BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, Pilani
Pilani Campus
AUGS/ AGSR Division

SECOND SEMESTER 2020-21
COURSE HANDOUT

Date: 16.01.2021

In addition to part I (General Handout for all courses appended to the Time table) this portion gives further specific details regarding the course.

Course No	:	**MATH F424**
Course Title	:	**Stochastic Processes and their Applications**
Instructor-in-Charge	:	**Dr. Anirudh Singh Rana**
Instructor(s)	:	**Dr. Anirudh Singh Rana**
Tutorial/Practical Instructors:		**Dr. Anirudh Singh Rana**

1. Course Description:

A stochastic process is a mathematical model describing the evolution of a system via sequences of random events. Stochastic processes, as a branch of statistics, finds its applications in many disciplines including core sciences such as biology, chemistry, economics, ecology, finance, neuroscience, and physics as well as technology and engineering related fields such as the modelling of spread of infectious diseases, the evolution of genetic sequences, models for climate change, reliability theory, image processing, signal processing, information theory, computer science, cryptography and telecommunications.

2. Scope and Objective of the Course:

The primary objective of this course is to familiarize students with the fundamental concepts and simulation techniques of probability theory and stochastic process.

3. Text Books:

1. J. Medhi, Stochastic Processes, New Age International Publication, 4th edition, 2009.

4. Reference Books:

1. S. Karlin and H. M. Taylor, First Course in Stochastic Processes, Academic Press, 2nd edition, 1975.
2. P.G. Hoel, S.C. Port and C.J. Stone, Introduction to Stochastic Processes, 1st edition, Waveland Pr Inc (1 December 1986).
3. V.G. Kulkarni, Introduction to Modseling and Analysis of Stochastic System, Springer, 2nd edition, 2011.
4. S.M. Ross, Stochastic Processes, Wiley; 2 edition (February 8, 1995).
5. M. Lefebvre, Applied Stochastic Processes, Springer, New York, NY, 2006.

5. Course Plan:

Module No.	Lecture Session	Reference	Learning outcomes
M.1	**L1.1**: Axiomatic construction of probability spaces, random variables and vectors, probability distributions, joint and conditional distributions, **L1.2**: Conditional expectation and properties, functions of random variables; mathematical expectations, **L1.3**: Transforms and generating functions, laws of large numbers, central limit theorem. **LAB1.1** based on Generation random variables of probability distribution, Monte Carlo integration	**R-1** **R-5**	Review of Probability Theory
	.	**T-1**	

M.2	**L2.1 Definition and examples of SPs**, classification of random processes according to state space and parameter space, types of SPs, elementary problems. **L2.2-2.3 Stationary Process**: Weakly stationary and strongly stationary processes, moving average and auto regressive processes.	**T-1** Chapter 1 Sec 1.5	By the end of module students are able to appreciate the basics of Stochastic Process and Stationary Processes
M.3 (Lecture No. 9-15)	**L3.1** Definition of Markov chain with denumerable state space, **L3.2** Transition probability matrix, order of Markov chain, **L3.3** Markov chain as graphs, higher transition probabilities, **L3.4** Generalization of independent Bernoulli trials, classification of states and chains, **L.3.5-3.6** Stability of Markov systems, graph theoretic approach. **LAB 2.1** based on Stationarity of Markov chain.	**T-1** Chapter 2 Sec 2.1-2.7	Know Markov chains and their properties
M.4	**Continuous-time Markov Chains** (CTMCs): **L4.1** Poisson process, Poisson process and related distributions, **L4.2** Generalization of Poisson process, **L4.3** Pure birth process, birth-death process, **L4.4-4.5** Applications to queueing theory and communication networks. **LAB 3.1** based on calculation of probabilities for given birth and death rates, birth-death Process.	**T-1** Chapter 3 Sec 3.1-3.5	By the end of module students are able to analysis of models, that are characterized as discrete valued continuous time Markov chain (CTMC)
LAB 3		-	
Module 5	**Continuous time and continuous state space**: **L5.1** Brownian motion **L5.2-5.4** Wiener process, differential equation for Wiener process as a limit of random walk; Kolmogorov equations, **L5.5-5.6** Applications to finance and communication networks.	**T-1** Chapter 4 Sec 4.1-4.5	Students can understand of very special stochastic process in continuous time and continuous state space.
Module 6	**L 6.1-6.2 Martingales**: Definition and examples of martingales. **Lab 4.1** based on Brownian motion.	**T-1** Chapter 5 Sec 5.1-5.2	
Module 6	**L6.1-6.2 Renewal Processes** in discrete and continuous time **L6.3-6.4** Renewal equation, stopping time: Wald equation **L6.5-6.6** Renewal theorems **L6.6-6.8** Cost/rewards associated with renewals. Renewal Reward.	**T-1** Chapter 6 Sec 6.1- 6.5, 6.8.	Students are able to explain the key results of renewal processes in real life situations.

Module 7	**Branching Processes**: **L7.1** Galton-Watson branching process **L7.2-7.3** Definition and examples branching processes, probability generating function, mean and variance, probability of extinction.	**T-1** Chapter 9 Sec 9.1-9.3.	Motivate to apply the probability theory to study objects that can generate the object of similar kind.

6. Evaluation Scheme:

Component	**Duration**	**Weightage (%)**	**Date & Time**	**Nature of component (Close Book/ Open Book)**
Mid-Semester Test	90 Min.	30%	Will be announced by AUGSD-AGSRD	Open book
Comprehensive Examination	2 h	35%	Will be announced by AUGSD-AGSRD	Open book
Quizzes 2 (1 theory + 1 lab)	40 Min. each	20%	To be announced in class	Open Book
Project/Lab		15%	To be announced in class	Open Book

7. Chamber Consultation Hour: TBA (via Google Meet).

8. Notices: All notices related to this course will be put only on Nalanda.

9. Make-up Policy: Make-up for any component of evaluation will be given **only** in genuine cases of absence.

Dr. Anirudh Singh Rana

Instructor-in-charge
Course No. MATH F424