# <u>SYLLABUS FOR THE POST OF LECTURER (10+2)</u> <u>STATISTICS</u>

#### **Unit I- Statistical Methods**

Descriptive Statistics, Measures of central tendency, arithmetic mean, geometric mean, harmonic mean, median and mode for grouped and ungrouped data with examples. Measures of dispersion, range, quartile deviation, variance, standard deviation, coefficient of variation, Skewness and Kurtosis. Basics of Correlation and regression, Scatter diagram, Karl Pearson's coefficient of correlation, rank correlation, regression, lines of regression, regression coefficients, fitting of regression lines. Testing of hypothesis: Notion of hypothesis, null and alternative hypothesis, simple and composite hypothesis, test statistic, critical region, idea of one and two tailed test, type-I and type-II errors, level of significance, Hypothesis testing for mean and proportion. Uniformly most powerful (UMP) tests of unbiased tests. Likelihood ratio tests, Parameter Space, Properties of likelihood ratio test Chi- square test for independence of attributes. Non parametric tests, Advantages and disadvantages of non- parametric tests. Sign Test-one sample and two samples, Wilcoxon-Signed rank test, Linear rank statistics, distribution properties of the linear rank statistics.

# **Unit II- Probability and Distribution Theory**

Axiomatic approach to probability, Addition and multiplication theorem of probability, Conditional probability, Baye's theorem. Random variables (discrete and continuous), Distribution function and its properties, Relation of distribution function with uniform variate. Univariate distributions, Bernoulli, Binomial, Poisson, Hyper-geometric, Geometric, Negative binomial, Discrete uniform, Power series, Continuous uniform, Normal, Exponential, Gamma, Beta, Cauchy, Weibull, Pareto, Laplace, Lognormal (elementary properties and applications only), Truncated distributions, Compound distributions. Functions of random variables, their distributions in case of univariate random variables and its applications. Sampling distributions t- distribution, Fdistribution,

# **Unit III -Statistical Inference**

Concept of statistical inference, Criteria of good estimators, unbiasedness, consistency, efficiency and sufficiency. principle, factorization theorem, minimal sufficiency,

minimal sufficient partition, construction of minimal sufficient statistic, minimal sufficient statistic for exponential families, power series family and pitman family. Completeness, bounded completeness, ancillary statistic. Point estimation, unbiased estimators, minimum variance unbiased estimator (MVUE). Rao-Blackwell and Lehmann-Scheffe theorems and their uses. Necessary and sufficient condition for MVUE. Methods of Estimation, Method of maximum likelihood estimation (MLE) and small sample properties of MLE. Method of moments, Method of minimum chi-square, Method of scoring.

Testing of hypothesis, Basic concepts, randomized and nonrandomized test procedures, Neyman-Pearson Lemma, Families with MLR property, UMP Test with applications to exponential families, UMP unbiased tests with application to one sample and two sample problems in normal populations. Likelihood ration test and its properties (without proof) and applications to normal distribution, Interval estimation, confidence level, construction of confidence, intervals using pivots, shortest expected length confidence interval,

Wald's SPRT

# **Unit IV – Sampling Theory**

Concepts of population and sample, need for sampling, census and sample surveys, designing of a questionnaire, sampling and non-sampling errors, sample size determination, finite population sampling techniques-SRSWR, SRSWOR, estimation of mean and total in each case and their variances. Stratified sampling, allocation problems in stratified sampling, estimation of mean or total in each case and their variances. Systematic sampling: Linear and circular systematic sampling. The sample mean and its variance, comparison of systematic sampling with random sampling, comparison of systematic sampling with stratified sampling. Unequal probability sampling, PPSWR Methods, cumulative total method, Lahiri's method, related estimation problems, PPSWOR method and related estimation of a finite population mean. Ratio and regression estimators based on SRSWOR method of sampling, Double sampling, Cluster sampling, Two-stage sampling with equal number of second stage units.

## **Unit V- Multivariate Analysis**

Multivariate normal distribution and its properties, Maximum likelihood estimates of mean vector and dispersion matrix, Distribution of sample mean vector, Wishart matrix-its distribution and properties. Null distribution of simple, partial and multiple correlation coefficients and their testing of significance. Hotelling's  $T^2$  statistic-its distribution and application in testing of mean vector for one and more multivariate normal populations, Mahalanobis  $D^2$  statistic and its applications. Problem of classification, probabilities of misclassification and their estimation, classification into more than two multivariate normal populations, Discrimination procedures for discriminating between two multivariate populations-sample discriminant function. Principal Components Analysis, Factor Analysis, Canonical variates and canonical correlations, Multivariate Analysis of Variance (MANOVA) of one- and two-way classified data.

#### **Unit VI - Operations Research & Industrial Statistics**

Scope of Operational research, Necessity of Operations Research in Industry; phases in Operations Research. Linear Programming, Simplex method and Extreme point theorems, Revised Simplex Method, Transportation and Assignment Problems with their methods of solution. Duality in LPP, Symmetric and asymmetric dual problems, duality theorems, Primal-Dual Relations, Complementary Slackness Theorem and Complementary Slackness conditions, Dual Simplex Method. Statistical Quality Control, Stewarts control chart, Statistical basis of a control chart, control chart for variables (X, R, & S) charts. Control charts for attributes (np, p & C) charts. Moving average charts. Operating Characteristic function (OC) and Average Run length (ARL) of X-bar chart. Capability indices Cp, Cpk and Cpm. estimation, confidence intervals relating to capability indices for normally distributed characteristics. Reliability concepts, hazard rate, distribution of longevity and moments. Some important theorems based on reliability theory.

#### **Unit VII – Linear Models and Regression Analysis**

Linear models, Gauss Markov set up, Model classification, Normal equations and least squares estimates, Error and estimation space, Variance and covariance of least square estimates, Estimation of error variance, estimation with correlated observations, least square estimates with restriction on parameters. Experimental Design Models, Introduction, Point estimation, Re-parameterization, Variance and Covariance of estimable function, testing of hypotheses, Regression models. Simple linear regression fit of polynomials, Residual and their plot as tests for departure from assumption such as fitness of model, normality, and homogeneity of variances and detection of outliers, Analysis of covariance, estimation and testing ,one way model with one covariance, two way model with two covariance Simple linear regression model, Assumptions and estimation of model parameters, Standard error of estimators, Testing of hypotheses on slope and intercept. Coefficient of determination (R2).

## **Unit VIII – Stochastic Process**

Definition of Stochastic process, Finite dimensional distributions. Examples of various stochastic processes. Markov chain and its Examples. Chapman-Kolmogorov equation, calculation of n-step transition probabilities. Classification of states of Markov chain, irreducible Markov chain, period of the state, First entrance theorem, First passage time distribution. Long run distribution of Markov chain, relation of mean recurrence time and stationary distribution. Random walk and gambler's ruin problem. Discrete state space continuous time Markov chain. Poisson process and related results. Birth and death processes and associated cases. M/M/1, M/M/S queuing models and related properties, Galton-Watson branching process. Probability of ultimate extinction, distribution of population size and associated results. Simulation of Markov chain, Poisson process, branching process (Algorithms).

## Unit IX – Demography

Introduction to Demography, Definition and uses of demographic data, Source of vital statistics: Census method-Registration method, Sources of demography data: secondary sources - SRS– surveys. Mortality and Fertility, Nature and uses of mortality statistics, Mortality measures: Crude death rate (CDR) and Age-specific death rates (ASDR), Infant mortality rate (IMR). Fertility measures, Basic terms and concepts used in the study of fertility, Measures of fertility: Crude birth rate(CBR), Age specific fertility rate (ASFR), General fertility rate (GFR), Total fertility rate (TFR). Measurement of Population Growth, Pearl's vital index, Gross reproductive rate (GRR) and Net reproductive rate (NRR). Life table: Description of life table, construction of complete and abridged life tables, uses of life table. Concept of mobility and migration, types of migration, internal migration and its measurement, migration models, concept of international migration. Net-migration. International and postcensal estimates.

Projection method including logistic curve fitting. Decennial population census in India.

#### **Unit X – Design of Experiments**

Fixed, random and mixed effects linear models, Introduction to Design of Experiments: General Block Design and its information matrix (C), Criteria for connectedness, balance and orthogonality, intrablock analysis. CRD, RBD and LSD, Missing plot techniques in RBD and LSD, Symmetrical Factorial experiments with factors at two and three levels  $(2^n, 3^2, 3^3)$ , Confounding-Total and Partial in factorial experiments, Split plot Design, Strip plot design. Balanced incomplete block designs, partially balanced incomplete block design, methods of constructions and their analysis and Lattice. Analysis of Covariance in RBD, LSD and CRD, Analysis of Covariance in Non-orthogonal Data in two-way classification, Covariance and Analysis of experiments with missing observation.