Stochastic Modeling (MATH3425, HKUST)

Course outline 2024-2025 Spring

1 *Instructor & T.A.* .

Instructor: Kani Chen. Email: makchen@ust.hk; Phone: 2358-7425; Office: Room 3426. Office hour: Walk-in or by appointment.

TA: TBA

2 *Textbook & Reference Books*.

Lecture Notes: In the LALA system.

Textbook: An Introduction to Stochastic Modeling. (Academic Press 3rd Edition, 1998, ISBN012848874) by H.M. Taylor and S. Karlin.

(Or: An Introduction to Stochastic Modeling. (Academic Press 4th Edition, 2011, ISBN9780123814166) by M. A. Pinsky and S. Karlin.)

(The above two books are largely one same book, though we use the first one.)

Reference books: 1. Stochastic Modeling and the Theory of Queues. (Prentice-Hall International Edition) by R.W. Wolff. 2. Probability and Random Processes. 2nd edition. (Oxford Science Publications) by G.R. Grimmett & D.R. Stirzaker.

3 *Intended Learning Outcomes*:

Students will understand random processes such as Markov chains, Poisson processes, branching processes, birth/death processes and renewal processes and Brownian motion, and use them as models in real applications.

4 *Gradings and Exams*:

Homework (50%) and Final Exam (50%).

Final exam is open book.

Homework assessment: $0.5c/n + 0.5f(n/N)$, where $f(x) = ((x - 0.05)_+/.95)^{.25}$.

N is the total number of problems listed in the LALA, weighted by difficulty; n is the total number of problems you tried, weighted by difficulty; c is the total number of problems you solved correctly, weighted by difficulty.

For the j-th exercise/problem/DIY problem, listed in the LALA system, its difficulty is $d_j = m_j/(c_j + m_j)$ where c_j (m_j) is the number of students who did the j-th problem correctly (incorrectly). (A special case: $d_j = 1$ if $c_j + m_j \leq 3$.)

5 *Prerequisites*:

Math2421 (Probability) or equivalents.

6 *Course AI Policy*

Students are allowed to consult any person (including the instructor, TA, classmates, friends outside HKUST) in any homework for ideas and hints, but are required to write up the solutions by themselves. You are required to list the persons and references you have consulted in every homework.

The use of ChatGPT or other generative AI is allowed, and they are regarded as persons you have consulted, and therefore must be listed in your homework. However, please be warned that at the current stage of development of AI, the response to problems in advanced courses especially those

in pure mathematics is not quite reliable. Students should be critical of the response generated by AI and do not blindly copy the generated responses to your homework.

7 *Letter Grades*

Students should aim at getting a course total of 85% or above for A-/A/A+, and about 60% or above for B-/B/B+. For getting A- or above, students will need to achieve 85% of the course total.

8 *Grades Short Description*

A (Excellent Performance) The student has mastered almost all concepts and techniques of stochastic process taught in the course, has excellent understanding of the deepest content of the subject, and acquired workable knowledge for further studies

B (Good Performance) The student has mastered most computational techniques of stochastic process taught in the course, yet the understanding of some challenging concepts may not be deep enough for further studies on related advanced subjects.

C (Satisfactory Performance) The student meets the minimum expectation of the instructor, has acquired some basic computational techniques of the subject, yet some concepts were not clearly understood.

D (Marginal Pass) The student is only able to recall some fragments of topics and is able to complete some of the easiest computations.

F (Fail) The student does not have sufficient understanding of even some fragments of topics, and is not even able to complete some of the easiest computations.

9 *Tentative Schedules*.

Wk 1. (Ch.1-2, all sections). Review of the fundamentals of probability theory.

Wk 2-5. (Ch.3, sections 3.1-3.4; 3.8-3.9). Introduction to Markov chains: definitions, transition probability matrices, some Markov models, first step analysis; branching processes, branching processes and generating functions.

Wk 6-7. (Ch.4, sections 4.1-4.3). Markov chains: regular transition probability matrices, limit theorems, classification of states.

* Reading: basic limit theorems. (section 4.4).

Wk 8-9. (Ch.5, sections 5.1-5.3). Poisson processes: Poisson distribution and the Poisson process, the law of rare events, distributions,

* Reading: uniform distribution and Poisson processes. (section 5.4).

Wk 10-11. (Ch.6, sections 6.1-6.2). Continuous time Markov chains: birth-death processes.

* Reading: the limiting behavior, finite state continuous time Markov chains. (sections 6.4-6.5).

Wk 12-13. (Ch.7, sections 7.1-7.4). The renewal phenomena: definitions, examples, Poisson process viewed as renewal process, asymptotic theory.

Wk ... (Ch.8, sections 8.1-8.3). Introduction to Brownian motion (if time allows.)

Remark: The above course schedule may be subject to minor changes depending upon the teaching progress.