Lingnan University
Course Syllabus

Course Title	:	Stochastic Process
Course Code	:	CDS4007
Recommended Study Year	:	4
No. of Credits/Term	:	3
Mode of Tuition	:	Sectional Approach
Class Contact Hours	:	3 hours per week
Category in Major Prog.	:	Electives
Prerequisite(s)	:	CDS2001 Probability and Statistics 2
Co-requisite	:	Nil
Exclusion	:	Nil
Exemption Requirement	:	Nil

Brief Course Description:

The stochastic process is an important tool in modelling and analysing random patterns in data science, with significant ethical implications in its applications. This course aims to equip students with key concepts and theories in stochastic processes, such as sample space, probability (and conditional probability), expectation (and conditional expectation), discrete time Markov chain, continuous time Markov chain and renewal process. The course provides a rigorous development of relevant concepts and models, emphasizing responsible data science practices. In addition to technical rigorousness, we want to develop our students' ability to apply the theories and models in real applications in various disciplines while considering potential biases and societal impact. This course should help build a solid background in stochastic processes and models for students and enable them to solve real problems of a stochastic nature while adhering to ethical considerations.

Aims:

This course adopts a systematic approach to foster students' understanding of phenomena in various disciplines with a stochastic nature. Students are expected to gain a comprehensive understanding of

1. Understand key concepts and theories in stochastic processes and critically evaluate their potential societal impact;
2. Perform stochastic process-related calculations while identifying and mitigating potential biases within models and datasets;
3. Applications of stochastic process techniques in various disciplines, emphasizing responsible use, transparency, and accountability in decision-making.

Learning Outcomes (LOs):

On completion of this course, students are expected to be able to:

1. Understand key concepts and theories in stochastic processes and critically evaluate their potential societal impact;
2. Perform stochastic process-related calculations while identifying and mitigating potential biases within models and datasets;

3. Apply stochastic processes to model daily activities, communicate findings and limitations to diverse audiences, and analyze the ethical implications in decision-making;
4. Be familiar with the applications of stochastic processes to solve problems in multiple disciplines, ensuring ethical practice and accountability in all applications.

Indicative Contents:

Chapter 1. Random variables:
Definition of random variables; discrete random variables (Bernoulli, Binomial, Geometric and Poisson random variables); continuous random variables (uniform, exponential, Gamma, Normal random variables); expectation of a random variable; jointly distributed random variables; moment generating functions; limit theorems.

Chapter 2. Conditional probabilities and conditional expectation
Conditional probability; independent events; discrete case; continuous case; computing expectations by conditioning; computing probabilities by conditioning; applications in various disciplines (List Model, Random Graph).

Chapter 3. Markov Chains
Introduction; Chapman-Kolmogorov equation; classification of states; limiting probabilities; applications in various disciplines (The Gambler's Ruin Problem; Algorithmic Efficiency; Satisfiability Problem).

Chapter 4. Exponential distribution and Poisson process
Properties of exponential distribution; counting process; Poisson process and its properties; applications in various disciplines (Software Reliability, Car Encounter Problem).

Chapter 5. Continuous-time Markov Chains (CTMC)
Introduction and definition of CTMC; birth and death process; the transition probability function; limiting probabilities; uniformization; applications in various disciplines (Population of Organisms; Machine Breakdown).

Chapter 6. Renewal theory and applications
Distribution of a counting process; limit theorems and applications; renewal reward processes; regenerative processes; applications in various disciplines (The Insurance Ruin Problem; The Inspection Paradox).

Teaching Method:

1) Lectures: Delivery key concepts and main theories, analyze real-world examples where stochastic models were used, highlighting both successes and ethical challenges.
2) In-class exercises: Through some in-class exercises, students can get chance to practice what they have learnt immediately.
3) In-class discussions: Students are required to think and share with others about what they think before we formally address the problems. This should drive students to think about and solve problems independently, considering responsible data science practices.
4) Assignments: Students are expected to finish those assignments after having a clear understanding about what they have learnt in class, and some reasoning is needed, including analysis of potential ethical challenges and societal impact related to their work.

Measurement of Learning Outcomes:

Learning outcome	In-class Participation	Written assignments	Midterm Examination	Final Examination
Understand key concepts and theories in stochastic processes and critically evaluate their potential societal impact. (LO1)	X		X	X
Perform stochastic process-related calculations while identifying and mitigating potential biases within models and datasets. (LO2)	X	X	X	X
Apply stochastic processes to model daily activities, communicate findings and limitations to diverse audiences, and analyse the ethical implications in decision-making. (LO3)	X		X	X
Be familiar with the applications of stochastic processes to solve problems in multiple disciplines, ensuring ethical practice and accountability in all applications. (LO4)	X	X	X	X

Assessment:

In-class Participation	10%
Attendance	
In-class exercises	
Active participation in in-class discussion	
Written assignments	40%
Midterm Examination	20%
Final Examination	30%
Final	100%

Required/Essential Readings:

1. Sheldon M. Ross, *Introduction to Probability Models*, Academic Press, 2023.

Recommended/Supplementary Readings:

1. Durrett, R. (2016). *Essentials of Stochastic Processes* (Springer Texts in Statistics). Springer. 2016 Edition.
2. Ghahramani, S. (2018). *Fundamentals of Probability: With Stochastic Processes.* Chapman and Hall/CRC.
3. Dobrow, R. P. (2016). *Introduction to Stochastic Processes with R*. John Wiley & Sons.
4. Kulkarni, V. G. (2016). Modeling and Analysis of Stochastic Systems. Chapman and Hall/CRC.
5. Ananth, C., Anbazhagan, N., & Goh, M. (Eds.). (2023). Stochastic Processes and Their Applications in Artificial Intelligence. IGI Global.
6. Ghahramani, Z. (2015). Probabilistic machine learning and artificial intelligence. Nature, 521(7553), 452-459.

Important Notes:

(1) Students are expected to spend a total of 9 hours (i.e. 3 hours of class contact and 6 hours of personal study) per week to achieve the course learning outcomes.

(2) Students shall be aware of the University regulations about dishonest practice in course work, tests and examinations, and the possible consequences as stipulated in the Regulations Governing University Examinations and Coursework. In particular, plagiarism, being a kind of dishonest practice, is "the presentation of another person's work without proper acknowledgement of the source, including exact phrases, or summarised ideas, or even footnotes/citations, whether protected by copyright or not, as the student's own work". Students are required to strictly follow university regulations governing academic integrity and honesty.

(3) Students are required to submit writing assignment(s) using Turnitin.

(4) To enhance students' understanding of plagiarism, a mini-course "Online Tutorial on Plagiarism Awareness" is available on https://pla.ln.edu.hk/.

(5) Students must adhere to the University's guidelines and practices when using Generative Artificial Intelligence (GAI) tools. The official documents *"Guidelines for Using GAI Tools at Lingnan University" and "Best Practices for Ethical and Responsible Use of GAI Tools in Course Assessments" can be found here: https://www.ln.edu.hk/tlc/generative-artificial-intelligence/gai-guidelines-best-practices* .

Rubric for In-Class Participation of CDS4007 – Stochastic Process

Criteria	Excellent	Good	Needs Improvement	Unacceptable
Attendance (60%)	Less than three absences throughout the semester (60 marks)	Three to five absences throughout the semester (40 marks)	Six to eight absences throughout the semester (20 marks)	Nine or more absences throughout the semester (0 mark)
In-Class Exercises (20%)	Able to work out most in-class exercises independently (20 marks)	Able to work out many in-class exercises independently (14 marks)	Able to work out some in-class exercises with some hints (7 marks)	Unable to work out in-class exercises (0 mark)
In-Class Participation in Discussion (20%)	Proactively shares views and thoughts in class (20 marks)	Able to respond to questions properly without any hints (14 marks)	Able to respond to questions with some hints (7 marks)	Unable to respond to questions (0 mark)

Rubric for Written assignments of CDS4007 – Stochastic Process

Criteria	Excellent	Good	Needs Improvement	Unacceptable
Understand key concepts and theories in stochastic process (20%)	Understands most concepts and tools/theories to solve problems (16-20 marks)	Know the major concepts and tools/theories to solve problems (11-15 marks)	Know some basic concepts and tools/theories to solve problems (6-10 marks)	Unable to link concepts, tools/theories to problem solving (0-5 marks)
Familiarity with stochastic process related calculations (40%)	Grasps all the major techniques to perform stochastic process related calculations (31-40 marks)	Understands most of the major techniques to perform stochastic process related calculations (21-30 marks)	Understands some basic techniques to perform stochastic process related calculations (11-20 marks)	Fails to apply suitable techniques to perform most stochastic process related calculations (0-10 marks)
Apply critical thinking skills to model daily activities (20%)	Able to apply stochastic process models to model most daily activities (16-20 marks)	Able to apply stochastic process models to model some daily activities (11-15 marks)	Able to apply stochastic process models to model very basic daily activities (6-10 marks)	Fails to apply stochastic process models to model daily activities (0-5 marks)
Familiarity with the applications of stochastic process (20%)	Understands what concrete techniques to apply in all application problems (16-20 marks)	Understands what concrete techniques to apply in most application problems (11-15 marks)	Capable of identifying relevant techniques for some applications (6-10 marks)	Can occasionally identify relevant techniques for applications (0-5 marks)

Rubric for Midterm Examination of CDS4007 – Stochastic Process

Criteria	Excellent	Good	Needs Improvement	Unacceptable
Understand key concepts and theories in stochastic process (20%)	Understands most concepts and tools/theories to solve problems (16-20 marks)	Knows the major concepts and tools/theories to solve problems (11-15 marks)	Knows some basic concepts and tools/theories to solve problems (6-10 marks)	Unable to link concepts, tools/theories to problem solving (0-5 marks)
Familiarity with stochastic process related calculations (40%)	Grasps all the major techniques to perform stochastic process related calculations (31-40 marks)	Understands most of the major techniques to perform stochastic process related calculations (21-30 marks)	Understands some basic techniques to perform stochastic process related calculations (11-20 marks)	Fails to apply suitable techniques to perform most stochastic process related calculations (0-10 marks)
Apply critical thinking skills to model daily activities (20%)	Able to apply stochastic process models to model most daily activities (16-20 marks)	Able to apply stochastic process models to model some daily activities (11-15 marks)	Able to apply stochastic process models to model very basic daily activities (6-10 marks)	Fails to apply stochastic process models to model daily activities (0-5 marks)
Familiarity with the applications of stochastic process (20%)	Understands what concrete techniques to apply in all application problems (16-20 marks)	Understands what concrete techniques to apply in most application problems (11-15 marks)	Capable of identifying relevant techniques for some applications (6-10 marks)	Can occasionally identify relevant techniques for applications (0-5 marks)

Rubric for Final Examination of CDS4007 – Stochastic Process

Criteria	Excellent	Good	Needs Improvement	Unacceptable
Understand key concepts and theories in stochastic process (20%)	Understand all/most concepts and tools/theories to solve problems (16-20 marks)	Know the major concepts and tools/theories to solve problems (11-15 marks)	Know some basic concepts and tools/theories to solve problems (6-10 marks)	Unable to link concepts, tools/theories to problem solving (0-5 marks)
Familiarity with stochastic process related calculations (40%)	Grasp all the all/major techniques to perform stochastic process related calculations (31-40 marks)	Understand most of the major techniques to perform stochastic process related calculations (21-30 marks)	Understand some basic techniques to perform stochastic process related calculations (11-20 marks)	Fails to apply suitable techniques to perform most stochastic process related calculations (0-10 marks)
Apply critical thinking skills to model daily activities (20%)	Able to apply stochastic process models to model all/most daily activities (16-20 marks)	Able to apply stochastic process models to model some daily activities (11-15 marks)	Able to apply stochastic process models to model very basic daily activities (6-10 marks)	Fails to apply stochastic process models to model daily activities (0-5 marks)
Familiarity with the applications of stochastic process (20%)	Understand what concrete techniques to apply in all application problems (16-20 marks)	Understand what concrete techniques to apply in most application problems (11-15 marks)	Capable of identifying relevant techniques for some applications (6-10 marks)	Can occasionally identify relevant techniques for applications (0-5 marks)