance or religious beliefs may contact the Office for Inclusion and Equity. The University does not maintain a list of religious holy days.

### **Absence for Military Service**

In accordance with section 51.9111 of the Texas Education code and University policies on class attendance, a student is excused from attending classes or engaging in other required activities, including exams, if they are called to active military service of a reasonably brief

duration. The maximum time for which the student may be excused has been defined by the Texas Higher Education Coordinating Board as “no more than 25 percent of the total number of class meetings or the contact hour equivalent (not including the final examination period) for the specific course or courses in which the student is currently enrolled at the beginning of the period of active military service.” The student will be allowed a reasonable time after the absence to complete assignments and take exams.

[https://healthyhorns.utexas.edu/coronavirus\\_vaccination.html](https://healthyhorns.utexas.edu/coronavirus_vaccination.html),

### **Safety Information**

If you have concerns about the safety or behavior of students, TAs, Professors, or others, call the Behavioral Concerns Advice Line at 512-232-5050. Your call can be anonymous. If something doesn't feel right, it probably isn't. Trust your instincts and share your concerns.

Occupants of buildings are required to evacuate buildings when a fire alarm is activated. Alarm activation or announcement requires exiting and assembling outside.

- Familiarize yourself with all exit doors of each classroom and building you may occupy. The nearest exit door may not be the one you used when entering the building.
- Students requiring assistance in evacuation shall inform their instructor in writing during the first week of class.
- In the event of an evacuation, follow the instruction of faculty or class instructors. Do not re-enter a building unless given instructions by the following: Austin Fire Department, UT Austin Police Department, or Fire Prevention Services.
- Information regarding emergency evacuation routes and emergency procedures.

More safety information.

### **Sanger Learning Center**

More than one-third of undergraduates use the Sanger Learning Center each year to improve their academic performance. All students are welcome to join their classes and workshops and make appointments for their private learning specialists, peer academic coaches, and tutors. For more information, see the Sanger Web site or call 512-471-3614 (JES A332).

### **Title IX Reporting**

Title IX is a federal law that protects against sex and gender-based discrimination, sexual harassment, sexual assault, sexual misconduct, dating/domestic violence and stalking at federally funded educational institutions. UT Austin is committed to fostering a learning and working environment free from discrimination in all its forms where all students, faculty, and staff can learn, work, and thrive. When sexual misconduct occurs in our community, the university can:

1. Intervene to prevent harmful behavior from continuing or escalating.
2. Provide support and remedies to students and employees who have experienced harm or have become involved in a Title IX investigation.
3. Investigate and discipline violations of the university's relevant policies.

Faculty members and certain staff members are considered “Responsible Employees” or “Mandatory Reporters,” which means that they are required to report violations of Title IX to the Title IX Coordinator at UT Austin. **I am a Responsible Employee and must report any Title IX related incidents** that are disclosed in writing, discussion, or one-on-one. Before talking with me, or with any faculty or staff member about a Title IX related incident, be sure to ask whether they are a responsible employee. If you want to speak with someone for support or remedies without making an official report to the university, email [advocate@austin.utexas.edu](mailto:advocate@austin.utexas.edu). For more info about reporting options and resources, visit the campus resources page or e-mail the Title IX Office at [titleix@austin.utexas.edu](mailto:titleix@austin.utexas.edu).

### Campus Carry

“The University of Texas at Austin is committed to providing a safe environment for students, employees, university affiliates, and visitors, and to respecting the right of individuals who are licensed to carry a handgun as permitted by Texas state law.” More information.

### Land Acknowledgment

I would like to acknowledge that we are meeting on the Indigenous lands of Turtle Island, the ancestral name for what now is called North America. Moreover, I would like to acknowledge the Alabama-Coushatta, Caddo, Carrizo/Comecrudo, Coahuiltecan, Comanche, Kickapoo, Lipan Apache, Tonkawa and Ysleta Del Sur Pueblo, and all the American Indian and Indigenous Peoples and communities who have been or have become a part of these lands and territories in Texas. (Pronunciation guide)

### References

In the section **Use of AI Generated Content**, the wording is from Harvard University, and the table of Generative AI tools is from the UT AI Tools Taskforce - Arts & Design Subcommittee. This syllabus uses wording suggested by Prof. Mary Steinhardt and effective syllabus template from the Faculty Innovation Center at UT Austin. The above Land Acknowledgment was drafted by a faculty Committee on Land Acknowledgment and passed by the UT Austin Faculty Council on September 21, 2020, and approved by the UT Austin President.