Syllabus template

Semester: IV	
Programme: Mathematics	
Course: Probability Theory & Calculus-2 [Eco+Comp.Sc]	
Paper code: B2MT230421T	**Credits: 4**
Hours/week: 4	
Category: Core/MDC/SEC/VAC: Minor	
Theory / Practical / Composite: Theory	
No of Modules: NA	
Course Overview: This combined module introduces foundational concepts in probability theory and selected topics from multivariable calculus, emphasizing rigorous definitions, properties, examples, and problem-solving applications. The probability section builds from basic experiments to multivariate distributions and moments, while the calculus portion focuses on functions of two variables, partial differentiation, and optimization techniques.	
Course Outcome: On successful completion of this course, the student will be able to:	
1. State Kolmogorov axioms, probability properties, standard distributions (Binomial, Poisson, Uniform, Normal), key definitions (PMF, PDF, CDF, expectation, variance, correlation, partial derivatives, Lagrange multipliers).	
2. Explain classical/frequency interpretation limitations, CDF properties, pairwise vs mutual independence, Bayes' theorem, chain rule, Schwarz's theorem, exact differentials.	
3. Compute probabilities (axioms, conditional, Bayes), expectations, variances, correlations, marginal/conditional distributions.	
4. Find distributions of transformed variables (1D & 2D).	
5. Calculate partial derivatives; solve unconstrained and Lagrange-constrained optimization.	
6. Distinguish pairwise/mutual independence; compare standard distributions; analyse bivariate joint/marginal/conditional relations. Examine mixed partials equality.	
7. Verify validity of probability measures, CDFs, PMFs/PDFs; assess independence assumptions; critique correlation use; judge optimization solutions.	
8. Build simple probability models; derive transformed distributions; formulate & solve applied constrained optimization problems; construct counterexamples (e.g., pairwise but not mutual independence).	
Prerequisites:	
SYLLABUS	

UNIT/Module	**CONTENT**	**HOURS or NUMBER OF CLASSES**	**CO Mapping**	**COGNITIVE LEVEL**
I. Probability Theory	Experiments: Deterministic and Non-deterministic; Sample space connected to different random experiments, examples [finite, countably infinite	**40 classes**	**CO1, CO2, CO3, CO4, CO5, CO6,**	**K1, K2, K3, K4, K5, K6.**

	and uncountable]. Events: Elementary and compound events, examples. Formation of new events through different algebraic operations on them[union, intersection, complement]. Definitions of sure event; impossible event, mutually exclusive events along with examples. Idea of pair-wise disjoint /mutually exclusive, mutually exhaustive events for a class of events, examples. Introduction to the idea of probability: different interpretations: Frequency interpretation; Classical interpretation [criticism or shortcomings of this approach, problems] Kolmogorov's Axiomatic approach[Kolmogorov's probability axioms]. Properties of probability function.Boole's and Bonferroni's inequality Conditional Probability. definition, examples, multiplication rule of probability, Bayes' theorem, related problems. Independence of two events. extension to a finite/ countably infinite collection of events, pairwise and mutual independence, problems. Trials. Independent trials [Bernoulli] Introduction to random variables: Distribution function. Properties. Classification of random variables: discrete and absolutely continuous random variables. Probability mass function		**CO7, CO8**	

	and probability density function and properties Transformation of one dimensional random variable (discrete and absolutely continuous) and related problems. Examples of Discrete and Absolutely Continuous random variables: Binomial, Poission, Uniform, Normal . Moments for univariate distributions. Raw and central. Properties, Expectation and variance and related problems. Two-dimensional random variable: definition and examples, joint distribution function. Properties; marginal distributions; joint probability mass function and joint probability density function definition.; transformation for two-dimensional random variables and related problems. Conditional distribution functions for discrete and continuous random variables; Conditional Moments; Correlation Co-efficient and its properties.			
II.Calculus-2	Functions of two variables: Partial derivative: knowledge and use of chain rule. Exact differentials: definition and examples (emphasis on problem solving only). Successive partial derivatives: statement of Schwarz's theorem on commutativity of mixed partial derivatives.Unconstrained	**12 classes**	**CO1, CO2, CO3, CO4, CO5, CO6, CO7, CO8**	**K1, K2, K3, K4, K5, K6.**

	optimization of functions of two variables, Lagrange's method of constrained optimization—problems only.			

Text Books
1. Mathematical Probability: Banerjee, De, Sen.
2. Differential Calculus: An Introduction to Analysis: Maity & Ghosh.
3. Real Analysis: S.K.Mapa.
Suggested readings
1. Introduction to Probability Theory: Sheldon Ross
2. Basic Probability Theory: Robert B Ash.
3. Mathematical Analysis: Malik & Arora.
Web Resources
1.
2.
3.
4.
Evaluation: Theory CIA: 20+5+5=30; Semester Exam: 70.
Paper Structure for Theory Semester Exam Module: 7 questions each carrying 10 marks need to be answered out of 12/13 questions.

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive levels
CO1	State Kolmogorov axioms, probability properties, standard distributions (Binomial, Poisson, Uniform, Normal), key definitions (PMF, PDF, CDF, expectation, variance, correlation, partial derivatives, Lagrange multipliers).	**K1**
CO2	Explain classical/frequency interpretation limitations, CDF properties, pairwise vs mutual independence, Bayes' theorem, chain rule, Schwarz's theorem, exact differentials.	**K2**
CO3	Compute probabilities (axioms, conditional, Bayes), expectations, variances, correlations, marginal/conditional distributions.	**K3**
CO4	Find distributions of transformed variables (1D & 2D).	**K3**
CO5	Calculate partial derivatives; solve unconstrained and Lagrange-constrained optimization.	**K3**
CO6	Distinguish pairwise/mutual independence; compare standard distributions; analyse bivariate	**K4**

	joint/marginal/conditional relations. Examine mixed partials equality.	
CO7	Verify validity of probability measures, CDFs, PMFs/PDFs; assess independence assumptions; critique correlation use; judge optimization solutions.	**K5**
CO8	Build simple probability models; derive transformed distributions; formulate & solve applied constrained optimization problems; construct counterexamples (e.g., pairwise but not mutual independence).	**K6**