Boston University
Department of Electrical and Computer Engineering

EC505 – STOCHASTIC PROCESSES, DETECTION, AND ESTIMATION

Information Sheet
Fall 2022

Professor:	David Castañón Rm 434, 8 St. Mary's Street 353-9880, **dac@bu.edu**
Office hours:	Tuesday & Wednesday, 10–11AM
Class:	MW 2:30-4:15, PHO 202
Web Site:	On Blackboard Learn
Required text:	Random Processes for Engineers, Bruce Hajek, Cambridge University Press Older version available as pdf: https://hajek.ece.illinois.edu/Papers/randomprocJuly14.pdf
Notes:	*Course Notes on Stochastic Processes* by D. A. Castañón & W. C. Karl available from the class web site. In addition, other materials will be handed out throughout the term.
Prerequisites:	EC381 or EK500, Introduction to Probability EC401, Signals and Systems MA142, Linear Algebra In general the course assumes a fluency in linear systems as well as basic probability. A facility with linear algebra is strongly recommended and helpful. The subject material demands a high level of maturity, dedication, and commitment to understanding the concepts in depth.
Homework:	Homework will be assigned roughly weekly. They are for you to clear up your confusions with the material through extended thought, to develop proficiency through practice, and to learn the concepts. They must be handed in to me by the date they are due. No late homework will be accepted. Doing the homework will be essential to your understanding of the material. Do not wait till the last minute before doing the homework!
Exams:	There will be 2 exams during the semester and a final during the final exam period. Midterm 1 – 2nd week October Midterm 2 – 2nd week November Final – ???
Grading Policy:	Homework: 25% Midterm 1: 25% Midterm 2: 25% Final: 25%

Course Policies

Academic Conduct

The student handbook defines Academic Misconduct as follows: "Academic misconduct occurs when a student intentionally misrepresents his or her academic accomplishments or impedes other students' chances of being judged fairly for their academic work. Knowingly allowing others to represent your work as theirs is as serious an offense as submitting another's work as your own." This basic definition applies to EC505. If you are ever in doubt as to the legitimacy of an action, please talk to me immediately. The penalities for plagiarism at BU are severe.

Make-ups

There will be no make-up exams. If you have a legitimate excuse, such as illness as documented by a doctor's note, then the scores of your other exams will be weighted more highly to compensate for the missed exam. If you do not have a legitimate excuse, you will be given a grade of zero for the exam.

Incompletes

Incompletes will not be given to students who wish to improve their grade by taking the course in a subsequent semester. An incomplete may be given for medical reasons where a doctor's note is provided. The purpose of incompletes are to allow a student *who has essentially completed the course* and who has a legitimate interruption in the course, to complete the remaining material in another semester. Students will not be given an opportunity to improve their grade by doing "extra work".

Homework, Dates, Etc.

Homeworks are due by 6 pm on the days they are due. Homeworks will be submitted on Gradescope, scanned as pdf documents. Late homeworks will not be accepted. Each homework will be submitted twice, where the second submission will be your corrections of the first submission based on examining the posted solutions. The overall grade for each homework will be based on submission of both the original and corrected homeworks on time, and how well both solutions reflect the answers to the problem.

Students are responsible for being aware of the drop dates for the current semester. Drop forms will not be back-dated.

Collaboration policy:

Students may collaborate on homework, provided this collaboration is acknowledged in the solution. Students are not allowed to collaborate on exams.

Copyright

Reference Texts

1. H. Stark and J. W. Woods, *Probability Random Processes and Estimation Theory for Engineers,* Prentice-Hall, 1986. Nice alternative to text for some topics in the course, especially early on. On reserve.

2. K. Sam Shanmugan, *Random Signals: Detection, Estimation, and Data Analysis,* Wiley, 1988. On reserve.

3. A. Papoulis, *Probability, Random Variables, and Stochastic Processes,* 3rd ed., McGraw-Hill, 1991. On reserve.

4. R. M. Gray and L. D. Davisson,*Random Processes: A Mathematical Approach for Engineers,* Prentice-Hall, 1986. Bridges the gap between formal mathematical texts and engineering texts on probability theory. On reserve.

5. A. Drake, *Fundamentals of Applied Probability Theory,* McGraw-Hill, 1967. Basic engineering text on probability theory.

6. W. Feller, *An Introduction to Probability Theory and Its Applications,* Vols. I and II, Wiley, 1968. Valuable formal reference set on probability theory.

7. S. M. Kay,*Fundamentals of Statistical Signal Processing and Estimation Theory,* Prentice-Hall, 1993. Accessible and thorough treatment of estimation theory.

8. E. Lee and D. G. Messerschmitt,*Digital Communication,* Kluwer Academic, 1988. Advanced reading on applications in communication theory

9. M. Loeve,*Probability Theory I,* Springer-Verlag, fourth ed., 1977. Formal, rigorous treatment of probability theory. A classic.

10. A. V. Oppenheim and R. W. Schafer,*Discrete-Time Signal Processing,* Prentice-Hall, 1989. Standard text on discrete-time linear systems and signals.

11. A. V. Oppenheim and A.S. Willsky, *Signals and Systems,* Prentice-Hall, 1983. Basic undergraduate text on both continuous-time and discrete-time linear systems and signals.

12. E. Parzen,*Stochastic Processes,* Holden-Day, 1962. Classic, formal text on stochastic processes.

13. G. Strang, *Linear Algebra and its Applications,* Harcourt Brace Jovanovich, third ed., 1968. Standard reference text on linear algebra.

14. C. W. Therrien, *Discrete Random Signals and Statistical Signal Processing,* Prentice-Hall, 1992. Very accessible alternative to text for some topics in the course (all done in discrete-time).

15. H. L. Van Trees, *Detection, Estimation and Modulation Theory, Part I*, Wiley, 1968. Classic and valuable reference text on detection and estimation theory

Syllabus
EC505 STOCHASTIC PROCESSES
Fall 2022

Topic	# Lectures	Reading
I. Probability review	2	Ch 1, Hajek; Ch 1, Notes
Probability space, axioms, definitions		
Random variables, random vectors		
Useful families of random variables		
II. Random Vectors and Estimation	4-5	Ch 3, Hajek; Ch 3,4 Notes
Estimation of random variables: MMSE, LLSE		
Estimation of nonrandom variables, Maximum-likelihood		
Bounds on estimation errors		
Discrete time Kalman filtering		
III. Signal detection	3	Notes Ch. 5
Detection/classification of a random variable		
Detection of vectors & disc. time signals		
Exam 1	1	
IV. Characterization of random processes	3–4	Ch 4 Hajek; Ch 6 Notes
Distribution description		
Moments, important classes of processes		
Stationarity, time averages and ergodicity		
V. Discrete State Random Processes	3	Chs 4, 6 Hajek; Ch 7 Notes
Space time structure, discrete and continuous time		
Classification and convergence		
Exit probabilities and exit times		
Birth-death processes, queuing		
Exam 2	1	
VI. Calculus for Random Processes	4	Ch 7 Hajek; Ch 8 Notes
Mean square calculus: differentiation, integration		
Ergodicity		
VII. Linear Systems with random inputs, spectral analysis	3	Ch 8 Hajek; Ch 9 Notes
Power spectral density		
Discrete time linear models		
Shaping filters, Wiener filtering		
VIII. Advanced Topics	?	Ch 9 Hajek; Chs 10, 11 Notes
Karhunen-Loève expansions		
Detection for stochastic processes Wiener and Kalman filtering		
Final Exam		