



Course Syllabus: Stochastic Methods in Engineering - AMCS 308

Division	Computer, Electrical and Mathematical Sciences & Engineering
Course Number	AMCS 308
Course Title	Stochastic Methods in Engineering
Academic Semester	Spring
Academic Year	2017/2018
Semester Start Date	01/28/2018
Semester End Date	05/24/2018
Class Schedule (Days & Time)	04:00 PM - 05:30 PM Mon Wed

Instructor(s)

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Teaching Assistant(s)

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Course Information

Comprehensive Course Description	<p>COURSE OUTLINE: Probability Basics</p> <ul style="list-style-type: none"> •Probability refresher •Conditional Expectation •Bayesian Statistics <p>The Monte Carlo Method</p> <ul style="list-style-type: none"> •Sampling of random variables •The Central Limit Theorem and related results •Convergence rates and condence intervals •Variance reduction techniques •Kernel density estimators •Cherno inequality and large deviations •Resampling techniques <p>Linear and Gaussian Models Discrete Time Markov Chains Bayesian Filters, Kalman Filters and state estimation Continuous-Time Markov Chains</p> <ul style="list-style-type: none"> •Pure jump processes •SSA and Tau leap <p>Markov Chain Monte Carlo</p> <p>Additional topics such as, for instance, Bayesian Experimental Design, Stochastic Control, Model Selection and Model Validation, can be covered along the course, if time allows for, or can be the subject of the course projects.</p>
Course Description from Program Guide	Review of basic probability; Monte Carlo simulation; state space models and time series; parameter estimation, prediction and filtering; Markov chains and processes; stochastic control; Markov chain Monte Carlo. Examples from various engineering disciplines.

Goals and Objectives	The student who follows this course will get acquainted with different mathematical models and computational tools used to analyze systems with uncertainty arising in engineering, physics, chemistry, and economics.
Required Knowledge	The prerequisite for the course is knowledge of basic courses in mathematics, probability, and numerical analysis, or the equivalent. Some experience of computer programming and the use of UNIX/LINUX/WINDOWS systems or personal computers is assumed.
Reference Texts	<ol style="list-style-type: none"> 1. [1] S. Asmussen and P. W. Glynn. Stochastic Simulation: Algorithms and Analysis. Springer, 2007. A broad treatment of sampling-based computational methods with mathematical analysis of the convergence properties of the methods discussed. 2. [2] D. Gamerman and H. F. Lopes. Markov Chain Monte Carlo. Chapman & Hall/CRC, second edition, 2006. 3. [3] P. W. Glynn. Stochastic Methods in Engineering. Stanford University. Lecture Notes for the corresponding course at Stanford. 4. [4] J. Kaipio and E. Somersalo. Statistical and Computational Inverse Problems. Springer, 2005. 5. [5] J. R. Norris. Markov Chains. Cambridge University Press, 1997. Discrete-time and continuous-time Markov chains with applications to simulation in Chemistry and Physics, economics, optimal control, genetics, queues and many other topics. 6. [6] D. S. Sivia and J. Skilling. Data Analysis, a Bayesian Tutorial. Oxford University Press, second edition, 2006. Basic principles of Bayesian probability theory – their use illustrated with examples ranging from elementary parameter estimation to image processing. Other topics covered include reliability analysis, multivariate optimization, least-squares and maximum likelihood, error-propagation, hypothesis testing, maximum entropy and experimental design. 7. [7] J. Voss. An Introduction to Statistical Computing. Wiley, 2014.
Method of evaluation	<p>20.00% - Course Project(s) 10.00% - Presentation 40.00% - Homework /Assignments 30.00% - Final exam</p>
Nature of the assignments	<p>There will be a closed book, classroom, final examination, as scheduled by the registrar during final week. The grading consists of three parts: homework problems, oral presentations and a written exam. The homework and the presentations are carried out by groups of students. Each group hands in a report for each of the assignments, including the final project presentation.</p> <p>Numerical course grades will be determined according to the formula</p> $\text{Total Score} = (30 * (\text{Final Exam}) + 40 * (\text{Average Homework}) + 10 * (\text{Book Chapter presentation}) + 20 * (\text{Final Project Presentation}))/100$
Course Policies	<p>If you have personal activity, a family, or a religious conflict with the course schedule, you may announce it to the instructor. Please contact the instructor by the end of the second week of the term to discuss appropriate accommodations for any conflicts that can be foreseen. For illness-related absences, there are standard procedures to follow.</p> <p>EXAM POLICY: No quizzes or tests other than the final exam will normally be given. Acceptable medical excuses must state explicitly that the student should be excused from class.</p> <p>HONOR CODE: The Academic Honor of KAUST is based on the premise that each student has the responsibility 1) to uphold the highest standards of academic integrity in the student's own work, 2) to refuse to tolerate violations of academic integrity in the University community, and 3) to foster a high sense of integrity and social responsibility on the part of the University community. Please note that violations of this Academic Honor System will not be tolerated in this class. Specifically, incidents of plagiarism of any type or referring to any unauthorized material during examinations will be rigorously pursued by this instructor. Before submitting any work for this class, please make sure you understand the above and ask the instructor to clarify any of its expectations that you do not understand.</p>
Additional Information	

Tentative Course Schedule

(Time, topic/emphasis & resources)

Week	Lectures	Topic
1	Mon 01/29/2018 Wed 01/31/2018	Admin details, probability refresher
2	Mon 02/05/2018 Wed 02/07/2018	probability refresher
3	Mon 02/12/2018 Wed 02/14/2018	Statistics and Bayesian Statistics refresher
4	Mon 02/19/2018 Wed 02/21/2018	Monte Carlo Sampling, error estimation and control
5	Mon 02/26/2018 Wed 02/28/2018	Variance reduction for Monte Carlo, Multilevel Monte Carlo
6	Mon 03/05/2018 Wed 03/07/2018	Kernel Density Estimation and Bootstrapping Techniques
7	Mon 03/12/2018 Wed 03/14/2018	Large Deviation Theory, connections with Importance Sampling
8	Mon 03/19/2018 Wed 03/21/2018	Stochastic Processes refresher
9	Mon 03/26/2018 Wed 03/28/2018	Filtering problem, Kalman Filter
10	Mon 04/02/2018 Wed 04/04/2018	Kalman Filter
11	Mon 04/09/2018 Wed 04/11/2018	Book Chapter presentations
12	Mon 04/16/2018 Wed 04/18/2018	Discrete Markov Chains
13	Mon 04/23/2018 Wed 04/25/2018	Continuous Time Markov Chains
14	Mon 04/30/2018 Wed 05/02/2018	Nested expectations and Optimal Experimental Design
15	Mon 05/07/2018 Wed 05/09/2018	Final Projects
16	Mon 05/14/2018 Wed 05/16/2018	Final Projects presentations
17	Mon 05/21/2018 Wed 05/23/2018	
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Note

The instructor reserves the right to make changes to this syllabus as necessary.