Strathmore University

STA 8405- PROBABILITY AND STOCHASTIC PROCESSES

STRATHMORE INSTITUTE OF MATHEMATICAL SCIENCES

Course Outline and Delivery Plan

Course aim: This course is designed to introduce students to ideas of stochastic modelling in the context of practical problems in industry, business, and science. It aims to give a firm foundation of the relevant theory and to develop the ability to formulate practical problems in terms of appropriate stochastic models, and, where appropriate, use the models for forecasting.
Course Objectives (Indicative learning outcomes)
On successful completion of this course students should be able to: • Apply the theory of Markov processes in continuous time and discrete state space, including the global balance equations for equilibrium and the detailed balance equations for reversible processes; • Formulate practical problems in terms of appropriate stochastic models; • Apply a selection of advanced time series models, including hidden Markov models, AR models and transfer function models; • Fit such time series models to observed data using a statistical package such as R, Python, and use them for forecasting;
Contact Hours: 45
Pre- requisite: DSA 8205, DSA 8301
Lecturer Name: Dr. Collins Odhiambo

Course Plan

Week	Topic	Learning outcomes	Learning activities
Week 1	Discrete and continuous stochastic processes.	• Explain meaning of Discrete and continuous stochastic processes. • Explain different stochastic processes. • Evaluate stochastic probabilities using the probability theorems	Use of lectures/ illustrations Questions done / Discussions in pairs/groups Weekly practical Assignment
Week2	Applied stochastic processes including Random walk, Gambler's Ruin problem	Differentiate between Random walk, Gambler's Ruin problem	Use of lectures/ illustrations Questions done / Discussions in pairs/groups Weekly practical Assignment
Week 3-4	Markov chain and Hidden Markov Chain. Convergence stability analysis of discrete Markov	• Explain properties of Markov chain and Hidden Markov Chain. Convergence stability analysis of discrete Markov chains	Use of lectures/ illustrations Questions done / Discussions in pairs/groups Weekly practical Assignment

	chains	• Apply Markov chain and Hidden Markov Chain. Convergence stability analysis of discrete Markov chains to solve real life problems	
Week 5	Branching processes	• Explain properties of Branching processes • Apply Branching processes to solve real life problems	Use of lectures/ illustrations Questions done / Discussions in pairs/groups Weekly practical Assignment
Week 6	Poisson process and continuous time Markov chains	Explain the Poisson process and continuous time Markov chains Evaluate probabilities of Poisson process and continuous time Markov chains and demonstrate its Demonstrate applications in real life	Use of lectures/ illustrations Questions done / Discussions in pairs/groups Weekly practical Assignment
Week 7	Linear systems theory, and AR models, transfer function modelling	▪ Learn the definition of Linear systems theory, and AR models, transfer function modelling variables. ▪ Learn how to use Linear systems theory, and AR models, transfer function modelling to solve real life problms	Use of lectures/ illustrations Questions done / Discussions in pairs/groups Weekly practical Assignment
Week 8	Martingale theory, Brownian motion, diffusion and jump processes.	▪ Define Martingale theory and other associated theorems ▪ Describe Brownian motion ▪ Describe diffusion and jump processes	Use of lectures/ illustrations Questions done / Discussions in pairs/groups Weekly practical Assignment
Week 9-10	Renewal processes, regenerative and renewal-reward processes	Differentiate between Renewal processes, regenerative and renewal-reward processes Evaluate Renewal processes, regenerative and renewal-reward processes	Use of lectures/ illustrations Questions done / Discussions in pairs/groups Weekly practical Assignment
Week 11-12	Queuing Models and systems	▪ Explain M/M/1 models ▪ Evaluate performance measure of a queuing system ▪ Apply queuing systems to solve real life problems	Use of lectures/ illustrations Questions done / Discussions in pairs/groups Weekly practical Assignment
Week 13	Birth and Death processes	▪ Explain Yule Walker Process ▪ Evaluate for pure birth and death process and apply concepts in prediction	Use of lectures/ illustrations/Discussions in pairs/groups Weekly practical Assignment
Week 14	Revision of previous topics	Revise sections of the syllabus using questions from students	Use of lectures and practical Assignment

Week 15	Revision	Revise sections of the syllabus using questions from students	

Teaching and Learning Methods

The course will be a mixture of lectures, discussion of research papers, case studies, tutorials or group discussions, and computer-based practical classes. Exercises from practical classes will be submitted for feedback. Students will also be required to undertake a certain amount of independent study as directed by the instructor. The format will be three (3) lecture hours per week including discussion of research papers, tutorials or group discussions, case studies, practical classes, and independent study.

Assessment

Assessment will comprise Continuous Assessment and End of Semester Examination. Continuous Assessment will comprise two Continuous Assessment Tests, a number of group projects to test the students' ability to apply stochastic models to real phenomena plus an individual project that will test the student's ability to formulate a selected stochastic model to study a substantive real-life problem. The marks will be distributed as follows:

- Continuous Assessment: 40%
- End of Semester Examination 60%

Core Reading Materials

1. Ross, S. M., 2007. Introduction to Probability Models; 9th Edition; London: Academic Press; (The relevant sections of earlier editions are just as good for the purposes of this course.) ISBN: 0125980620, 9780125980623.
2. Tijms, H. C., 2003. A First Course in Stochastic Models; 8th Edition; Chichester: Wiley; DOI: 10.1002/047001363X.
3. Grimmett, G. and Stirzaker, D., 2001. Probability and Random Processes; 3rd Edition; Oxford: Oxford University Press; ISBN: 0198572220

Recommended Reading Materials

1. Durrett R., 2010. Probability: Theory and Examples. 4th Edition. Cambridge University Press.
2. Meyn S., Tweedie R, 1993. Markov chain and stochastic stability, Springer-Verlag.
3. Zucchini, W. and MacDonald, I.L., 2009. Hidden Markov Models for Time Series: An Introduction using R; 6th Edition; Boca Raton: Chapman and Hall/CRC (2009); ISBN: 978-3-642-10382-7, ISBN: 978-3-642-10383-4

Journals

1. Stochastic Processes and their Applications Journal - Elsevier
2. Journal of the American Statistical Association, American Statistical Association
3. Journal of Probability and Statistics, Brazilian Statistical Society
4. Journal of Theoretical Probability, Springer
5. Probability Theory and Related Fields, Springer
6. Theory of Probability and its Applications, Society for industrial and applied mathematics.

Recommended Statistical Software

1. R Studio
2. Python