B.Sc. (Honours) Statistics Degree Program
Faculty of Applied Sciences
University of Sri Jayewardenepura

Course Title	**Stochastic Processes**
Course Code	**STA 331 2.0**
Credit Value	02
Status	Core
Year/ Level	Year 3
Semester	2
Theory: Practical: Independent Learning	30 : 00 : 70
Other: Pre-requisite course/s	STA 114 2.0 Probability and Distribution Theory I, STA 123 2.0 Probability and Distribution Theory II, STA 326 2.0 Programming and Data Analysis with R

Aims of the Course:

The word *stochastic* is jargon for random. Many systems evolve over time with an inherent amount of randomness. A stochastic process is a system which evolves in time or space while undergoing chance fluctuations. We can describe such a system by defining a family of random variables. The aim of this course unit is to introduce the theory of stochastic processes, in particular Markov processes. The theory is illustrated with examples from operations research, biology, finance and economy. The study of probability models for stochastic processes involves a broad range of mathematical and computational tools. This course will strike a balance between the theory and the computing

Intended Learning Outcomes:

On the successful completion of this course, the student should be able to:

1. Define Markov chains in discrete and continuous parameter space.
2. Explain and write logical and coherent proofs for the most important theorems.
3. Distinguish different classes of states in Markov chains and characterize the classes.
4. Calculate probabilities of transition for discrete parameter Markov chains and continuous parameter Markov chains.
5. Solve problems which require the knowledge of basic notions and methods of the theory of discrete parameter Markov chains and continuous parameter Markov chains.
6. Demonstrate capacity for reading and understanding texts and research papers on related topics.

Course Content:

1. Introduction to Stochastic Processes
    - 1.1 Introduction
    - 1.2 Definitions and notations
    - 1.3 Probability theory vs stochastic theory
    - 1.4 Parameter space and State space
    - 1.5 Classification of processes
    - 1.6 Some applications

2. Discrete Parameter Markov Chains
   - 2.1 Introduction
   - 2.2 One-step transition probabilities
   - 2.3 Estimating transition probabilities
   - 2.4 Chapman-Kolmogorov equations
   - 2.5 Higher transition probabilities
   - 2.6 Classification of states
   - 2.7 Limiting probabilities
   - 2.8 Applications
3. Continuous Parameter Markov Chains
   - 3.1 Introduction
   - 3.2 Distribution of length of stay
   - 3.3 Transition probabilities
   - 3.4 Poisson processes
   - 3.5 Birth and death processes
   - 3.6 Applications

Scope and Schedule of Teaching - Learning Activities:

Topic No.	Topic/Sub Topic	No. of Hrs			Teaching Method	Assessment Criteria	ILO Alignment
		T	P	IL			
1	Introduction: Definition, parameter space vs State space, Classification of parameter space, Classification of state space, Classifications of stochastic processes	2	0	4	Lecture/ Practice questions/ Virtual Discussion Forum		1
2	Markov chains: transition probabilities, Chapman-Kolmogrov equations	2	0	4	Lecture/ Practice questions/ Virtual Discussion Forum		1, 2
3	Markov chains: types of states, definitions and theorems (accessible, communication), equivalence class, irreducible	2	0	4	Lecture/ Flipped classroom **Compute transition probabilities using R programming language**		1,2
4	Classification of states and related theorems: recurrent and transient states.	2	0	4	Lecture/ Practice questions/ Virtual Discussion Forum		2 , 3
5	Limiting probabilities, Definitions: period-d, aperiodic, positive recurrent, ergodic, fundamental theorem for Markov chains	2	0	4	Lecture/Practice questions/ Virtual Discussion Forum		2, 3, 4

cont.

Scope and Schedule of Teaching - Learning Activities (cont.):

Topic No.	Topic/Sub Topic	No. of Hrs			Teaching Method	Assessment Criteria	ILO Alignment
		T	P	IL			
6	Continuous parameter Markov chains: transition probabilities, homogeneous transition probabilities, Introduction to Poisson process	2	0	5	Lecture/ Practice questions		2, 4, 5
7	Poisson process	2	0	5	Lecture **FA1: Mid**	40% of Final Marks	2, 4, 5
8	Poisson process (cont.) inter-arrival time, exponential distribution, memoryless property, waiting time, Gamma distribution	2	0	5	Lecture/ Virtual Discussion Forum/ Practice questions		2, 4, 5
9	Thinning/ Splitting of a Poisson process, Compound Poisson process	2	0	5	Lecture/ Practice questions/ Virtual Discussion Forum		2, 4, 5
10	Applications	2	0	5	Lecture/ Kaggle competition		2, 4, 5, 6
11	Non-homogeneous Poisson Process	2	0	5	Lecture/ Practice questions/ Virtual Discussion Forum		2, 4, 5, 6
12	Introduction to birth-and-death process, pure-birth process, recap: partial differential equations	2	0	5	Lecture/Practice questions/ Virtual Discussion Forum		2, 5
13	Pure death process/ Birth-and-death process	2	0	5	Lecture/Online-discussion forum/ Virtual Discussion Forum		2, 5, 6
14	Birth-and-Death Process - important results and applications	2	0	5	Lecture/ Practice questions/ Virtual Discussion Forum		2, 4, 5
15	Recap/ Open questions	2	0	5	Lecture/ Individual presentations of FA 3.		1, 2, 3, 4, 5, 6
	Total	30	00	70			

Linking Program Outcomes with ILOs:

Program Outcomes: B.Sc. Honours degree

1. Demonstrate competency in theoretical knowledge and practical and/or technical skills in the respective field of specialization (statistics).
2. Communicate efficiently and effectively in the respective field of specialization using written, oral, visual and/or electronic forms.
3. Facilitate and participate as an empathetic and emotionally intelligent team player with leadership qualities, in a group, diverse team or organization.
4. Apply subject-specific knowledge and skills creatively to solve real-world problems by making context-specific operational decisions while adapting to changing environments.
5. Integrate creativity, innovation, and entrepreneurial and managerial proficiencies to build values.

6. Implement subject-based solutions in keeping with ethical, societal and environmental norms and need for sustainable development.
7. Secure life goals through lifelong learning with the aim of scholarly advancement and/or strengthening professional skills, and ensuring the betterment of the community.

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7
ILO 1	***	*		*	*		*
ILO 2	***	***		**	*		*
ILO 3	**	**			**		*
ILO 4	***	***			**		*
ILO 5	***	***	***	***	***		**
ILO 6	***	***	***	***	***	***	***

*** - Strongly linked; ** - Medium linked; * - Weekly linked

Mode of Assessment:

Formative Assessment (FA): FA1 = 40% of total marks

Summative Assessment (SA): End Semester Examination: 2-hour paper covering MCQs and or Short Questions, Structured Essay-type questions and Essay-type question = 60% of total marks

References:

- Talagala, T. S. (2020). Course website: STA 331 2.0 Stochastic Processes, *Course website.* https://thiyanga.netlify.app/courses/sta33120_stochastic_processes_2020/
- Ross, S. M. (2014). *Introduction to probability models.* Academic press.
- Pishro-Nik, H. (2016). *Introduction to probability, statistics, and random processes.* https://www.probabilitycourse.com/