USC EE 562a – Introduction to Random Processes for Engineers – Fall 2013

Instructor: Keith M. Chugg
EEB 500A
213-740-7294 (Voice); 213-740-8729 (Fax)
chugg@usc.edu – Include 562a in subject
Office Hours: Tuesday 2:00-4:00, Wednesday 12:30-2:00

TA: Mr. Yongxiong (Roy) Ren
EEB 518
(213) 740-1488 (lab), (213) 814-9456 (cell)
yongxior@usc.edu – Include 562a in subject
Office Hours: Monday, Thursday, 3:00-4:400

Grader: Mr. Fang Yang
fangyang@usc.edu – Include 562a in subject
Office Hours: contact the grader for grading questions only

Lecture: Monday, Wednesday 10:00-12:20 in OHE 100B
Discussion: Friday, 5:00-5:50 in OHE 100C

Webpage: DEN Blackboard System

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

Prereqs: Probability and Random Variables (EE464 or 465)
and Linear Algebra (EE441)
or passing score on placement exams

Other Requirements: Basic computer skills (i.e., simple programs and plotting).
Grading: 10% Homework
36% Midterm Exam (1.3 hours)
54% Final Exam (2 hours)

Exam Dates:

- **Midterm Exam:** Wednesday, Oct. 30, 2012, 11:00-12:20
- **Final Exam:** Wednesday, December 11, 11:00-1:00 (set by university)

Course Objective: To understand the basics of random processes (vectors, sequences, waveforms), second moment descriptions in time and frequency, effects of LTI systems in terms of second moments, and applications to communications, control, and signal processing.

Grading Policies:

- **Final grades** will be assigned by a combination of student score distribution (curve) and 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.

- **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.
- **Academic Integrity Policy:** As per university guidelines published in SCampus

Textbooks:

- **Required Textbooks:**

  1. Supplemental Notes on Random Processes, Prof. Scholtz (posted to Blackboard)

- **Optional Textbooks (ordered):**

  1. A. Leon-Garcia, Probability, Statistics, and Random Processes for Electrical Engineering, 3rd Edition, Addison Wesley, 2012.
  2. H. Stark and J. W. Woods, *Probability, Random Processes, and Estimation Theory for Engineers 4th Ed.*, Prentice-Hall, 2011.

- **Note:** Additional materials will be posted to the class webpage.

Course Outline

1. Preliminaries
   (a) Random process definition
   (b) Complete statistical description
   (c) Second order (incomplete) description
   (d) Complex random processes
2. Random Vectors
   (a) Second order description (mean vector, covariance and correlation matrices, etc.)
   (b) Effect of linear systems on second order random processes
   (c) Three fundamental problems
      i. Simulation (second order)
      ii. Whitening (second order)

iii. Representation (KL Expansion)

(d) Covariance matrix factorization

i. Eigenvectors and Eigenvalues

ii. Cholesky factorization

(e) Hypothesis Testing

(f) Minimum Mean-Squared-Error Estimation Theory

i. The Hilbert Space Projection Theorem

ii. Constrained and unconstrained Solutions

(g) Gaussian Random Vectors

i. Characteristic function, density

ii. Conditional density and the relation to Minimum MSE estimation

iii. Circular complex density

3. MIDTERM (subject to change)

4. Linear Systems and Second Order Random Processes

(a) Eigenvectors of LTI systems

(b) WSS random processes and their relation to LTI systems

(c) WSS/LTI Processing on a finite index set - circulant matrix theory

(d) A detour into modes of stochastic convergence

i. Completeness and Cauchy sequences for second order random processes

5. Random Sequences (discrete time)

(a) Power Spectral Density and the relation to LTI systems

i. The discrete time Wiener-Khintchine Theorem

(b) The three fundamental problems revisited

i. Causal Spectral Factorization for WSS sequences

(c) Minimum MSE Estimation for WSS sequences

i. linear prediction

6. Continuous Time Random Processes

(a) Power Spectral Density and the relation to LTI systems

i. The continuous time Wiener-Khintchine Theorem

(b) The three fundamental problems revisited

i. Causal Spectral Factorization for WSS processes

ii. The (real) K-L expansion

(c) Minimum MSE Estimation for WSS processes

(d) Continuity, Differentiability and Integrability in the mss

7. Classic topics and applications

(a) Ergodicity
(b) Strict Stationarity
(c) Wiener Process and the engineer's "white noise"
(d) Poisson Process and the Random Telegraph Waves
(e) Likelihood functionals for AWGN and matched filters