MATH-463 Stochastic Processes

Credit Hours: 3-0

Prerequisites: MATH-263 Probability Theory

Course Objectives: This course is intended as an introduction to stochastic processes. The course will introduce the students to a broad range of stochastic processes that underlay models in fields such as engineering, computer science, management science, the physical and social sciences, and operations research. The focus of this course will be discrete time Markov chains, continuous Markov processes, Stationary processes, Brownian motion, Poisson Process, Gaussian Process and Stochastic Calculus

Core Contents: Markov Chains, Continuous-Time Markov Chains, Random processes, Stationary processes, Brownian motion, Poisson Process, Gaussian Process and Stochastic Calculus

Detailed Course Contents: Introduction to stochastic process and review of conditional probability. Markov chain computation and mathematical induction. Limiting distribution, stationary distribution, irreducible markov chains, periodicity, ergodic markov chains, time reversibility, absorbing chains, regeneration and the strong markov property. Limit theorems. Branching processes, mean generation size, probability generating functions and extinction probability. Markov chain montecarlo, metropolis–hastings algorithm and gibbs sampler. Poisson process, arrival, interarrival times, infinitesimal probabilities, thinning, superposition, Uniform distribution, spatial poisson process, nonhomogeneous poisson process and parting paradox. Continuous-time markov chains, alarm clocks and transition rates, infinitesimal generator, long-term behavior, time reversibility, queueing theory, poisson subordination. Brownian motion, brownian motion and random walk, gaussian process, Transformations and properties, variations and applications, martingales. Stochastic calculus, ito integral and stochastic differential equations.

Learning Outcomes: The students are expected to understand:

- mathematical aspects of theory of Stochastic Processes
- discrete and Continuous-Time Markov Chains
- Random Processes and Stationary Processes
- Poisson and Gaussian Process
- Stochastic Calculus

Text Book: Robert P. Dobrow, Introduction to stochastic processes with r John Wiley & Sons,Inc., 2016.

Recommended Books

1. Sheldon M. Ross, Introduction to Probability Models (9th Edition) Elsevier 2007.
2. Mark Pinsky, Samuel Karlin, An Introduction to Stochastic Modeling, Elsevier

2007.
3. Samuel Karlin and Howard M. Taylor, A First Course in Stochastic Processes, (2nd Edition), Academic Press, 1975.
4. Cinlar, E., Introduction to Stochastic Processes, Prentice-Hall, Englewood Cliffs, New Jersey, 1975
5. Heyman D., and Sobel, M., Stochastic Models in Operations Research, (Vol. 1), McGraw-Hill, 1982
6. Wolff, R., Stochastic Modeling and the Theory of Queues, Englewood Cliffs, NJ, 1989

Weekly Breakdown		
Week	***Section***	***Topics***
1	1.1-1.5	Introduction to stochastic process and review of conditional probability.
2	2.1-2.6	Markov Chain computation and mathematical induction. Classification of chains
3	3.1-3.5	Limiting Distribution, Stationary Distribution, Irreducible Markov Chains, Periodicity
4	3.6-3.10	Ergodic Markov Chains, Time Reversibility, Absorbing Chains, Regeneration and the Strong Markov Property. Limit Theorems.
5	4.1-4.4	Branching Processes, Mean Generation Size, Probability Generating Functions, Extinction Probability
6	5.1-5.3	Markov Chain Monte Carlo, Metropolis–Hastings Algorithm and Gibbs Sampler
7	6.1-6.4	Poisson Process, Arrival, Interarrival Times, Infinitesimal Probabilities, Thinning, Superposition
8	6.5-6.8	Uniform Distribution, Spatial Poisson Process, Nonhomogeneous Poisson Process and Parting Paradox.
9	**Mid Semester Exam**	
10	7.1-7.3	Continuous-Time Markov Chains, Alarm Clocks and Transition Rates, Infinitesimal Generator,
11	7.4-7.7	Long-Term Behavior, Time Reversibility, Queueing Theory, Poisson Subordination
12	8.1-8.3	Brownian Motion and Random Walk, Gaussian Process
13	8.4-8.6	Transformations and Properties, Variations and Applications, Martingales
14	9.1-9.2	Stochastic Calculus, Ito Integral
15	9.3	Stochastic Differential Equations
16		Applications and Revisions
17		Revision
18	**End Semester Exam**	