City University of Hong Kong
Course Syllabus

offered by School of Data Science
with effect from Semester A 2019/20

Part I Course Overview

Course Title: **Stochastic Processes and Applications**

Course Code: **SDSC4019**

Course Duration: **One Semester**

Credit Units: **3**

Level: **B4**

Proposed Area:
(for GE courses only)

- ☐ Arts and Humanities
- ☐ Study of Societies, Social and Business Organisations
- ☐ Science and Technology

Medium of Instruction: **English**

Medium of Assessment: **English**

Prerequisites:
(Course Code and Title) **MA2506 Probability and Statistics**

Precursors:
(Course Code and Title) **Nil**

Equivalent Courses:
(Course Code and Title) **Nil**

Exclusive Courses:
(Course Code and Title) **Nil**

Part II Course Details

1. Abstract

(A 150-word description about the course)

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.

2. Course Intended Learning Outcomes (CILOs)

(CILOs state what the student is expected to be able to do at the end of the course according to a given standard of performance.)

No.	CILOs#	Weighting* (if applicable)	Discovery-enriched curriculum related learning outcomes (please tick where appropriate)		
			A1	*A2*	*A3*
1.	Explain concepts of stochastic processes, Markovian property, transition probability and transition matrix	30%	√		
2.	Describe and understand the theory of discrete time stationary Markov chain	30%	√		
3.	Perform basic numerical methods to compute limiting distributions and mean first passage time	20%		√	
4.	Apply basic knowledge of Markov chain to analyze some network and graph problems in data science.	20%			√
		100%			

** If weighting is assigned to CILOs, they should add up to 100%.*

 # Please specify the alignment of CILOs to the Gateway Education Programme Intended Learning outcomes (PILOs) in Section A of Annex.

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 self-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.

3. Teaching and Learning Activities (TLAs)

(TLAs designed to facilitate students' achievement of the CILOs.)

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

4. Assessment Tasks/Activities (ATs)

(ATs are designed to assess how well the students achieve the CILOs.)

Assessment Tasks/Activities	CILO No.				Weighting*	Remarks
	1	2	3	4		
Continuous Assessment: 40%						
Test	√	√		√	10~30%	Questions are designed for the first part of the course to see how well students have learned the concepts and theories of stochastic processes.
Quizw	√	√		√	0~15%	These are skills based assessment to help students understand concepts and basic methods in stochastic models.
Formative take-home assignments		√	√	√	10%	The assignments provide students chances to demonstrate their understanding of properties of stochastic process and their achievements on the applications.
Examination: 60% (duration: 2 hours)	√	√	√	√	60%	Examination questions are designed to see how far students have achieved their intended learning outcomes. Questions will primarily be skills and understanding based to assess the student's versatility in concepts and theories of stochastic processes and the applications.
**The weightings should add up to 100%.*					100%	

For a student to pass the course, at least 30% of the maximum mark for the examination must be obtained.

5. Assessment Rubrics

(Grading of student achievements is based on student performance in assessment tasks/activities with the following rubrics.)

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B, B-)	Fair (C+, C, C-)	Marginal (D)	Failure (F)
1. Test	Correct application of methods and correct calculations	High	Significant	Moderate	Basic	Not even reaching marginal levels
2. Quiz	Skills of solving problems	High	Significant	Moderate	Basic	Not even reaching marginal levels
3. Formative take-home assignments	Submission on time and independent work	High	Significant	Moderate	Basic	Not even reaching marginal levels
4. Examination	Overall performance of understanding key concepts, applying right methods and performing correct computation	High	Significant	Moderate	Basic	Not even reaching marginal levels

Part III Other Information (more details can be provided separately in the teaching plan)

1. Keyword Syllabus

(An indication of the key topics of the course.)

- 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:
  - ❖ stochastic matrix, transition matrix, multi-step transition probability; Chapman-Kolmogorov equation, master equation;
  - ❖ limit distribution, stationary distribution, occupancy measure; communication class; reducible and irreducible, period of Markov chain;
  - ❖ mean first passage time and distribution of exit location;
  - ❖ random walk on 1D lattice; gambling ruin problem;
  - ❖ detailed balance, reversibility.
- Application to graph and network science (elementary spectral graph theory): notions of graph; adjacent matrix, Laplacian matrix and its spectrum

2. Reading List

2.1. Compulsory Readings

(Compulsory readings can include books, book chapters, or journal/magazine articles. There are also collections of e-books, e-journals available from the CityU Library.)

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

2.2. Additional Readings

(Additional references for students to learn to expand their knowledge about the subject.)

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