Georgia Tech Lorraine — Georgia Institute of Technology's European Campus

ECE 3084 – Signals & Systems - Fall 2022	**Schedule**: Tuesday & Thursday 1:30-2:50, Brown Room
Instructor: Prof. Jean Paul Salvestrini, Office 204	email: jean-paul.salvestrini@georgiatech-metz.fr
Office Hours: Wednesday morning (9:00-12:00) or on appointment (pre-arranged preferably by email).	Cell (emergencies only!) +33(0)6 45 53 46 41

Course Description

The subject area of signals and systems is a fundamental and general part of science and engineering in that it provides the abstractions to understand a whole lot! Much of the world around us—and engineered systems—obey *linear partial differential equations*. Their solutions can be easily expressed in ways involving Fourier and Laplace transforms. Even systems that are not linear can often be treated approximately as linear, with the nonlinearities included as a next step. This course investigates signals and systems via Fourier and Laplace transforms, linear systems theory, and applications drawn from many aspects of electrical engineering.

Course Objectives

As part of this course, students:

- ✓ Understand basic concepts of continuous-time linear systems and signals, their mathematical representations, and computational tools.
- ✓ Develop and solve mathematical representations using Fourier and Laplace transforms for continuous-time linear systems.

Course Outcomes

Upon successful completion of this course, students should be able to:

- ✓ Assess the linearity, time-invariance, and causality of systems
- ✓ Compute the convolution and correlation of signals
- ✓ Compute the output of a system from its impulse response
- ✓ Compute direct and inverse Fourier transform of signals
- ✓ Solve differential equations in the s domain
- ✓ Assess the stability of LTI systems
- ✓ Analyze the frequency response and step response of first and second order systems
- ✓ Design and implement filters
- ✓ Design and implement control of systems (stability and tracking efficiency)

Prerequisites:

ECE 2026 and ECE 2040.

Texts

- Lanterman, Michaels, and Egerstedt, *Signals and Systems for All Electrical Engineers* (required reading; a work in progress with updated drafts posted to Canvas)
- McClellan, Schafer, and Yoder, *Signal Processing First*, Prentice Hall; Chapters 9-12 map cover the first half of ECE3084, so we suggest that you keep your ECE2026 text for a while. Do not buy it; if you do not have it, the notes will be fairly self-contained.
- Chen, *Signals and Systems*, 3rd Edition, Oxford University Press, 2004 (for historical reasons, this is the "official" text, **but it is not needed for ECE3084 this semester**).
- Chen, *Signals and Systems: A Fresh Look* (http://www.ece.sunysb.edu/~ctchen/media/freshlook.pdf).
- Kamen and Heck, *Fundamentals of Signals and Systems*, 3rd Edition, Prentice Hall (good reference, but do not go out and buy it unless you really want to do so).
- ECE3084 Website: http://ece3084.ece.gatech.edu

Lecture Videos by Aaron Lanterman

https://www.youtube.com/playlist?list=PLOunECWxELQRYwsuj4BL4Hu1nvj9dxRQ6

Class Attendance

Class attendance is mandatory! Class attendance is the easiest way I know of to attain a first attempt at an understanding of the material. Participation in lectures will be an important way to stay engaged with the course. (Of course, this has to be supplemented by working homework problems, reading the text and other materials, and other practice.) Class size is usually small. This allows for splitting class into teams and solving problems.

Covid-19

The Covid 19 pandemic forces us to review the way courses are being taught. At GTL, all classes will be taught in residential. In case of a new lockdown, all courses will be taught online and recorded. Each of us has a responsibility to ourselves and our fellow Yellow Jackets to be mindful of our shared commitment.

• Since July 20 of 2021, a French policy states that the wearing of a mask is mandatory in any confined area in France. We are therefore all required to wear a face covering while inside GTL, including during in-person classes, and to adhere to social distancing of at least 6 feet. If an individual forgets to bring a face covering to class or into any indoor space, there will be a clearly marked supply of these in each building.

If a student fails to follow Georgia Tech's policies on social distancing and face coverings, they will initially be reminded of the policy and if necessary, asked to leave the class, meeting, or space. If they still fail to follow the policy, they may be referred to Dr Paul Voss, representative of the Dean of Students. Information on the Institute's policy on face coverings.

• Students are expected to sit in assigned seats and to come to class only on days that are assigned to them.

• Papers, projects, tests, homework, and other assignments will only be accepted in electronic form unless the assignment is a physical artifact.

Student illness or exposure to Covid-19: In case of Covid-19 or suspicion of Covid 19, you will inform Dr Paul Voss at paul.voss@ece.gatech.edu or Adeline Kremer at adeline.kremer@georgiatech-metz.fr for support and academic accommodation. You will be then quarantined in your room at the dorm and be tested.

Faculty illness: In case I fall sick, Dr Bertrand Boussert is my backup and will teach the course.

Homework

Problems (9 HWs) will be assigned at intervals; they are graded. Solutions will be made available. The problem sets are **essential** as these will provide that practice that will lead to mastery of the subject matter. Feel free to work with other students, but I advise you (1) to attempt problems on your own before working with other students and (2) making sure you can do the problems cold on your own without the help of other students once you have discussed them. Note that the last one or two problem sets, depending on the pace of the lectures, might be assigned during the last week of classes; it is nonetheless your responsibility to learn the material. Students who do not work diligently on the problem sets will not be able to do well on quizzes!

Quizzes

There will be four in-class quizzes as given tentatively in the schedule below. The quizzes will be heavily drawn from problems given in the homeworks. **Thus, mastery of homework problems is likely to translate into high quiz** (and exam!) **grades**.

Each quiz will concentrate on material covered between specified cutoffs (TBA)—typically from the cutoff from the previous quiz, but will nonetheless be comprehensive. That is, while the emphasis will be as described above, knowledge of material that came before in the course will be required to do well on the quizzes and there may be specific questions or parts of questions that focus on earlier work.

Failure to take a quiz (see above) may result in a grade of zero unless you present **written documentation** that you have a valid excuse and that I accept the excuse. If you have any questions, please consult me AND Prof. Paul Voss. Unless the excuse is related to an obviously unforeseen emergency, this documentation must be presented one week prior to the quiz or a grade of zero may result. Specifically, travel will not constitute a valid excuse.

Quizzes must be taken on the dates indicated. Failure to take a quiz at the indicated time will result in a grade of zero. Quiz times might be changed only for the entire class under exceptional circumstances, provided no student objects, but not for individual students. Please consult the syllabi for all your courses immediately so that you can budget your study time.

Final Exam

The final exam is cumulative and comprehensive.

Grading

The course grade will be computed according to the following weights:
Each quiz (4): 15 %
Final exam: 30 %
HWs: 10 %

The final grade will be curved based on your attendance, performance and participation. Over two unexcused absences, no curving will be applied. In case of a health issue that prevent you taking an exam, I will require a note from a doctor before rescheduling the exam otherwise you will have an F to the exam.

Academic Conduct

As noted above, you are free to work with other students on problem sets. You must work strictly alone on quizzes and the final exam. On quizzes and the final exam, unless I expressly grant exceptions later in the course, no notes, books, calculators, electronic devices, or any other aids will be permitted. I will supply a formula sheet that will be made available to you prior to the quizzes and final exam.

Students in this class are expected to abide by the Georgia Tech Honor Code and avoid any instance of academic misconduct, including but not limited to:

- Possessing, using, or exchanging improperly acquired oral or written information in the preparation of a quiz or the final project.
- Submission of material that is substantially identical to that created or published by another individual, except as noted below.
- False claims of performance or work that has been submitted by the student.

Be sure to report observed instances of violations of the Honor Code! Remember, the Honor Code is about honor. Apart from devaluing your own work, the work of your classmates, and the Georgia Tech degree, Violations of the Honor Code carry significant penalties, here at Tech, and for life. Do you want to be labeled as having cheated? The trustworthiness of engineering and science (as well as the reliability and safety of products!) relies on the basic honesty of engineers and scientists. Students may work in groups on the final project as will be discussed in a future handout, though each must student make a good-faith effort to contribute to the group. Each student must also write up and turn in his/her work to integrate the knowledge.

Please turn off notifications on cell phones, etc. Some students may choose to use computers for note taking during class; however, if I perceive that they are a distraction, I might ask that they be put away. See the Georgia Tech Honor Code for further information or ask instructor.

Communications

You are responsible for all announcements (which may include information about the homework, quizzes, and the final exam) made in class. Quizzes will likely strongly reflect material covered in class. If you miss class, do not ask me what was covered. Handouts may also be distributed from time to time in class; it is your responsibility to obtain information from classmates if you are not present when information is given or materials are distributed, though materials are likely to be posted on Canvas. I may also email the class various information.

Notes, problem sets, solutions, and various other useful information will be posted on Canvas.

The best way to contact me is via email, briefly immediately before or after class or by appointment.

Getting Help

The material in this course builds on earlier material, so it is very important to not get behind. Be sure to contact me (see above) or use other resources that are available. As noted above, email questions or arrange for an appointment. While some resources may be more difficult to access at GTL than in Atlanta, class sizes tend to be small, so use this to your advantage!

Why are you here??

• The world is full of physical and information systems that can be treated in terms of the course concepts. As educated people, we should know what is going on!

• Linear systems make the world go round; the fundamental equations of physics are second-order linear partial differential equations. This translates into engineered systems that also obey linear partial differential equations. These linear partial differential equations (in many cases) are the systems of interest and the solutions signals. As scientists and engineers, we have to know the basics.

• But signals-and-systems concepts extend to entirely synthetic arenas (think computers).

What do you have to do??

• Come to class.
• Master the concepts.
• Do the problem sets.
• Master problem solving.
• Avoid the cookbook approach to the above.
• Keep up with the material covered in lectures.
• Read the book.
• Come see me.
• Keep an open mind.
• Ask questions.

Tentative Syllabus:

It is unlikely that the listed topics and homework assignments will match up exactly on the listed dates. This is just a rough estimate of how the material will flow and homework coverage to give you a sense of where we are headed. However, the quiz dates are unlikely to be changed. The classes during the 3 first weeks will be done online.

Class	Topic	Book Chapt.	HW assign./sol.
1	Syllabus, introduction, course outline; Signals as functions; unit step and Dirac δ functions;	1, 2	HW1
2	Systems; linearity, time-invariance, and causality	1, 2	
3	Impulse response; convolution; why LTI systems are important	3, 4	
4	Graphical convolution	5	hw1sol / HW2
5	Correlation and matched filtering	5	
6	More convolution/correlation practice	5	hw2sol
7	**Quiz #1**	***HW 1, 2***	
8	Review of Fourier series	6	HW3
9	Fourier transforms & properties; Parseval's theorem	7, 17	
10	AM communications, baseband signal representations. Duality of sampling and periodicity	9	hw3sol / HW4
11	Laplace transforms, properties, PFEs, ODEs, part 1	10	
12	Laplace transforms, properties, PFEs, ODEs, part 2	11	hw4sol / HW5
13	Transfer functions; poles and zeros; stability	11	
14	Frequency responses 1st and 2nd order systems – Part 1	12	
15	Frequency responses 1st and 2nd order systems – Part 2	12	hw5sol / HW6
16	**Quiz #2**	***HW 3, 4, 5***	
17	Step responses of 1st and 2nd order systems – Part 1	14	hw6sol / HW7
18	Step responses of 1st and 2nd order systems – Part 2	14	
19	Filter design and implementation (pole-zero matching)	13	
20	Laplace-domain circuit analysis	13, 15	hw7sol
21	Laplace-domain circuit analysis, part 2 + practice problems	15	
22	**Quiz #3**	***HW 6, 7***	HW8
23	Feedback control systems, part 1	16	
24	Feedback control systems, part 2	16	hw8sol / HW9
25	Feedback control systems, part 3	16	
26	Catch-up day		hw9sol
27	**Quiz #4**	***HW 8,9***	
28	Review		
29	Review		
	Final	***HW 1-9***	