SDSC4019: STOCHASTIC PROCESSES AND APPLICATIONS

Effective Term
Semester B 2023/24

Part I Course Overview

Course Title
Stochastic Processes and Applications

Subject Code
SDSC - School of Data Science
Course Number
4019

Academic Unit
School of Data Science (DS)

College/School
School of Data Science (DS)

Course Duration
One Semester

Credit Units
3

Level
B1, B2, B3, B4 - Bachelor's Degree

Medium of Instruction
English

Medium of Assessment
English

Prerequisites
MA2506 Probability and Statistics or MA2510 Probability and Statistics

Precursors
Nil

Equivalent Courses
MA4546 Introduction to Stochastic Processes

Exclusive Courses
Nil

Part II Course Details

Abstract

This course is an introduction to the probability models and stochastic processes (without measure theory) with the focus restricted to discrete time discrete state Markov chain and the applications to network science and data science. It also provides elementary numerical methods for solving real stochastic problems.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Explain concepts of stochastic processes, Markovian property, transition probability and transition matrix	30	x		
2	Describe and understand the theory of discrete time stationary Markov chain	30	x		
3	Perform basic numerical methods to compute limiting distributions and mean first passage time	20		x	
4	Apply basic knowledge of Markov chain to analyze some network and graph problems in data science.	20			x

A1: Attitude
Develop an attitude of discovery/innovation/creativity, as demonstrated by students possessing a strong sense of curiosity, asking questions actively, challenging assumptions or engaging in inquiry together with teachers.

A2: Ability
Develop the ability/skill needed to discover/innovate/create, as demonstrated by students possessing critical thinking skills to assess ideas, acquiring research skills, synthesizing knowledge across disciplines or applying academic knowledge to real-life problems.

A3: Accomplishments
Demonstrate accomplishment of discovery/innovation/creativity through producing /constructing creative works/new artefacts, effective solutions to real-life problems or new processes.

Teaching and Learning Activities (TLAs)

	TLAs	Brief Description	CILO No.	Hours/week (if applicable)
1	Lectures	Learning through teaching is primarily based on lectures.	1, 2, 3, 4	39 hours in total
2	Take-home assignments	Learning through take-home assignments helps students understand basic concepts and theories of the stochastic processes and applications	1, 2, 3, 4	after-class

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks (e.g. Parameter for GenAI use)
1	Test	1, 2, 4	15	Questions are designed for the first part of the course to see how well students have learned the concepts and theories of stochastic processes. (10-30%)
2	Quiz	1, 2, 4	15	These are skills based assessment to help students understand concepts and basic methods in stochastic models. (0-15%)
3	Formative take-home assignments	2, 3, 4	10	The assignments provide students chances to demonstrate their understanding of properties of stochastic process and their achievements on the applications.

Continuous Assessment (%)

40

Examination (%)

60

Examination Duration (Hours)

2

Additional Information for ATs

Note: To pass the course, apart from obtaining a minimum of 40% in the overall mark, a student must also obtain a minimum mark of 30% in both continuous assessment and examination components.

Assessment Rubrics (AR)

Assessment Task

Test

Criterion

Correct application of methods and correct calculations

Excellent (A+, A, A-)

High

Good (B+, B, B-)

Significant

Fair (C+, C, C-)

Moderate

Marginal (D)
Basic

Failure (F)
Not even reaching marginal levels

Assessment Task
Quiz

Criterion
Skills of solving problems

Excellent (A+, A, A-)
High

Good (B+, B, B-)
Significant

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic

Failure (F)
Not even reaching marginal levels

Assessment Task
Formative take-home assignments

Criterion
Submission on time and independent work

Excellent (A+, A, A-)
High

Good (B+, B, B-)
Significant

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic

Failure (F)
Not even reaching marginal levels

Assessment Task
Examination

Criterion
Overall performance of understanding key concepts, applying right methods and performing correct computation

Excellent (A+, A, A-)
High

Good (B+, B, B-)
Significant

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic

Failure (F)
Not even reaching marginal levels

Part III Other Information

Keyword Syllabus

- Review of Probability and basics of stochastic process:

conditional probability and expectation, tower expectation theorem, Wald’ s equality;

stationary, covariance, spectrum; Markov property, definitions of (discrete time) stopping time and martingale;

- Markov chain with a finite number of states:
  i. stochastic matrix, transition matrix, multi-step transition probability; Chapman-Kolmogorov equation, master equation;
  ii. limit distribution, stationary distribution, occupancy measure; communication class; reducible and irreducible, period of Markov chain;
  iii. mean first passage time and distribution of exit location;
  iv. random walk on 1D lattice; gambling ruin problem;
  v. detailed balance, reversibility.
- Generating random variables, Sampling techniques, Variance reduction, Basics of Markov Chain Monte Carlo.
- Applications to some problems in practice such as for network science or data science

Reading List

Compulsory Readings

	Title
1	Lecture note
2	Introduction to Modeling and Analysis of Stochastic Systems, Second Edition, by V.G. Kulkarni, Springer, 2011

Additional Readings

	Title
1	Understanding Markov Chains: Examples and Applications, by Nicolas Privault, Springer Undergraduate Mathematics Series, 2013.

2	Introduction to Probability Models, Tenth Edition, by Sheldon M. Ross, Academic Press, 2009
3	An Introduction to Stochastic Modeling, Third Edition, by Howard Taylor and Samuel Karlin, Academic Press, 1998