Department of Statistics & Informatics

College of Administration and Economics

University of Salahaddin -Erbil

Subject: Stochastic Processes

Course Book: Fourth stage (1st Course)

Lecturer's Name: Dr. Drakhshan Jalal Hassan

Academic Year: 2023 - 2024

Course Book

1. Course name	Stochastic Processes
2. Lecturer in charge	Dr. Drakhshan Jalal Hassan
3. Department/ College	Statistics & Informatics /College of Administration and Economics
4. Contact	e-mail: drakhshan.hassan@su.edu.krd Mobile:07504902074
5. Time (in hours) per week	Theory: (2 hours) Practical: (1 hour)
6. Office hours	Sunday 8:30 AM to 12:30 PM Tuesday 9:30 AM to 11:30 AM
7. Course code	
8. Teacher's academic profile	I graduated from Salahaddin University-Erbil in 2003 in College of Administration & Economics Statistics department.in 2011, I had master's degree in Statistics from the same university, and I start as assistant lecturer teaching in Statistics department teaching Principle of Statistics, Computer Applications, Operation Research and supervising BSc. students. From 2018, my scientific level changes to lecture, after that I accepted in the PhD in the same college. In 2023, my scientific level changes to assistant professor. Now I am teaching Stochastic Process in the same department.
9. Keywords	probability theory, stochastic process, random process, Markov chain, probability distributions

In probability theory, a stochastic process, or often random process, is a collection of random variables, representing the evolution of some system of random values over time. This is the probabilistic counterpart to a deterministic process (or deterministic system). Instead of describing a process which can only evolve in one way (as in the case, for example, of solutions of an ordinary differential equation), in a stochastic or random process there is some indeterminacy: even if the initial condition (or starting point) is known, there are several (often infinitely many) directions in

which the process may evolve. In the simple case of discrete time, as opposed to continuous time, a stochastic process involves a sequence of random variables and the time series associated with these random variables (for example, see Markov chain, also known as discrete-time Markov chain). One approach to stochastic processes treats them as functions of one or several deterministic arguments (inputs; in most cases this will be the time parameter) whose values (outputs) are random variables: non-deterministic (single) quantities which have certain probability distributions. Random variables corresponding to various times (or points, in the case of random fields) may be completely different. The main requirement is that these different random quantities all take values in the same space (the codomain of the function). Although the random values of a stochastic process at different times may be independent random variables, in most commonly considered situations they exhibit complicated statistical correlations.

11. Course objective:

The students who succeeded in this course; At the end of the course the students are expected to:

1) Know the properties and usage of special probability distributions.

2) Understand the notion of stochastic process and analyse different types of stochastic processes.

3) classify states and compute probabilities for Markov Chains.

4) Model different real-life situations with the help of stochastic processes topological space instead of limited to real values representing time.

12. Student's obligation

Students are expected to:

❖ Follow university policies when attending class and lab, and taking sudden quizzes and exams.

❖ Student should be proud of the work that he/she do in this class. Do not allow someone else to copy your homework and do not provide answers to quizzes or tests. If this does occur, credit will be lost and a referral will be written.

13. Forms of teaching

The focus will be on some forms of teaching such as classical teaching with PowerPoint presentations for the head titles, whiteboard, definitions and summary of conclusions, classification of materials and any other illustrations, solving the examples by sharing the students to get them will understand, and students should participate as much as possible in lecture's discussions.

14. Assessment scheme

During the academic semester the exam is closed book. There for I grade will be based upon the following criteria:

The student must be examined twice in each course. The last grade is (30).

Putting grades for daily activities, homework, for (10) marks.

The annual work of the material (40) marks.

The final exam out of (60) marks.

15. Student learning outcome:

After the completion of this course in this academic semester, the students will be able to do the following:

- On successful completion of the course, students should be able to:
- Explain fundamentals of probability theory, random variables and random processes.
- Understand the mathematical concepts related to probability theory and random processes.
- Understand the characterization of random processes and their properties.
- Formulate and solve the engineering problems involving random processes.
- Analyse the given probabilistic model of the problem.
- Make precise statements about random processes.
- Use computational techniques to generate simulation results.

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16. Course Reading List and References:

1) Jason L. Speyer, Walter H. Chung (2008). Stochastic Processes, Estimation, and Control, University of California, Los Angeles
2) Hwei P. Hsu (1997). Theory and Problems of Probability, Random Variables, and Random Processes, Fairleigh Dickinson University, The McGraw-Hill Companies
3) Y. Suhov and M. Kelbert (2008). Probability and Statistics by Example: II Markov Chains: a Primer in Random Processes and their Applications

17. The Topics:		**Lecturer's name**
Week-1	**Capter-1**: Probability Theory 1.1 Probability Theory as a Set of Outcomes 1.2 Set Theory	Dr. Drakhshan Jalal Hassan Three hours a week

	1.3 Probability Space and the Probability Measure	
Week-2	1.4 Key Concepts in Probability Theory and exercise	
Week-3	**Capter-2:** Random Variables and Stochastic Processes 2.1 Random Variables 2.2 Probabilistic Concepts Applied to Random Variables	
Week-4	2.3 Functions of a Random Variable 2.4 Expectations and Moments of a Random Variable	
Week-5	2.5 Probability generating Function 2.6 Stochastic Processes , Extending the Concept of Random Vectors	
Week-6	**Capter-3 :** Stochastic Processes Solved Problems About Stochastic Processes	
Week-7	3-1 CLASSIFICATION of stochastic process 1. Stochastic Processes with Discrete Parameter and State Spaces with examples. 2. Stochastic Processes with Continuous Parameter and Discrete State Space with examples. 3. Stochastic Processes with Discrete Parameter and Continuous State Space with examples. 4. Stochastic Processes with Continuous Parameter and State Spaces with examples.	
Week-8	3-2 A. Stationary Processes B. Wide-Sense Stationary Processes Solved Problems About Stationary Processes & Wide-Sense Stationary Processes	
Week-9	C. Independent Processes. D. Processes with Stationary Independent Increments Solved Problems about Independent Processes & Processes with Stationary Independent Increments	
Week-10	**Capter-4 :** 4-1 Markov Processes Solved Problems about Markov Processes	
Week-11	4-2 Discrete-Parameter Markov Chains A. Transition Probability Matrix	

Week-12	Solved Problems about Discrete-Parameter Markov Chains & Transition Probability Matrix	
Week-13	B. Higher- Order Transition Probabilities-Chapman-Kolmogorov Equation C. The Probability Distribution of $\{x_n, n \geq 0\}$	
Week-14	Solved Problems about Higher- Order Transition Probabilities-ChapmanKolmogorov Equation & The Probability Distribution of $\{x_n, n \geq 0\}$	
Week-15	D. Classification of States Solved Problems about Classification of States	

18. Examinations:

1. In New England, 84% of the houses have a garage and 65% of the houses have a garage and a back yard. What is the probability that a house has a back yard given that it has a garage?
2. bag contains 7 yellow balls and 5 red balls. One ball is taken from the bag at random and is not replaced. A second ball is then taken from the bag. Determine the probability that at least one ball is yellow?
3. Find the mean and variance for binomial distribution by p.g.f
4. define

1-Sample Space 2-Stochastic Processes 3-Stationary independent increment 4-Random variable 5-Number of success

5. Difference between (stochastic process and probability) with example
6. Classification Stochastic Process.
7. Find the transition Matrix.

- What is the probability that he has lost all his money at the end of 2 plays.
- How many communicating state, absorbing state, Irreducible Markov chain with transition diagrams.

8. If you have the transition Matrix? Find M and F

$$P= \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0.6 & 0.3 & 0.1 & 0 \\ 0.3 & 0 & 0.2 & 0.5 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

9-A psychologist makes the following assumptions concerning the behavior of mice subjected to a particular feeding schedule. For any particular trial 80% of the mice that went right in the previous experiment will go right in this trial, and 60% of those mice that went left in the previous experiment will go right in this trial. If 50% went right in the first trial, what would he predict for
(a) The second trial? (b) The thousandth trial

$$P = \begin{pmatrix} 0.3 & 0.2 & 0.1 & 0.4 \\ 0 & 0 & 1 & 0 \\ 0.6 & 0.2 & 0 & 0.2 \\ 0.4 & 0.2 & 0 & 0.4 \end{pmatrix}$$

10- If you have the transition Matrix?

- Find the transition diagrams.
- How many communicating state, absorbing state, Irreducible Markov chain and Transient and Recurrent States.

11- for the experiment of tossing a coin
(a) once and (b) twice. Explain each of them (trial, outcome, random experimental, sample space, events)? and what difference between sample space and Events.

19 Extra notes

If any student cannot make it to an in-class exam due to a documentable reason, please let me know as soon as possible. Makeup will not be allowed for home works. However, I will double count student's future graded assignments in the cases of excused absences.

20. Peer review