Details of the syllabus according to the guidelines

Detailed Contents

Semester I

Paper (Theoretical)

Descriptive Statistics I, Probability I and Linear algebra I

Descriptive Statistics I (Core Course I):

Introduction : Nature of Statistics, Uses of Statistics, Statistics in relation to other disciplines, Abuses of Statistics.

Types of Data: Concepts of population and sample, quantitative and qualitative data, cross-sectional and time-series data, discrete and continuous data, different types of scales.

Collection of Scrutiny of Data: Primary data – designing a questionnaire and a schedule, checking its consistency. Secondary data – its major sources. Complete enumeration. Controlled experiments, Observational studies and Sample Surveys. Scrutiny of data for internal consistency and detection of errors in recording. Ideas of cross-validation.

Presentation of data: Construction of Tables with one or more factors of classification, diagrammatic representation frequency distributions and cumulative frequency distributions and their graphical representations, stem and leaf displays.

Univariate data – different measures of location, dispersion, relative dispersion, skewness and kurtosis, Moments, Liaponouv's inequality, Quantiles and measures based on them – comparison with moment measures. Box plot, outlier Detection

Probability I (Core Course II):

Random Experiment: Trial, Sample point, Sample space, Different types of events.

Definition of probability: Classical and relative-frequency approach to probability, Kolmogorov's Axiomatic definition (detailed discussion on discrete space only), limitations of Classical definition. Probability of union and intersection of events, Probability of occurrence of exactly m and atleast m events out of n events. Conditional probability and Independence of events, Bayes' Theorem and it's applications. Examples based on classical approach and repeated trials

Linear Algebra I (Core Course II):

Vector Algebra: Vector spaces with real field, Basis and dimension of a vector space, Orthogonal vectors, Gram-Schmidt Orthogonalization

Practical I (Core Course I)

Semester II

Paper (Theoretical)

Descriptive Statistics II, Linear Algebra II, Probability II and Population Statistics

Descriptive Statistics II (Core Course III):

Bivariate data – scatter diagram, correlation coefficient and its properties, Correlation ratio, Correlation Index, Intraclass correlation, Concept of Regression, Principles of least squares, Fitting of polynomial andexponential curves. Rank correlation – Spearman's and Kendall's measures.

Linear Alegbra II (Core Course III)::

Linear transformation and Matrices, Matrix operations, Elementary matrices and their uses, Rank of a matrix and related results, Inverse of a matrix, Determinants, the Sweep-out and the Pivotal Condensation methods, Characteristic roots and vectors , Quadratic forms– classification and canonical reduction. Systems of Linear Equations: Homogeneous and Non-homogeneous systems– Conditions for solvability.

Probability II (Core Course IV)::

Random Variables : Definition of discrete and continuous random variables, cumulative distribution function (c.d.f.) and its properties (with proof), probability mass function (p.m.f.) and probability density function (p.d.f.), Expectation and Moments, Dispersion, Skewness, Kurtosis, Quantiles. The c.d.f., p.m.f. and p.d.f. in bivariate case. Marginal and Conditional distributions, Independence, Conditional Expectation, Correlation and Regression. Theorems on sum and product of expectations ofrandom variables. Probability Inequalities: Markov's &Chebyshev's inequalities.

Population Statistics (Core Course IV)::

Introduction: Sources of Population Data– Census data, Registration data and the errors in such data. Rates and ratios of vital events. Measurements of Mortality: Crude death rate, specific death rate, standardized death rate, case fatality rate and cause of death rate, Infant mortality rate, Neonatal and Perinatal mortality rates.

Life tables: Descriptions of Complete and Abridged Life Tables and their uses, Cohort vs. Current Life Tables, Stable population and Stationary population, Construction of complete life table using population and death statistics.

Measurements of Fertility: Crude Birth Rate, General Fertility Rate, Age Specific Fertility Rate, Total Fertility Rate. Measurement of Population Growth: Crude Rate of Natural Increase and Vital Index, Gross and Net Reproduction Rates.

Population Estimation, Projection and Forecasting: Use of A.P. and G.P. methods for population estimates, Fitting of Logistic curve for population forecasting using Rhode's method.

Practical II (Core Course III)

Practical III (Core Course IV)

Semester III

Paper (Theoretical)

Numerical and Mathematical methods, Probability Models, Official and Economic Statistics

Numerical and Mathematical methods(Core Course V):

Approximation of numbers and functions, Absolute and Relative errors.
Interpolation: Polynomial approximation, Difference Table, Newton's Forward and Backward interpolation formulae and Lagrange's general interpolation formula, Error terms
Numerical Differentiation and its applications.
Numerical Integration: Trapezoidal and Simpson's ⅓ rules.
Numerical solution of equations: method of fixed point iteration and Newton-Raphson method in one unknown, Conditions of convergence, rates of convergence. Extension of the iteration method to two unknowns (without convergence) Stirling's approximation to factorial n.
Maxima and minima for functions of several variables, Constrained maximization and minimization – use of Lagrange multiplier, Multiple integrals, Transformation of Variables and Jacobian, Polar and Orthogonal transformations

Probability Models (Core Course VI):

Generating Functions: Probability generating function and moment generating function in the univariate and bivariate cases.
Univariate Discrete Distributions: Uniform, Bernoulli, Hypergeometric, Binomial, Poisson, Negative Binomial, Geometric distributions and their properties.
Univariate Continuous Distributions: Rectangular, Normal (Normal approximation of the Poisson distribution), Cauchy, Gamma, Beta, Exponential, Laplace, Logistic, Pareto, Log-normal distributions and their properties. Truncated distributions (Binomial, Poisson and Normal).
Scaling methods: Z, Percentile, Thurstone, Equivalent scaling procedures
Bivariate Normal Distribution and its properties.

Official and Economic Statistics (Core Course VII):

Official Statistics
The Statistical system in India: The Central and State Government organizations, the functions of the Central Statistical Office (CSO), the National Sample Survey Office (NSSO)
National Income statistics: Income, expenditure and production approaches. Their applications in various sectors in India
Economic Statistics
Index Numbers: Price, Quantity and Value indices.
Price Index Numbers: Construction, Uses, Limitations, Tests for index numbers, Various formulae and their comparisons, Chain Index Number.
Some Important Indices: Consumer Price Index, Wholesale Price Index and Index of Industrial Production – methods of construction and uses.
Measurement of income inequality: Gini's coefficient, Lorenz curves, Application of Pareto and Lognormal as income distributions

Practical IV (Core Course V)

Practical V (Core Course VI)

Practical VI (Core Course VII)

Semester IV

Paper (Theoretical)

Sampling Distribution, Inference I and Statistical Quality Control

Sampling Distribution(Core Course VIII):

Introduction: Concepts of Random Sampling, Statistics and Sampling Distributions of Statistics. Illustrations using different distributions, reproductive properties of the distributions.
Some Standard Sampling Distributions: $\chi 2$ distribution, distributions of the mean and variance of a random sample from a normal population, t and F distributions. Distributions of means, variances and correlation coefficient (null case) of a random sample from a bivariate normal population, Distributions of Order Statistics and Sample Range.

Inference I (Core Course IX):

Idea of Inference - Point & Interval Estimations and Testing of Hypothesis
Point estimation: Sufficient Statistic and Factorization Theorem (Discrete case only), Requirements of a good estimator– notions of Mean Square Error, Unbiasedness, Consistency, Efficiency (asymptotic) Minimum Variance unbiasedness and Best Linear Unbisedness, Properties of minimum variance, unbiased estimators, consistent estimators and asymptotic efficiency, Cramer-Rao lower bound, Rao-Blackwell Theorem.
Methods of Estimation– Moment, Least-square, Maximum Likelihood & Minimum $\chi 2$ methods and their properties (excluding proofs of large sample properties).

Statistical Quality Control (Core Course X):

Introduction: Concepts of Quality, and Quality Control, Process Control and Product Control
Process Control: Control Charts and their uses, Choice of Subgroup sizes, Construction of control charts by attributes (np, p,c) (including unequal subgroup size) and variables (X bar R chart),(X bar S chart). Interpretation of non- random patterns of points.
Product Control: Producer's Risk, Consumer's Risk, Acceptance Sampling Plan, Single and Double sampling plans by attributes, their OC, ASN (and ATI), LTPD and AOQL. Single sampling plan for inspection by variables (one-sided specification, known and unknown σ cases), Use of IS plans and tables

Practical VII (Core Course VIII)

Practical VIII (Core Course IX)

Practical IX (Core Course X)

Semester V

Paper (Theoretical)

Multivariate and Introduction to Time Series, Linear Model and large Sample

Multivariate and Introduction to Time Series: (Core Course XI)

Multivariate data–multiple regression, multiple correlation and partial correlation–their properties and related results.
Random Vector: Probability mass and density functions, Distribution Function, Mean vector and Dispersion matrix, Marginal and Conditional Distributions, Ellipsoid of Concentration, Multiple Regression, Multiple Correlation, Partial Correlation.
Multivariate Distributions: Multinomial, Multivariate Normal distributions and their properties

Time Series Analysis
Introduction: Examples of time series from various fields, Components of a times series, Additive and Multiplicative models.
Trend and Seasonal Components: Estimation of trend by linear filtering (simple and weighted moving-averages) and curve fitting (polynomial, exponential and Gompertz), Detrending. Estimation of seasonal component by ratio- to- moving-average method, ratio to trend method, Deseasonalization.

Linear Model and large Sample (Core Course XII):

Introduction to Linear Models and Estimation
Introduction: Heterogeneity and Analysis of Variance and Covariance, Linear Hypothesis, Orthogonal splitting of total variation, Selection of Valid Error.
Applications of the ANOVA technique to: one-way classified data, two-way classified data with equal number of observations per cell, testing simple regression coefficients, tests for parallelism and identity, correlation ratio, linearity of simple regression, multiple correlation and partial correlation coefficients
Large Sample
Convergence in Probability, Weak Law of Large Numbers and its applications, Convergence in Distribution, De Moivre Laplace limit theorem, Statement of Central Limit Theorem (i.i.d. case) & its applications.
Delta method, Derivation of large sample standard error of sample moments, standard deviation, coefficient of variation, b1 and b2 measure s, and correlation coefficient and their uses in large sample tests under normality assumption, Large sample distribution of sample quantile
Transformations of Statistics to stabilize variance: derivation and use of Sin-1, square root, logarithmic and z-transformations.
Large sample tests for binomial proportions, Poisson means (single and two independent samples cases) and correlation coefficients.
Large Sample distribution of Pearsonian $\chi 2$–statistic and its uses. Yate's correction in a 2x2 contingency table.

Practical X (Core Course XI)

Practical XI (Core Course XII)

Semester VI

Paper (Theoretical)

Inference II, Introduction to Design of Experiments and Sample Survey

Inference II (Core Course XIII)

Elements of Hypothesis Testing: Null and Alternative hypotheses, Simple and Composite hypotheses, Critical Region, Type I and Type II Errors, Level of Significance and Size, p-value, Power
Tests of Significance related to a single Binomial proportion and Poisson parameter; two Binomial proportions and Poisson parameters; the mean(s) and variance(s) of a single univariate normal distribution, two independent normal distributions and a single bivariate normal distribution; regression and correlation coefficients of a single bivariate normal distribution, Combination of Probabilities in tests of significance
Theory of Hypothesis Testing: Most Powerful (MP), Uniformly Most Powerful (UMP), Randomized and Nonrandomized tests, Neyman-Pearson Fundamental Lemma (sufficiency part only), and its use in the construction of MP and UMP tests (single parameter with range independent of the parameters), Uniformly Most Powerful Unbiased (UMPU) tests (definition only).
Likelihood Ratio tests and its applications to tests for the equality of means and variances of several normal populations.
Interval Estimation: Confidence intervals

Introduction to Design of Experiments and Sample Survey(Core Course XIV)

Design of Experiments
Principles of experimental design: Randomization, Replication and Local Control, Uniformity trials, Shapes and Sizes of Plots and Blocks. (4L)
Standard Designs and their Analyses: Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD), comparison of efficiencies. Applications of the techniques of ANOVA to the analysis of the above designs.

Sample Survey
Introduction: Concepts of Finite Population and Sample, Need for Sampling, Complete Enumeration and Sample Surveys.
General Ideas: Planning and execution of sample surveys, analysis of data and reporting, Biases and Errors. Judgment and probability sampling schemes. Tables of Random Numbers and their uses
Simple Random Sampling with and without replacement, Determination of sample size in simple random sampling. Sratified Random Sampling

Practical XII (Core Course XIII)

Practical XIII (Core Course XIV)

DSE

Time Series Analysis (DSE)

Stationary Time series: Weak stationarity, Autocorrelation Function and Correlogram
Some Special Processes: Moving-average (MA) process and Autoregressive (AR) process of orders one and two, Estimation of the parameters of AR(1) and AR(2) – Yule-Walker equations, Exponential smoothing method of forecasting

Design of Experiments (DSE)

Split Plot Design and Strip arrangements. Factorial Experiments: 2n experiments, Advantages, Total and Partial Confounding, Analysis Missing Plot Technique: Analysis with one missing plot in a RBD and in a LSD.
Analysis of Covariance (ANCOVA): Application of the ANCOVA technique to one-way classified data and to two-way classified data with equal number of observations per cell, use in the control of error in CRD, RBD and LSD

Sample Survey Methods (DSE)

Linear and Circular Systematic Sampling, Cluster sampling, Two-stage (with equal-sized first stage units) sampling with equal selection probabilities at each stage. Associated unbiased estimators of population total, mean, and proportion, their variances and unbiased variance estimators. Allocation problem in stratified random sampling and optimum choice of sampling and sub-sampling fractions in two - stage sampling, Interpenetrating sub-sampling technique for unbiased variance estimation in systematic sampling
Ratio and Regression methods of estimation in simple random sampling. Double sampling for ratio and regression estimators.

Inference III (DSE)

Concepts of Uniformly Most Accurate (UMA) confidence sets, relationship with tests of hypotheses.
Nonparametric Methods: Sign test, Mann-Whitney test, Run test, Test of randomness, Confidence limits for Quantiles based on Sign test statistic. Sequential Probability Ratio test

Stochastic Process (DSE)

Introduction, Transition function and initial distribution of Random Walk, Gamblers ruin chain, Queuing chain, , Birth and Death Chain, Branching chain; Markov Chain and transition probability matrix and its Classification of States: transient, recurrent; closed and irreducible states.

Computation and Data Analysis (DSE)

Computer Programming C
Computer Programming:
1. Input-output statements
2. Operator-relational and logical, conditional operator
3. Library functions
4. Data type
5. Decision making and branching-If, If-else, Nesting of if statement, goto statement
6. Arrays
7. Use of Functions
8. File structure
9. Some selected C programs:
(i) Selection and Bubble sort, Computation of quantiles, Computation of Spearman's rank correlation coefficient (no tie case)
(ii) Fitting of Binomial and Poisson distributions
(iii) Interpolation by Lagrange's formula.
10. Looping structure (control statement)–while, do while
(iv) Numerical integration (Trapezoidal and Simpson's1/3rule) with convergence;
(vi) Solution of numerical equations by Newton Raphson and iterative method (single variable);
(vii) Addition, multiplication, transpose of matrices
(viii) Trace, determinant and inverse of square matrices
(ix) Generation of random samples from Normal ,Chi-square, t and F distributions.

Computation and Data Analysis encompassing all topics taught in the three years. Uses may be made of all computational methods taught in the three years with analysis tool pack of EXCEL and modules of MINITAB