



# ADVANCED PROBABILITY THEORY

**PROF. NILADRI CHATTERJEE**

Department of Mathematics  
IIT Delhi

**TYPE OF COURSE** : Rerun | Core | UG/PG

**COURSE DURATION** : 12 weeks (24 Jan' 22 - 15 Apr' 22)

**EXAM DATE** : 24 Apr 2022

**PRE-REQUISITES** : Basics of Real Analysis, Functions of two variables, Convergence of a function.

**INTENDED AUDIENCE** : Undergraduate and postgraduate students in Statistics, Mathematics, and Machine Learning

**INDUSTRIES APPLICABLE TO** : Most Financial companies

## **COURSE OUTLINE :**

The course introduces the concept of probability through Kolmogorov's Axioms. It develops the concept of probability density function, cumulative distribution function, and introduces the concept of a random variable. Different theoretical probability distributions, both discrete and continuous are introduced, and their properties are studied. Different generating functions, viz. MGF, PGF, and characteristic functions of different variables are discussed. It also introduces functions of one or two random variables, and derived random variables, such as  $t$ ,  $\text{chisq}$ ,  $F$  are studied in details. The concept of Order Statistics is introduced, and derivation of distribution of range, median etc. are discussed. Different limit theorems are discussed in detail.

## **ABOUT INSTRUCTOR :**

Prof. Niladri Chatterjee is a professor of Department of Mathematics, IIT Delhi. He is B.Stat and M.Stat from Indian Statistical Institute Kolkata. He is an M.Tech in Computer Science and PhD in Computer science from University College London. His major research interests are Statistical Modeling, Big Data, Artificial Intelligence, Machine Learning, Natural Language Processing and so on. He has more than 30 years of research and teaching experience. He is also member of several Government committees related to data science. He is currently Chair Professor in AI and Machine Learning.

## **COURSE PLAN :**

**Week 1** : Introduction, Sample Space, Probability Axioms, Theorems on Union and Intersections of events in a Sample Spaces. Bertrand's Paradox.

**Week 2** : Conditional Probability, Bayes Theorem, Probability on Finite Sample Spaces. Independence of Events..

**Week 3** : Introduction to Random variables – discrete & continuous Random variables Discrete random variables - Uniform, Bernoulli, Binomial, Geometric, Poisson Distributions, Hypergeometric, Negative Binomial

**Week 4** : Continuous Random variables: Uniform, Normal, Exponential, Gamma, Cauchy, Beta1 and Beta2

**Week 5** : Moments of a distribution, Bivariate distribution, Covariance and Correlation

**Week 6** : Generating Functions and their properties: Moment Generating Function Characteristic Functions and Probability Generating Function

**Week 7** : Poisson Process, Conditional Expectations and Variance, Chebyshev's Inequality and Introduction to Bivariate Normal.

**Week 8** : Functions of Random Variables, Introduction to  $t$  and  $F$  distribution.

**Week 9** : Order Statistics

**Week 10** : Limit Theorems: Mode of Convergence

**Week 11** : Laws of Large numbers

**Week 12** : Central Limit Theorems