USC Viterbi School of Engineering

EE503: Probability for Electrical and Computer Engineers (Spring 2018)

Units: 4

Instructor: Mohammad Reza Rajati, PhD
PHE 414
rajati@usc.edu – Include 503 in subject
Office Hours: Monday 1:00 –3:00

TA(s): Ethan Sung
yuchens@usc.edu – Include EE 503 in subject
Office Hours: Thursday 3:00-5:00 PM
Office Location: TBD

Md Nasir
mdnasir@usc.edu – Include EE 503 in subject
Office Hours: TBD
Office Location: TBD

Grader(s): Chengyu Ke
chengyuk@usc.edu – Include EE 503 in subject
Llingzhi Lin
llingzhl@usc.edu – Include EE 503 in subject
Shixiang Zhu
shixianz@usc.edu – Include EE 503 in subject

Lecture(s): Monday, Wednesday, 8 - 9:50 am in ZHS 352 (Section 30677)
Monday, Wednesday, 10 - 11:50 am in OHE 122 (Section 30755)
Discussion(s): Friday, 8:00-8:50 am in OHE 132
Friday, 9:00-9:50 am in ZHS 352

Webpages: Piazza Class Page for everything except grades
and USC DEN Class Page for grades and homework submission
– All HWs, handouts, solutions will be posted in PDF format
– *Student has the responsibility to stay current with webpage material*

Prerequisites: Prior courses in multivariate calculus, linear algebra, and linear system theory.
– This course is a prerequisite or corequisite to many courses including EE 511, 5
– 535, 555, 556, 559, 562, 563, 564, 565, 583, 649, and 660.

Other Requirements: Basic computer skills (e.g., plotting, Matlab, Excel, Python, etc.).

Tentative Grading: Assignments 15%
Three Midterm Exams 45%
Final Exam 40%
Participation on Piazza* 5%

Letter Grade Distribution:

≥ 93.00	A	73.00 - 76.99	C
90.00 - 92.99	A-	70.00 - 72.99	C-
87.00 - 89.99	B+	67.00 - 69.99	D+
83.00 - 86.99	B	63.00 - 66.99	D
80.00 - 82.99	B-	60.00 - 62.99	D-
77.00 - 79.99	C+	≤ 59.99	F

Disclaimer: Although the instructor does not expect this syllabus to drastically change, he reserves every right to change this syllabus any time in the semester.

Note on e-mail vs. Piazza: If you have a question about the material or logistics of the class and wish to ask it electronically, please post it on the piazza page (not e-mail). You may post it anonymously if you wish. Often times, if one student has a question/comment, other also have a similar question/comment. Use e-mail with the professor, TA, graders only for issues that are specific to your individually (e.g., a scheduling issue or grade issue).

Catalogue Description: Rigorous coverage of probability, discrete and continuous random variables, functions of multiple random variables, covariance, correlation, random sequences, Markov chains, estimation, and introduction to statistics.

Course Objectives: Upon successful completion of this course a student will

- Understand the rigorous mathematical foundations of probability and random variables, due to exposure to introductory measure-theoretic concepts
- Develope probabilistic reasoning skills to deal with probabilistic uncertainty
- Precisely formulate real-world engineering problems via the framework of probability
- Obtain adequate mathematical maturity to be prepared for future courses including those in controls, signal processing, communications, statistics, data analysis, bioinformatics, and machine learning

Exam Dates:

- **Midterm Exam 1:** Friday, February 9, 8:00 - 9:50 AM
- **Midterm Exam 2:** Friday, March 9, 8:00 - 9:50 AM
- **Midterm Exam 3:** Friday, April 6, 8:00 - 9:50 AM
- **Final Exam:** Monday, May 7, 8:00 - 10 AM as set by the university

Textbooks:

- **Required Textbooks:**

  1. *Probability and Random Processes for Electrical and Computer Engineers*, 1st Edition **Author:** John A. Gubner; Cambridge University Press, 2006. **ISBN-13:** 978-0511220234

2. *Probability and Random Processes*, 3rd Edition
   Authors: Geoffery R. Grimmet and David R. Stirzaker; Oxford University Press; 2001. **ISBN-13:** 978-0198572220

- **Recommended Textbooks:**

1. *Introduction to Probability*, 2nd Edition
   Authors: Dimitri P. Bertsekas and John N. Tsitsiklis; Athena Scientific, 2008. **ISBN-13:** 978-1886529236
2. *Introduction to Probability Models*, 11th Edition
   Authors: Sheldon M. Ross, Academic Press, 2010. **ISBN-13:** 978-0124079489
3. *One Thousand Exercises in Probability*, 1st Edition
   Authors: Geoffery R. Grimmet and David R. Stirzaker; Oxford University Press; 2001. **ISBN-13:** 978-0198572213
4. *Schaum's Outline of Probability, Random Variables, and Random Processes*, 3rd Edition
   Author: Hwei P. Hsu; McGraw-Hill Education; 2014. **ISBN-13:** 978-0071368100
5. *Schaum's Outline of Probability and Statistics*, 4th Edition
   Authors: John J. Schiller Jr., R. Alu Srinivasan, Murray R Spiegel; McGraw-Hill Education; 2012. **ISBN-13:** 978-0071795579

Grading Policies:

- The letter grade distribution table guarantees the *minimum* grade each student will receive based on their final score. When appropriate, relative performance measures will be used to assign the final grade, at the discretion of the instructor.
  - Final grades are non-negotiable and are assigned at the discretion of the instructor. If you cannot accept this condition, you should not enroll in this course.
  - Three of your lowest homework grades will be dropped from the final grade.
  - The lowest score of your midterms will be dropped from the final grade.
  - *Participation on Piazza has up to 5% extra credit, which is granted on a competetive basis *at the discretion of the instructor.*

- **Homework Policy**
  - Homework is assigned on a weekly basis. *Absolutely no late homework will be accepted. A late assignment results in a zero grade.*
  - Homework solutions should be typed or *scanned* using scanners or mobile scanner applications like CamScanner and uploaded on blackboard (photos taken by cell-phone cameras and in formats other than pdf will NOT be accepted). Programs and simulation results have to be uploaded on blackboard as well.
  - Students are encouraged to discuss homework problems with one another, but each student must do their own work and submit individual solutions written/ coded in their own hand. Copying the solutions or submitting identical homework sets is written evidence of cheating. The penalty ranges from F on the homework or exam, to an F in the course, to recommended expulsion.

  - Posting the homework assignments and their solutions to online forums or sharing them with other students is strictly prohibited and infringes the copyright of the instructor. Instances will be reported to USC officials as academic dishonesty for disciplinary action.

- **Exam Policy**

  - **Make-up Exams:** No make-up exams will be given. If you cannot make the above dates due to a class schedule conflict or personal matter, you must drop the class. In the case of a required business trip or a medical emergency, a signed letter from your manager or physician has to be submitted. This letter must include the contact of your physician or manager.
  - Midterms and final exams will be closed book and notes. No calculators are allowed nor are computers and cell-phones or any devices that have internet capability. One letter size cheat sheet (back and front) is allowed for the midterms. Two letter size cheat sheets (back and front) are allowed for the final.
  - All exams are cumulative, with an emphasis on material presented since the last exam.

- **Attendance:**

  - Students are required to attend all the lectures and discussion sessions and actively participate in class discussions. Use of cellphones and laptops is prohibited in the classroom. If you need your electronic devices to take notes, you should discuss with the instructor at the beginning of the semester.

Important Notes:

- Textbooks are secondary to the lecture notes and homework assignments.
- Handouts and course material will be distributed.
- Please use your USC email to register on Piazza and to contact the instructor and TAs.

Tentative Course Outline

Monday	Wednesday
Jan 8th **1** **Introduction** **Logic**	10th **2** **Set Theory**
15th Martin Luther King Day	17th **3** **Set Theory** , **Probability Models** • Sample Space, • σ-algebra of events • Probability as An Additive Measure • Continuity of Probability • Conditional Probability
22nd **4** **Probability Models and Independence** • Total Probability • The Baye's Rule • The Multiplication Rule	24th **5** **Probability Models** • The Borel-Cantelli Lemmas **Random Variables** • Definitions
29th **6** **Random Variables** • Definitions • CDFs • Borel Sets	31st **7** **Random Variables** • CDFs • Independence • Multiple Random Variables **Combinatorics**

Monday	Wednesday
Feb 5th **8** **Combinatorics** **Discrete Random Variables** PMFs Famous Discrete Random Variables	7th **9** **Discrete Random Variables** • Famous Discrete Random Variables • Multiple Random Variables • Joint PMFs • Marginal PMFs • Conditional PMFs • Total Probability • Substitution Law • Independence
12th **10** **Discrete Random Variables** • Derived Distributions **Moments of Discrete Random Variables** • Expectation • The Law of The Unconscious Statistician • Properties of Expectation • Higher Order Moments	14th **11** **Moments of Discrete Random Variables** • Variance and Standard Deviation • Moments of Famous Discrete Random Variables • Factorial Moments • Existence of Expectations • Covariance and Correlation and Their Properties • Expectation As Norm and Inner Product • The Cauchy-Schwartz-Bunyakovsky Lemma

Monday	Wednesday
19th President's Day	21st **12** **Moments of Discrete Random Variables** • Expectation As Norm and Inner Product • The Cauchy-Schwartz-Bunyakovsky Lemma **Conditional Expectation** • The Law of The Unconscious Statistician • Substitution Law for Conditional Expectation • Total Expectation
26th **13** **Conditional Expectation** • Conditional Expectation as A Random Variable • Properties of Conditional Expectation • Existence of Conditional Expectation • Conditional Probability as Conditional Expectation • Wald's Equality • Higher Order Conditional Moments • Projections, Projection Theorem, Principle of Orthogonality • Conditional Expectation as an Estimator	28th **14** **Continuous Random Variables** • PDFs • Important Continuous Random Variables

Monday	Wednesday
Mar 5th **15** **Continuous Random Variables** • Important Continuous Random Variables • Multiple Random Variables and Joint PDFs • Marginal PDFs • Independence • Conditional Probability and Conditional PDFs • Moments of Continuous Random Variables	7th **16** **Continuous Random Variables** • Existence and Properties of Moments • Moments of Famous Continuous Random Variables • The Law of The Unconscious Statistician (LOTUS)
12th Spring Break	14th Spring Break
19th **17** **Continuous Random Variables** • The Law of Total Probability • The Substitution Law • Total Probability • Total Expectation • Total Probability and Expectation for Multiple Random Variables • Conditional Expectation **Mixed Random Variables**	21st **18** **Mixed Random Variables** • Mixed Joint CDFs and PDFs • Mixed Versions of Total Probability and Baye's Rule **Types of Random Variables** **The Bivariate Normal Distribution**

Monday	Wednesday
26th **19** **Random Vectors** • Expectation of A Random Vector • Linearity of Expectation • Auto-correlation Matrix • Covariance Matrix • Positive Definiteness • Cross-correlation Matrix • Cross-covariance Matrix • The Multivariate Normal Distribution **Derived Distributions** • Monotonic Functions • Linear Functions	28th **20** **Derived Distributions** • Non-Monotonic Functions • Multivariable Functions • Linear Mappings • A Single Function of Multiple Random Variables • Order Statistics
Apr 2nd **21** **Derived Distributions** • Order Statistics • Sum of Independent Random Variables • Noraml Random Variables in Polar Cooridnates • The Rayleigh Distribution • Simulation of Random Variables • The Box-Muller Method	4th **22** **Generating Functions** • Moment Generating Functions • Region of Convergence • Inversion of MGFs • Properties of MGFs

Monday	Wednesday
9th **23** **Generating Functions** • Probability Generating Functions • Region of Convergence • Properties of PGFs • Random Sums of Random Variables • Laplace and Z transforms • Characteristic Functions • Generating Functions for Random Vectors • Joint Characteristic Functions	11th **24** **Concentration Inequalities** • Markov, Chebychev, and Chernoff Inequalities • Jensen, Holder, and Lyapunov Inequalities **Stochastic Convergence** • Modes of Convergence • Hierarchy of Modes of Convergence
16th **25** **Stochastic Convergence** • Hierarchy of Modes of Convergence • Examples and Counter-examples **Limit Theorems** • Weak Law of Large Numbers • Strong Law of Large Numbers • The Central Limit Theorem • Berry-Esseen Theorem	18th **26** **Statistics** • Point and Interval Estimation of The Mean • One-Sided and Two-Sided Confidence Intervals • Interpretation of Confidence Intervals • Estimation of Variance • Student's T-Statistic

Monday	Wednesday
23rd **27** **Statistics** • Point and Interval Estimation of Proportion • Frequentist (Fisherian) Hypothesis Testing • Parameter Estimation • Properties of Estimators • Method of Moments • Maximum Likelihood Estimation • The Cramér-Rao Bound • Maximum A-Posteriori Estimate • Minimum Mean-Squared Error Estimate	25th **28** **Markov Chains*** • The Markovian Property • Markov Chains • Random Walks • Homogeneous Chains • Transition Matrix • Transition Graph • The Chapman-Kolmogorov Equation • Steady State Behavior of Markov Chains • Categories of States in Markov Chains • Ergodic Markov Chains

*If time permits.

Notes:

- Items marked by * will be covered only if time permits.

Statement on Academic Integrity: USC seeks to maintain an optimal learning environment. General principles of academic honesty include the concept of respect for the intellectual property of others, the expectation that individual work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect one's own academic work from misuse by others as well as to avoid using another's work as one's own. All students are expected to understand and abide by these principles. SCampus, the Student Guidebook, contains the University Student Conduct Code (see University Governance, Section 11.00), while the recommended sanctions are located in Appendix A. See: http://scampus.usc.edu.

Emergency Preparedness/Course Continuity in a Crisis In case of a declared emergency if travel to campus is not feasible, USC executive leadership will announce an electronic way for instructors to teach students in their residence halls or homes using a combination of Blackboard, teleconferencing, and other technologies. See the university's site on Campus Safety and Emergency Preparedness: http://preparedness.usc.edu

Statement for Students with Disabilities: Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to me (or to TA) as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m.5:00 p.m., Monday through Friday. Website: http://sait.usc.edu/academicsupport/centerprograms/dsp/home_index.html

(213) 740-0776 (Phone), (213) 740-6948 (TDD only), (213) 740-8216 (FAX) ability@usc.edu.