ECE 3077: Intro to Probability and Statistics for ECEs

Summer 2014 Syllabus

Summary

ECE 3077 is a foundational course in probability.

The central theme of the course is the development of mathematical methods for understanding and modeling uncertainty.

Prerequisites

ECE 2025/2026 and 2040 or their equivalents. I will assume that you are comfortable with the fundamentals in calculus (calculating integrals, understanding limits, Taylor series expansions, etc) and linear algebra (matrix-vector multiply, solving systems of equations, dimension, rank, etc). I will also assume basic proficiency in MATLAB[1] — many of the homework assignments will require you to write some basic code.

Instructor

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Office Hours: I will typically hold scheduled office hours on Wednesday afternoon from 3-5pm. (Location TBA.) I am also available to meet in Centergy 5227 by appointment.

Teaching Assistant

TBA
Email:
Office hours: Time and location TBA.

[1] I very much prefer you do things in MATLAB, but if you feel strongly about using Python, Julia, R, Octave, or another language, come and see me.

Grading

Your grade will be assigned based on the following factors:

- **Quiz 1 (20%)** – Tentatively scheduled for June 10
- **Quiz 2 (20%)** – Tentatively scheduled for July 10
- **Final exam (30%)**
- **Homework (15%)** – There will be 8 (± 1) assignments, including an assignment to be due during the last week of class. See below.
- **Computer exercises (15%)** – See below.

Homework

Homework will be assigned weekly (approximately). Homework will be turned in at the beginning of lecture. **Late homework will get zero credit.**

You are encouraged to discuss the homework with other members of the class. However, everything that you turn in must be your own work. **You must write up the assignments (and accordingly the MATLAB code) by yourself, citing any outside references you use to arrive at your solution. Failure to do so will be considered a violation of the GT Academic Honor Code.**

Unauthorized use of any previous semester course materials, such as tests, quizzes, homework, and any other coursework, is prohibited in this course. **Using these materials will be considered a direct violation of the GT Academic Honor Code.** For any questions involving these or any other Academic Honor Code issues, please consult me or `http://www.honor.gatech.edu`.

The homework assignments will be hard; many of them will require significant amounts of time and effort to complete. But this is really where most of the learning takes place. You will get out of the assignments what you put into them. Solving problems in probability and statistics involves a style of thinking which is, at times, as much art as science. This style is best learnt through working examples. Students who complete all of the assignments in full will be rewarded with a deep understanding of the role that probability and statistics can play in both electrical and computer engineering as well as everyday life.

Effectively, homework is worth much more than 15% of your grade. In teaching this and other classes, **I have yet to see a case where a student does not put effort into the homework assignments but does well on the exams**.

Computer exercises

We will spend a portion of every lecture solving problems in class. There will be a set of required exercises that must be completed in class. These problems will be online and the website will only

be open for the class period and possibly for a short time afterwards. Thus, you will need to **bring your laptop to every class.** The exercises are not supposed to be a test, they are meant to help solidify your understanding of the material. In total, they are worth 15% of your grade.

Half of the credit will be based on the actual scores you receive on these assignments. The other half will essentially serve as a participation grade — at the end of each class I will check everyone's progress, and you will receive full credit as long as you are in class and have been making a good faith effort at completing the assignment. To receive credit, you must complete the entire assignment **and view the required feedback**.

Piazza and T-square

This course will make use of Piazza:
`http://piazza.com`
Please use this as a resource to post questions about lectures and homework assignments. I will also use this for general course announcements.

I also encourage students to answer questions. **Extra-credit consideration will be given on the final grade of notable Piazza contributors.**

Notes for the lectures, homework assignments, and other supplemental materials will be hosted on T-square (but announced through Piazza). We will also use T-square to record grades.

Textbook and other resources

The required text for the course is

- Bertsekas and Tsitsiklis: *Introduction to Probability*
  `http://amzn.to/YRPH3x`

Here are several other books that I can recommend for learning the material in this class. You couldn't possibly read them all over the next several weeks, but if you take the time to read any of them you will find it worthwhile.

- Feller: *An Introduction to Probability Theory and its Applications*
  Volume 1: `http://amzn.to/19kOOjf`, Volume 2: `http://amzn.to/13tXSm9`
  This book is an absolute classic written by one of the greatest probabilists of the 20th century. It was first published in 1950, but the writing style is so clear that it has held up perfectly. This book is a little more advanced mathematically than this course will be, but it is still very accessible. The material covered in Volume 1 is particularly relevant. I cannot recommend it enough as a supplement to the material in this course.
- Hamming: *The Art of Probability*
  `http://amzn.to/126Zyiu`
  This book is another classic. Hamming (of the Hamming window, Hamming code, Hamming distance, etc.) was trained as a mathematician, but spent much of his life at Bell Labs working

with engineers. This book (written late in his career) is a little different than Feller in that Hamming takes a strong position on various philosophical issues related to *what probability really is* and devotes a fair bit of discussion to these issues. If you're interested, this can be fascinating, but even if you're not, Hamming does an excellent job of giving lots of examples *and* trying to develop intuition for how to approach these problems to find the most elegant (i.e., easiest and fastest) solution. Chapter 4 is particularly good in this respect.

- Wasserman: *All of Statistics*
  `http://amzn.to/18GIDsc`
  If you like the material at the end of this course, check this out. Wasserman provides a fairly concise overview of, well, all of statistics. If you want to go get a job doing something related to "Big Data," read this book.

- Bernstein: *Against the Gods: The Remarkable Story of Risk*
  `http://amzn.to/19kPkxD`
  This is a fascinating history of the development of probability theory from the 16th century to the present.

- Mlodinow: *The Drunkard's Walk: How Randomness Rules our Lives*
  `http://amzn.to/11zCQoe`
  An easy read which has interesting tidbits about some of the historical figures in the development of probability theory, and modern experiments that show how bad human intuition is at judging probabilities.

- Taleb: *Fooled by Randomness*
  `http://amzn.to/15H1O6w`
  The theme of this book is how terrible humans are in general about understanding the role randomness plays in our lives (especially in finance).

- Silver: *The Signal and the Noise*
  `http://amzn.to/17Ygz2i`
  Nate Silver got a lot of attention for his accurate predictions in the 2008, 2010, an 2012 elections. This book examines how experts predict uncertain events (i.e., the weather, earthquakes, an athlete's performance, etc.) using probabilistic models.

You may also want to take advantage of some of the following online resources:

- MIT OpenCourseware
  `http://bit.ly/NA4aLP`
  This course used the same book, and will match our course pretty closely, at least through the first few weeks. There are alternative lecture notes, homework assignments (with solutions), and other materials at the website above.

- Harvard Statistics 110: Probability
  `http://bit.ly/NhMdxb`
  Harvard also has a similar course with video lectures available through iTunes.

- Khan Academy lectures on probability
  `http://bit.ly/PaBJmu`
  The Khan Academy has some fantastic (shortish) lectures available for many of the topics in this course. Many of them are centered on working specific problems.

Outline

We will start the course by following the book fairly closely for the first 5 chapters. After that, the material will overlap, but we will be choosing a more customized list of topics. The ordering of subjects in this outline is rough and subject to change.

1. Introduction to probability
   (a) simple probability models, the Kolmogorov axioms, the uniform law
   (b) independence
   (c) conditional probability and Bayes rule
   (d) basic combinatorics and counting
2. Discrete random variables
   (a) probability mass functions (pmfs)
   (b) expectation, variance, and moments
   (c) multiple discrete random variables, joint pmfs
   (d) conditional pmfs
   (e) example distributions: Bernoulli, Binomial, Geometric, Poisson, etc.
3. Continuous random variables
   (a) probability distributions and probability density functions (pdfs)
   (b) multiple continuous random variables, joint pdfs
   (c) conditional pdfs
   (d) example distributions: Uniform, Exponential, Gaussian/Normal, etc.
4. Functions of random variables
   (a) derived distributions
   (b) generating arbitrary random variables from a uniform random variable
   (c) adding independent random variables
   (d) central limit theorem
5. Basic statistics
   (a) sample mean and variance
   (b) confidence intervals, the student-t distribution
   (c) parameter estimation using maximum likelihood
   (d) parameter estimation using Bayesian inference