جامعة الملك عبدالله
للعلوم والتقنية
King Abdullah University of
Science and Technology

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	2018/2019
Semester Start Date	01/27/2019
Semester End Date	05/23/2019
Class Schedule (Days & Time)	04:00 PM - 05:30 PM | Mon Wed

Instructor(s)

Name	Email	Phone	Office Location	Office Hours
Raul Fidel Tempone	raul.tempone@kaust.edu.sa	+966128080310		

Teaching Assistant(s)

Name	Email
Gaukhar Shaimerdenova Marco Ballesio	

Course Information

Comprehensive Course Description	COURSE OUTLINE: Probability Basics **•Probability refresher** **•Conditional Expectation** •Introduction to **Bayesian Statistics** The Monte Carlo Sampling Method **•Sampling of random variables** **•The Central Limit Theorem and related results, analysis of the statistical error in the Monte Carlo Method.** **•Convergence rates and confidence intervals** **•Variance reduction techniques** **•Kernel density estimators, sampling with infinite variance.** **•Chernov inequality and large deviations** **•Resampling techniques, non-parametric variability intervals** Linear and Gaussian Models Discrete Time Markov Chains Bayesian Filters, Kalman Filters and state estimation Continuous-Time Markov Chains **•Pure jump processes** **•Stochastic Simulation Algorithm and the Tau leap discretization** Markov Chain Monte Carlo **Additional topics such as, for instance, Bayesian Experimental Design, Stochastic Optimal 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.**
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, commonly known as stochastic simulation and analysis tools, used to analyze systems with uncertainty arising in, among others, 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	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 cov- ered include reliability analysis, multivariate optimization, least-squares and maximum likelihood, error-propagation, hypothesis testing, maxi- mum entropy and experimental design. 7. [7] J. Voss. An Introduction to Statistical Computing. Wiley, 2014.
Method of evaluation	**10.00**% - Scientific review article presentation **40.00**% - Homework /Assignments **30.00**% - Final exam **20.00**% - Course Project(s)
Nature of the assignments	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. Numerical course grades will be determined according to the formula Total Score = (30* (Final Exam) + 40 * (Average Homework) + 10 * (Book Chapter presentation) + 20 * (Final Project Presentation))/100
Course Policies	If you a 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. EXAM POLICY: No quizzes or tests other than the final exam will nor-mally be given. Acceptable medical excuses must state explicitly that the student should be excused from class. HONOR CODE: The Academic Honor of KAUST is based on the premise that each student has the responsibility 1) to uphold the highest stan- dards 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 no understand.
Additional Information	

Tentative Course Schedule

(Time, topic/emphasis & resources)

Week	Lectures	Topic
1	Mon 01/28/2019 Wed 01/30/2019	Admin details, probability refresher
2	Mon 02/04/2019 Wed 02/06/2019	probability refresher
3	Mon 02/11/2019 Wed 02/13/2019	Statistics and Bayesian Statistics refresher
4	Mon 02/18/2019 Wed 02/20/2019	Monte Carlo Sampling, error estimation and control
5	Mon 02/25/2019 Wed 02/27/2019	Variance reduction for Monte Carlo, Multilevel Monte Carlo
6	Mon 03/04/2019 Wed 03/06/2019	Kernel Density Estimation and Bootstrapping Techniques
7	Mon 03/11/2019 Wed 03/13/2019	Large Deviation Theory, connections with Importance Sampling
8	Mon 03/18/2019 Wed 03/20/2019	Stochastic Processes refresher
9	Mon 03/25/2019 Wed 03/27/2019	Filtering problem, Kalman Filter
10	Mon 04/01/2019 Wed 04/03/2019	Kalman Filter
11	Mon 04/08/2019 Wed 04/10/2019	Book Chapter presentations
12	Mon 04/15/2019 Wed 04/17/2019	Discrete Markov Chains
13	Mon 04/22/2019 Wed 04/24/2019	Continous Time Markov Chains
14	Mon 04/29/2019 Wed 05/01/2019	Nested expectations and Optimal Experimental Design
15	Mon 05/06/2019 Wed 05/08/2019	Final Projects
16	Mon 05/13/2019 Wed 05/15/2019	Final Projects presentations
17	Mon 05/20/2019 Wed 05/22/2019	Final Exam Week

Note

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