DEPARTMENT OF STATISTICS AND OPERATIONS RESEARCH
FACULTY OF SCIENCE, A.M.U., ALIGARH

Syllabus for Ph.D Admission Test 2024-25 Onwards

STATISTICS

SECTION – B

Random variables (RV). Probability mass function (PMF), probability density function (PDF). Cumulative distribution function (CDF) and its properties. Joint, marginal and conditional distributions. Mathematical expectation and its properties. Compound, truncated and mixture distributions. Distribution of function of random variables.

Discrete and continuous distributions and their properties. Probability generating function (PGF), moment generating function (MGF), characteristic function and their properties. Inversion theorem of characteristic function. Central and non-central χ^2, t and F distributions. Multinomial distribution. Bivariate and multivariate normal distributions.

Inequality in probability and various mode of convergence and their inter-relationship. Weak and strong laws of large numbers. Central limit theorem.

Order statistics and distribution of order statistics. Moments of order statistics. Type I and type II censored samples.

Non-parametric tests: Sign test, signed rank test, Kolmogrov-Smirnov test, run test, Wilcoxon Mann-Whitney test, Median test, Ansari-Bradely test, Mood test, Kendalls tau test, test of randomness, consistency of test and ARE.

Criteria of a good estimator and different methods of estimation. Minimum variance unbiased estimator (MVUE) and application of Cramer-Rao inequality to obtain MVUE. Rao-Blackwell and Lehman-Scheffe theorems and their applications. Small and large sample properties of maximum likelihood estimator (MLE).

Most powerful (MP), uniformly most powerful (UMP) and uniformly most powerful unbiased (UMPU) tests. UMP tests for monotone likelihood ratio (MLR) family of distributions. Likelihood ratio test (LRT) and its asymptotic distribution. Construction of similar and UMPU tests through Neyman structure. Interval estimation and uniformly most accurate one sided interval and its relation to UMP test.

Idea of Bayesian inference, various loss functions, prior and posterior distributions. Bayes and minimax estimators. Bayesian hypothesis testing. Bayesian interval estimation.

Concept of simple random sampling (SRS) and stratified random sampling, estimates of mean, total and proportion and variance of the estimates. Systematic sampling and results on estimation of population mean and total. Ratio and regression method of estimation. Cluster sampling, estimation of population mean and its variance based on cluster of equal sizes. Variance in terms of intra-class correlation coefficient. Two stage sampling, estimate of population total and mean with equal first stage units. variances and their estimates. Optimum sampling and sub-sampling fractions. Double sampling for Ratio and Regression methods of estimation. Double sampling for stratification.

BLUE estimators, Gauss-Markov theorem. Test of linear hypothesis for one and two way classifications. Fixed, random and mixed effect models. Variance components. Bivariate, multiple and polynomial regressions and use of orthogonal polynomials. Residuals and their plots as test for departure from assumptions of fitness of model, homogeneity of variance and detection of outliers, multicollinearity.

Singular and non-singular multivariate normal distribution. Wishart distribution. Generalized variance. Distribution of quadratic forms. Estimation of simple, partial and multiple correlations and their null distribution. Hotelling T^2 and Mahalanobis- D^2. Principal component and canonical correlations.

Analysis of variance and covariance of CRD and RBD. Missing plot techniques. 2^n and 3^2 factorial designs. Complete and partial confounding. Fractional replication in 2^n systems. BIBD, simple lattice design, split-plot design and strip-plot design.

Theory of simplex methods, simplex algorithm, degeneracy, duality in linear programming.

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OPERATIONS RESEARCH

SECTION-B

Convex sets, Convex hull, Convex cone, Convex and Concave functions, Separating and Supporting Hyper-planes and their properties. Linear Programming Problems (LPP) and its Methods, Duality in LPP and its properties. Revised Simplex Method, Sensitivity Analysis in Linear Programming, Parametric Linear Programming. Bounded variable LPP theory, Multi-objective Optimization problems. Introduction to Integer programming, Cutting Plane and Branch & Bound Methods. Basic concept of network analysis, the maximal flow problem, max flow min cut theorem. The shortest route problem, minimal cost flow problem.

Non linear Programming, unconstrained optimization: univariate and multivariate optimization problems. Constrained optimization problem Kuhun-Tucker necessary conditions. Quadratic Programming, Geometric programming, Separable programming, Dynamic programming.

Concepts of Quality, Variables and Attributes Control charts, Moving Average and Moving Range, Exponentially weighted moving average, Cu-Sum Control Charts. Quality loss functions, Taguchi loss functions, Capability indices Cp, Cpk, and Cpm, Estimation of the proportion of defectives (rework and scrap) for Cp, Cpk, and Cpm. Acceptance Sampling, Single Sampling Plan and Double Sampling Plan.

Concept of a stochastic process and Markov chains and their properties, n-step transition probability, stationary distribution, classification of states and Markov chains, Branching Process, Probability of extinction, Random walk and gambler's ruin problem. Poisson processes, Nonhomogeneous Poisson processes, Birth and Death processes, Processes, Yule Process.

Concepts & Properties of Reliability function, conditional reliability, Hazard Function (linear and nonlinear) & Failure Rate. Standard Life distributions with their Reliability functions, conditional reliability function, Hazard Functions with Applications. System Reliability: Series systems, Parallel systems, Standby Systems, k-out-of-n systems, Series-Parallel systems, Parallel -Series systems, availability, point availability, interval availability.

Concepts of inventory, Analytical Structure of Inventory, Single Item Inventory Control Models, with and without Shortages, with Quantity Discounts(EOQ, POQ), Multi item Inventory Models with Constraints. Determining of Safety stock and service level, P-System and Q-system. Single and Multi period Inventory Control Models with Uncertain Demand, Scheduling Period system, Order level system with uniform and instantaneous demand. Economic Production Quantity Model (EPQ), Joint Economic Lot Sizing Model.

Concepts of Death and Birth process in Queuing system, Elements of Queuing System, steady state solution, Measures of effectiveness of M/M/1 with finite and infinity capacity, M/M/S with finite and infinity capacity, M/E$_k$/ 1 model.

Probability Measures & Properties,Conditional Probability, Bayes' Theorem. One-dimensional Random variable- Discrete and Continuous; Distribution functions and their properties; Bivariate Random Variables- Joint Probability functions, marginal distributions, conditional distribution functions; Independence of Random variables. Functions of random variables: introduction, distribution function technique, transformationtechnique: one variable, transformation technique: several variables, theory and applications. Expectation, Variance, and Co-variance of random variables; Conditional expectation and conditional variance. Chebyshev's Inequality; Weak Law of Large Numbers, Strong law of large numbers; Central Limit Theorem. Probability generating function (p.g.f.), moment generating function (m.g.f.). Discrete Distributions:Bernoulli, Binomial, Poisson, Geometric, Hypergeometric, Negative Binomial, Multinomial, distributions- definition, properties and applications with numerical problems.Continuous Distributions: Uniform, Normal distribution function, Exponential, Gamma, Beta distributions (First and Second kind), Weibull, Cauchy and Laplace distributions, lognormal, logistic, Pareto and Rayleigh distribution functions.

Algebra of matrices, Rank of Matrix and its Properties, Echelon matrix, Normal form, Row canonical form, Diagonal form, Triangular form, Inverse of a matrix, Product Form of Inverse, Partitioned matrices, Elementary matrices, Kronecker products, Eigenvalues and Eigenvectors, Caley-Hamilton theorem. Simultaneous linear equations, Gauss elimination method, Applications of System of Linear Equations, Gauss-Jordan-LU decomposition, Spectral Decomposition, Singular Value Decomposition, Quadratic forms, Reduction and Classification of Quadratic forms.