

**PHD ENTRANCE**  
**STATISTICS AND OPERATIONS RESEARCH**

**UNIT 1: Descriptive statistics and exploratory data analysis:**

Statistical Methods: Concepts of statistical population and sample, quantitative and qualitative data, Nominal, ordinal and time series data, discrete and continuous data. Presentation of frequency distributions by histogram and frequency polygon, cumulative frequency distributions and ogive curve. Measures of location and dispersion, measures of skewness and kurtosis, absolute moments and factorial moments, Sheppard corrections. Bivariate data, scatter diagram, principle of least squares. Simple and multiple Correlation and Regression analysis, Theory of attributes.

**UNIT 2: Probability and probability distribution:**

Definition of Probability. Classical and relative frequency approach to probability; Bayes theorem. Random variables and distribution functions (univariate and multivariate); expectation and moments. Independent random variables, marginal and conditional distributions. Characteristic and generating functions. Probability inequalities (Tchebyshef, Markov, Jensen). Modes of convergence, weak and strong laws of large numbers, Central Limit theorems (i.i.d. case). Markov chains with finite and countable state space, classification of states, limiting behaviour of n-step transition probabilities, stationary distribution. Probability distributions: Binomial, Poisson, exponential, Negative Binomial, Geometric, Hyper geometric, Normal, uniform, beta, gamma, Cauchy and Laplace.

**UNIT3: Statistical Sample Survey:**

Sample Surveys: Concepts of Population and sample. Complete enumeration vs sampling. Need for sampling. Principal and organisational aspects in the conduct of a sample survey. Probability sampling design. Properties of a good estimator. Sampling errors. Basic sampling methods: Simple random sampling with or without replacement, Determination of sample size. Probability proportional to size sampling (with replacement). Stratified random sampling: Different allocations. Post-stratification. Ratio and Regression methods of estimation, optimality of regression estimator. Linear and circular systematic sampling, Cluster sampling, Two stage sampling (Sub-sampling) with equal first stage units. Non sampling errors.

**UNIT4: Statistical Inference**

Tests of significance: Null and alternative hypotheses, level of significance, Type I and Type II errors, critical region and p-value. Large sample tests, use of CLT for testing single proportion, difference of two proportions, single mean, difference of two means, standard deviation and difference of standard

deviations. Tests of significance based on t, F and Chi-square distributions, Analysis of variances and Design of experiment.

Estimation: Parametric space, sample space, point estimation. Requirements of good estimator: Consistency, unbiasedness, efficiency, sufficiency and completeness. Minimum variance unbiased (MVU) estimators. Cramer-Rao inequality. Minimum Variance Bound (MVB) estimators, Interval estimation: Confidence intervals for the parameters of various distributions. Confidence intervals for difference of means and for ratio of variances.

### **UNIT 5: Operational Research:**

Introduction to OR, Linear Programming: Models, graphical solution, simplex method Big M, and two phase technique. Concept of duality, dual simplex method post-optimality analysis. Revised simplex method, Transportation and Assignment problems. Integer programming, Quadratic programming, CPM and PERT networking problems. Replacement model, Game Theory, Decision Theory, Deterministic and Stochastic inventory models, Queuing theory and sequencing problems. Dynamic Programming.

### **SUGGESTED READINGS:**

1. Cochran, W.G. and Cox, G.M. (1959): Experimental Design. Asis Publishing House.
2. Das, M.N. and Giri, N.C. (1986): Design and Analysis of Experiments. Wiley Eastern Ltd.
3. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005): Fundamentals of Statistics. Vol. II, 8th Edn. World Press, Kolkata.
4. Gupta, S.C. and Kapoor, V.K. (2007): Fundamentals of Mathematical Statistics, 11th Edn.(Reprint), Sultan Chand and Sons.
5. Rohatgi, V. K. and Saleh, A. K. Md. E. (2009): An Introduction to Probability and Statistics, 2<sup>nd</sup> Edn. (Reprint). John Wiley and Sons.
2. Hadley, G. (2002): Linear Programming (Reprint). Narosa Publishing House.
3. Hillier, F.S. and Lieberman, G. J. (2001): Introduction to Operational Research, 7th Edn. Irwin.
4. Kantiswarup, Gupta, P.K. and Manmohan (2008): Operations Research, 13th Edn. Sultan Chand