



ECE 8180: RANDOM PROCESS APPLICATIONS IN ENGINEERING

Section 001

FALL 2020

MEETING TIME: MWF 9:05-9:55 a.m.

MEETING LOCATION: Online.

INSTRUCTOR(s): Carl W. Baum, [baumc@clemson.edu](mailto:baumc@clemson.edu), 864-656-5928. (Not on campus this semester.)

OFFICE HOURS AND PROCEDURES: MWF 9:05-9:55 a.m. and TTh 11:00-11:50 a.m. or by appointment. Office hours are online via Zoom. See the Zoom section in Canvas for an invite to each day's session. Email is also extremely welcome.

COURSE MODALITY: ONLINE SYNCHRONOUS.

COURSE DESCRIPTION: Theory of random processes emphasizing engineering applications; stochastic convergence and limit theorems; mean-square calculus; Karhunen-Loeve expansions; systems with stochastic inputs; Poisson processes; shot noise; Weiner processes; white noise processes; Markov systems and chains.

COURSE PREREQUISITES: Students are expected to have completed courses comparable to ECE 3170 and ECE 3300 before enrolling in this course.

STUDENT LEARNING OUTCOMES: At the completion of the course, students should be able to:

1. Solve diverse problems using the tools of probability theory, random variables, and random processes.
2. Analyze random signals as to their properties and limiting behavior.
3. Analyze systems with random process inputs using time domain, and for stationary inputs in linear time-invariant systems, frequency domain techniques.
4. Analyze continuous- and discrete-time Markov chains.

REQUIRED MATERIALS:

1. No textbook is required. Detailed notes and videos are available through Canvas. The textbook *Probability, Random Variables, and Stochastic Processes* by Papoulis is a useful reference but will not be referred to directly in the course.
2. Every student is required to have a (laptop) computer, internet connectivity sufficient for reliably transmitting and receiving video, a video camera that works with Zoom, a microphone that works with Zoom, and a cell phone with software for taking a picture that immediately converts the picture to a pdf file. (Multiple free apps can do this.) A printer is not required but might be useful if you prefer to see your exam on paper while taking it.

## COURSE STRUCTURE AND ATTENDANCE POLICY:

This course is a SYNCHRONOUS ONLINE course. Videos are available for course lectures, and each video has a deadline by which it must be watched. Videos do not need to be watched during the course meeting time. The course meeting time on most days will be used for office hours via Zoom. Attendance of office hours is optional.

On test days, tests are SYNCHRONOUS. To take a test you must first log in to the Zoom session for that day. You then download the pdf exam and write your answers on blank or lined notebook paper. Prior to the deadline for turning in the exam, you must obtain pdf scans of your exam (using a phone with a direct-to-pdf app or a scanner) and upload them into the "quiz" on Canvas. Canvas announcements will provide additional details about testing procedures.

Timely canvas announcements and/or email will be used to inform students what to do if a technical problem (such as Zoom being down for everyone) occurs on a test day. In the event that you have a personal technical problem on a test day, call or email me *immediately*.

If a situation (such as COVID) causes you to be unable to participate in the course for a period of time, email me immediately with a description of the situation. In the unlikely event that you have a scheduled conflict with a test date, let me know in advance of the test. Decisions about whether an exam will be permitted to be made up will be made on a case by case basis.

## VIDEOS, HOMEWORK AND QUIZZES:

Videos, homework, and quizzes are generally due three times per week. You are welcome to get ahead of the published schedule (in Canvas and at the end of this syllabus). Items assigned on Monday are due Tuesday at 11:59pm. Items assigned on Wednesday are due Thursday at 11:59pm. Items assigned on Friday are due Sunday at 11:59pm. It is best not to wait until the last minute, as Canvas/internet problems are always possible.

Homework assignments should be written up (not typed) on blank or lined notebook paper and uploaded into Canvas. Homework must be in your own writing and your own work.

Quizzes are fully online in Canvas. Quizzes have no time limit (other than when they are due) and can be taken twice; the maximum score will be kept. Quizzes can be fill-in-the-blank, multiple choice, etc. Quizzes tend to emphasize conceptual understanding whereas the homework emphasizes analytical techniques. (Exams can draw from both, although there is a greater emphasis on analysis than on concepts.)

## EXAMS:

For Exam 1 you are permitted one 8.5x11 page of notes, front and back. You should write all equations you need to solve the problems; no equations are included on the exam. Your note sheet can be typed if you wish. You can also include examples. Although each exam only tests the material covered since the previous exams, the material by its nature builds on itself. For this reason, you are permitted two pages of notes for the second exam (the first page written for Exam 1 plus one more), three for the third exam, and so on. The final exam is cumulative for the entire course and permits six sheets of notes.

Calculators are permitted on exams. You are not permitted to use your computer (other than to look at the exam questions) or your phone (other than to scan your test when you are finished). For the duration of the exam you must remain in Zoom and have your computer camera pointed down towards

your hands and your paper where you are writing your exam. You must also keep your microphone on. You can turn down (or off) your speakers if you wish – actually, this is recommended to avoid being distracted by noises from the class. In the unlikely event you have an urgent question, use a private chat in Zoom to me.

Exams will run from 9:05 until 10:05 a.m. followed by an extra 15 minutes to scan and upload your test. If you have a decent internet connection, it should not take 15 minutes to upload, especially if you use a direct-to-pdf phone app as recommended to scan your work. (Other techniques may lead to a dramatically larger pdf file that takes much longer to upload.) Do not wait to start the scanning and uploading process; if you do not upload and submit by the deadline, immediately email your exam to me. But understand that there will be a penalty of 10% per MINUTE the exam is late, based on the time stamp within the email.

The final exam is cumulative for the entire course. Questions are in a format similar to that of the other tests, and the online procedure is also the same. The exam is designed to be a full 2.5-hour exam. The exam starts at 8:00 a.m. on Friday of finals week. You have an additional 15 minutes to scan and upload your work, so everything is due at 10:45 a.m. The final exam is worth the same amount as one of the other exams, and the lowest exam score is dropped. This means that if you have an “A” going into the final, there is no point in taking the exam.

DAILY SCHEDULE: For each course date expect a video, quiz, and homework assignment. Note that assignments are also assigned on test dates. Assignments are due at 11:59 p.m.; Monday assignments are due Tuesday, Wednesday assignments are due Thursday, and Friday assignments are due Sunday.

			Mon	9/28	3.2		Mon	11/9	5.4
Wed	8/19	1.1	Wed	9/30	3.3		Wed	11/11	5.5
Fri	8/21	1.2	Fri	10/2	3.4		Fri	11/13	5.6
Mon	8/24	1.3	Mon	10/5	3.5		Mon	11/16	Study
Wed	8/26	1.4	Wed	10/7	Study		Wed	11/18	Test 5; 6.1
Fri	8/28	1.5	Fri	10/9	Test 3; 4.1		Fri	11/20	6.2
Mon	8/31	1.6	Mon	10/12	4.2		Mon	11/23	6.3
Wed	9/2	1.7	Wed	10/14	4.3		Wed	11/25	Thanksgiving
Fri	9/4	Study	Fri	10/16	4.4		Fri	11/27	Thanksgiving
Mon	9/7	Test 1; 2.1	Mon	10/19	4.5		Mon	11/30	6.4; Study
Wed	9/9	2.2	Wed	10/21	4.6		Wed	12/2	Test 6
Fri	9/11	2.3	Fri	10/23	4.7		Fri	12/4	Study
Mon	9/14	2.4	Mon	10/26	4.8				
Wed	9/16	2.5	Wed	10/28	Study				
Fri	9/18	2.6	Fri	10/30	Test 4; 5.1		Fri	12/11	Final (8:00 a.m.)
Mon	9/21	2.7	Mon	11/2	Fall Break				
Wed	9/23	Study	Wed	11/4	5.2				
Fri	9/25	Test 2; 3.1	Fri	11/6	5.3				

## GRADING POLICY:

Grading is based on tests, homework, and quizzes and is adjusted based on a participation score.

The following items are graded:

Homework Assignments	10%	
Quizzes	10%	
6 Tests + final exam (lowest test dropped)	80%	(Tests + final are worth 13.33% each.)

Participation is graded by whether you turn in homework, quizzes, and exams by their due dates and times. It is also graded by whether you WATCH VIDEOS by their due dates and times. Video watching is measured based on the access log in Box, where the videos are located. The total number of late or skipped activities is used to adjust your total grade as follows:

0 to 3	+5%
4 to 6	+0%
7 to 9	-10%
10 to 12	-20%
13 to 15	-30%
16 or more	-40%

For example, if your total cumulative percentage in the course is 86% and you had 2 late or skipped activities, your adjusted percentage would be 91%; if instead you had 8 late or skipped activities, your total cumulative percentage would be 76%. Note that it is easy to accrue multiple late or skipped activities on a single day. If you skip a video, a quiz, and a homework assignment for a single date, you have added 3 to your total “non-participation count”.

Several additional activities are required. These count for participation but are only minimally graded. (They might count as one homework “point.”) These include a SYLLABUS QUIZ required at the beginning of the course and one or more PRACTICE TESTS used to make sure your (and my) technology is ready for the online exams. Any such requirements will be posted in Canvas announcements.

Final grades are based on the following thresholds: 90-100 A, 80-89.9 B, 70-79.9 C, below 70 F. These thresholds might be lowered slightly, based on assessed difficulty of the exams. For example, an A might become 88-100.

## TOPICAL OUTLINE:

1. *Probability and random variables*. Includes probability spaces, conditional probability and independence, random variables, functions of random variables, expectation, moment generating functions, conditional distributions, and conditional expectation. (2 weeks)
2. *Multiple random variables*. Includes random vectors, independence, functions of random vectors, expectation, covariance and correlation matrices, moment generating functions, complex random variables, conditional distributions and conditional expectation. (2 weeks)
3. *Random processes*. Includes m-th order distribution and density functions, mean, correlation, and covariance functions, independent and uncorrelated component processes, independent and uncorrelated increment processes, multiple random signals and complex random signals, sum signals and integral signals, difference signals and derivative signals, binomial processes, Poisson processes, Gaussian white noise and Wiener processes. (2 weeks)

4. *Properties and classification of random signals.* Includes periodicity, stationarity and spectral densities, cyclostationarity, convergence, law of large numbers, central limit theorem, stochastic continuity, energy and power signals, time averages and ergodicity, memory and the Markov property. (3 weeks)
5. *Systems with random inputs.* Includes stochastic response to linear and time-invariant systems, systems and stationarity, filtering of random processes, stochastic Fourier series, Karhunen-Loeve expansion. (2 weeks)
6. *Markov chains and related processes.* Includes discrete-time Markov chains, continuous-time Markov chains, state classification, ergodic chains, steady-state behavior, mean first passage times, mean recurrence times. (2 weeks)
7. *Testing.* (2 weeks)

ACCESSIBILITY: Clemson University values the diversity of our student body as a strength and a critical component of our dynamic community. Students with disabilities or temporary injuries/conditions may require accommodations due to barriers in the structure of facilities, course design, technology used for curricular purposes, or other campus resources. Students who experience a barrier to full access to a class should let the instructor know and make an appointment to meet with a staff member in Student Accessibility Services as soon as possible. You can make an appointment by calling 864-656-6848 or by emailing [studentaccess@lists.clemson.edu](mailto:studentaccess@lists.clemson.edu). Students who receive Academic Access Letters are strongly encouraged to request, obtain, and present these to their instructors as early in the semester as possible so that accommodations can be made in a timely manner. It is the student's responsibility to follow this process each semester. You can access further information here:

<http://www.clemson.edu/campus-life/campus-services/sds/>.

TITLE IX: Clemson University is committed to a policy of equal opportunity for all persons and does not discriminate on the basis of race, color, religion, sex, sexual orientation, gender, pregnancy, national origin, age, disability, veteran's status, genetic information or protected activity in employment, educational programs and activities, admissions and financial aid. This includes a prohibition against sexual harassment and sexual violence as mandated by Title IX of the Education Amendments of 1972.

SAFE CAMPUS: Clemson University is committed to providing a safe campus environment for students, faculty, staff, and visitors. As members of the community, we encourage you to take the following actions to be better prepared in case of an emergency:

- a. Ensure you are signed up for emergency alerts (<https://www.getrave.com/login/clemson>)
- b. Download the Rave Guardian app to your phone (<https://www.clemson.edu/cusafety/cupd/rave-guardian/>)
- c. Learn what you can do to prepare yourself in the event of an active threat (<http://www.clemson.edu/cusafety/EmergencyManagement/>)

ACADEMIC INTEGRITY: As members of the Clemson University community, we have inherited Thomas Green Clemson's vision of this institution as a 'high seminary of learning.' Fundamental to this vision is a mutual commitment to truthfulness, honor, and responsibility, without which we cannot earn the trust and respect of others. Furthermore, we recognize that academic dishonesty detracts from the value of a Clemson degree. Therefore, we shall not tolerate lying, cheating, or stealing in any form. In instances where academic standards may have been compromised, Clemson University has a responsibility to respond appropriately to charges of violations of academic integrity. Further information on Academic Integrity can be found in the [Undergraduate Announcements](#) and in the [Graduate School Policy Handbook](#).

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MODIFICATIONS: The instructor reserves the right to modify any aspect of the syllabus at any time during the semester for reasons including but not limited to COVID-related situations.

MORE ABOUT ME: <http://meettheprof.com/view/professors/entry/carl-baum/>

SYLLABUS VERSION AND DATE: 1.1. 8/18/2020. Fixed error in grading scale.  
1.0. 8/17/2020.