USC Viterbi School of Engineering

EE503: Probability for Electrical and Computer Engineers (Fall 2017)

Instructor: Keith M. Chugg
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Office Hours: TBD

TA: TBD

Grader: TBD

Webpage: Piazza Class Page for everything except grades
and USC Blackboard Class Page for grades

– All HWs, handouts, solutions will be posted in PDF format
– *Student has the responsibility to stay current with webpage material*

Prereqs: Multivariable calculus (Math 445 or equivalent)
Fundamentals of Linear System Theory (EE301 or equivalent)

Other Requirements: Basic computer skills (i.e., simple programs and plotting).

Grading: 16% Homework
42% Midterm Exam (1.3 hours)
42% Final Exam (2 hours)

Exam Dates:

- **Midterm Exam:** TBD
- **Final Exam:** TBD

Course Objective: To understand the basic tools of probability and random variables so as to provide a basis for analysis and design in subsequent (electrical and computer) engineering classes. Suitable for any engineering or applied science discipline, including computer science and financial engineering.

Grading Policies:

- **Final grades** will be assigned by a combination of student score distribution (curve) and the discretion of the instructor.
- **Late HW** will not be accepted. A late assignment results in a zero grade.
- **Make-up Exams:** No make-up exams will be given. If you cannot make the above dates due to a class schedule conflict, you must notify me by the last day to add/drop. If I cannot

accommodate your schedule, you must drop the class. In the case of a required business trip or medical emergency, a signed letter from your manager or doctor is required. This letter must include the telephone number of your doctor or supervisor. I must be notified as soon as possible in the case of an emergency.

- **Attendance:** Lecture attendance is encouraged but not mandatory. However, students are responsible for all material presented in lecture.

- **Statement on Academic Conduct:**

  Plagiarism – presenting someone elses ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Section 11, Behavior Violating University Standards https://scampus.usc.edu/1100-behavior-violating-university-standards-and-appropriate-sanctions/. Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on scientific misconduct, http://policy.usc.edu/scientific-misconduct/.

  Discrimination, sexual assault, and harassment are not tolerated by the university. You are encouraged to report any incidents to the Office of Equity and Diversity http://equity.usc.edu/ or to the Department of Public Safety http://capsnet.usc.edu/department/department-public-safety/online-forms/contact-us. This is important for the safety whole USC community. Another member of the university community – such as a friend, classmate, advisor, or faculty member – can help initiate the report, or can initiate the report on behalf of another person. The Center for Women and Men http://www.usc.edu/student-affairs/cwm/ provides 24/7 confidential support, and the sexual assault resource center webpage sarc@usc.edu describes reporting options and other resources.

- **Statement for Students with Disabilities:**

  A number of USCs schools provide support for students who need help with scholarly writing. Check with your advisor or program staff to find out more. Students whose primary language is not English should check with the American Language Institute http://dornsife.usc.edu/ali, which sponsors courses and workshops specifically for international graduate students. The Office of Disability Services and Programs http://sait.usc.edu/academicsupport/centerprograms/dsp/home_index.html provides certification for students with disabilities and helps arrange the relevant accommodations. If an officially declared emergency makes travel to campus infeasible, USC Emergency Information http://emergency.usc.edu/will provide safety and other updates, including ways in which instruction will be continued by means of blackboard, teleconferencing, and other technology.

Textbooks:

- **Required Textbooks:**

  1. A. Leon-Garcia, Probability, Statistics, and Random Processes for Electrical Engineering, 3rd Edition, Addison Wesley, 2012. (early editions are acceptable, just verify any problems assigned)

- **References:**

1. J. A. Gubner, Probability and Random Processes for Electrical and Computer Engineers, Cambridge University Press, 2006.
2. A. Papoulis, Probability, Random Variables, and Stochastic Processes, 3rd Ed., McGraw-Hill, 1991.
3. H. Stark and J. W. Woods, Probability, Random Processes, and Estimation Theory for Engineers, Prentice-Hall, 1986.

Course Outline

Examples and applications will be given throughout the course.

1. Preliminaries [1, 2.1-2.2]
   (a) Mathematical models and physical systems
   (b) Approaches to probability
      i. Relative Frequency Approach (Empirical)
      ii. Axiomatic Definition (Abstract space model)
   (c) Examples
2. Combinatorics (Classical probability using counting techniques) [2.2]
   (a) The "equiprobable assumption"
   (b) Basics
      i. The"multiplicative property"
      ii. Ordering and Replacement
   (c) Sampling with replacement and without ordering
      i. base n numbering
   (d) Sampling without replacement and with ordering
      i. permutations
   (e) Sampling without replacement and without ordering
      i. subpopulations
3. Set Probability Theory [2.4-2.6,2.8-2.9]
   (a) Probability space model and set theory review
   (b) Conditional probability
   (c) Independent events
   (d) Total probability and Bayes' Rule
   (e) Repeated independent Bernoulli trials
      i. Binomial Probability Law
         A. Poisson Law as an approximation
         B. Normal (Gaussian) Approximation
4. Random Variables [3-4]
   (a) Definition
   (b) Complete statistical description
      i. Cumulative Distribution Function (cdf)
         A. Three types of random variables
      ii. Probability Density (mass) Function (pdf)
   (c) Some important random variables
   (d) A rv as a conversion to a standard probability space (abstract space may be unknown)

(e) Complete statistical description conditioned on an event

(f) One rv as a deterministic function of another

i. cdf and pdf of $g(X(u))$

(g) Incomplete statistical descriptions

i. Expectation operator

ii. mean, variance, standard deviation and higher order central and noncentral moments

iii. moments of $g(X(u))$

(h) Alternate complete statistical description

i. Characteristic and/or Moment Generating Function(s)

ii. Moment calculation (definitions) from this complete stat. description

(i) Bounds on tail probabilities

i. Markov's bound and special cases:

A. Chebychev's bound

B. Chernoff's bound

5. Pairs (and finite collections) of random variables [5-6]

(a) Complete statistical descriptions

i. Joint cdf and pdf

ii. Marginal cdf (pdf) and conditional (cdf)

iii. Joint Characteristic Function

(b) Independent random variables

(c) Functions of two (or more) random variables

i. special cases: sums and affine combinations

(d) Vector functions of two or more rv's

i. special case: Affine and linear mappings

(e) Incomplete statistical descriptions

(f) joint moments and the correlation coefficient

MIDTERM (subject to change)

(g) Jointly Gaussian random variables

i. Application: Minimum Mean Square Error (MMSE) Estimation

A. Affine Constraint: relation to correlation coefficient

B. Unconstrained: Conditional Expectation

(h) Extension of the above topics to n dimensional random vectors

i. Correlation and Covariance Martrices

A. Properties

B. Eigen-vector and Eigen-value properties

C. Factorization methods

ii. Effect of linear processing on second moments

   iii. Principle Component Analysis (PCA) via Karhunen-Loeve (KL) expansion
   iv. Simulation and whitening of random vectors
   v. Gaussian random vectors

6. Stochastic Convergence and Introductory Statistics [7.1-7.4, 8.1, 8.4]
   (a) Review of deterministic convergence theory
   (b) Describing convergence in a random environment
   (c) modes of stochastic convergence
   (d) Sampling Distributions
   (e) Sample mean
   (f) Important Examples
      i. Weak Law of Large Numbers (WLLN)
      ii. Strong Law of Large Numbers (SLLN)
      iii. Connection between LLN and two approaches to probability
      iv. Central Limit Theorem
   (g) Confidence intervals for the mean
      i. Known mean, known variance (normal sample)
      ii. Unknown mean, unknown variance (normal sample)
      iii. Method of Batch means
      iv. Bernoulli sample

7. Discrete Time Markov Chains [11.2-11.3]
   (a) Definitions and examples in electrical engineering
   (b) Transient and steady-state behavior
   (c) Classes of states and stationary probability distributions

8. **FINAL EXAM**