Indian Institute of Technology, Kanpur
Department of Physics

PHY662A: Theory of Random Processes and Applications

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Course Description:

A) Objectives: Random processes are ubiquitous in nature. In this course a student will learn the theoretical techniques for quantitative analysis of such processes **from the perspective of physicists**. No existence and uniqueness theorem will be proved. Instead, methods will be presented with a flavor of **statistical physics**. Emphasis will be on understanding the concepts and techniques through applications. The key ideas will be explained with examples drawn not only from physics but also from several other disciplines, like chemistry, biology, cognitive science, ecology and environmental sciences.

B) Contents:

1. Probability and statistics: common examples of probability distributions (2 Lec)
2. Noise and fluctuations: noisy signals in time and frequency domains (2 Lec)
3. Random processes: common examples and their physical realizations (2 Lec)
4. Stochastic calculus: Stochastic differential equations, Stochastic integrals; applications to Brownian motion- Langevin and Fokker-Planck equations; Wiener and Ornstein-Uhlenbeck processes; Brownian oscillator and applications (6 Lec)
5. Markov processes in discrete time: Markov chains, Monte Carlo, Ergodicity (3 Lec)
6. Markov processes in continuous time: random walk and diffusion; chemical master equation; applications to single-molecule enzymology and chemical biology (6 Lec)
7. Asymmetric Simple Exclusion Process (ASEP), Exclusive Queueing Process (EQP), Zero-Range Process (ZRP) and applications in traffic science and engineering (6 Lec)
8. Level-crossing by random excursions in sequential processes: first-passage times; applications to mental chronometry of decision making in cognitive sciences (6 Lec)
9. Extreme value statistics: applications in dynamical modeling of environmental phenomena- extremes of climate, hydrology, forest fires and avalanches (6 Lec)
10. Wright-Fisher and Moran processes: models of biological evolution (3 Lec)

Text books:

(i) Random Processes: first passage and escape, J. Masoliver (World Scientific, 2018).
(ii) Stochasticity in Processes: fundamentals and applications, P. Schuster (Springer, 2016).

Evaluation Components & Policies:

End-semester Examination (weightage: 50%).
Term Paper (In lieu of Mid-semester Examination) (weightage: 30%)
Home Assignments and Quizzes (combined weightage: 20%)