Course Outcome of Core Course (Statistics)

Semester	Code of paper, title of the paper	Course Outcome
1	**STS-CC-T4-101** **Descriptive Statistics** **Credit 4** **[Marks:70** IA: 14 + End Sem:56]	**Unit1: Gives introduction to** Definition and scope of Statistics, concepts of statistical population and sample. Data: quantitative and qualitative, attributes, variables. Scales of measurement, nominal, ordinal, interval and ratio. Presentation: tabular and graphical, including histogram and ogives. Consistency and independence of data with special reference to attributes.
		UNIT II Gives an understanding of Measures of central tendency. Measures of Dispersion: range, quartile deviation, mean deviation, standard deviation, coefficient of variation, Moments, absolute moments, actorial moments, skewness and kurtosis, Sheppard's corrections.
		UNIT III Students learn Scatter diagram, simple, partial and multiple correlation (3 variables only), rank correlation. Simple linear regression, principle of least squares and fitting of polynomials and exponential curves.
		UNIT IV Gives knowledge of Definition, construction of index numbers and problems there of for weighted and unweighted index numbers including Laspeyre's, Paasche's, Edgeworth-Marshall and Fisher's. Chain index numbers, conversion of fixed based to chain based index numbers and vice-versa. Consumer price index numbers.
1	**STS-CC-P2-101: PRACTICAL/LAB. WORK**: Credit: 2 **[Marks:30** IA:6+ End Sem:24]	**Students gets numerical experience on** 1. Graphical representation of data. 2. Problems based on measures of central tendency. 3. Problems based on measures of dispersion.

		4. Problems based on combined mean and variance and coefficient of variation. 5. Problems based on moments, skewness and kurtosis. 6. Fitting of polynomials, exponential curves. 7. Karl Pearson correlation coefficient. 8. Correlation coefficient for a bivariate frequency distribution. 9. Lines of regression, angle between lines and estimated values of variables. 10. Spearman rank correlation with and without ties. 11. Partial and multiple correlations. 12. Planes of regression and variances of residuals for given simple correlations. 13. Planes of regression and variances of residuals for raw data. 14. Calculate price and quantity index numbers using simple and weighted average of price relatives. 15. To calculate the Chain Base index numbers. 16. To calculate consumer price index number.
1	**STS-C C-T6-102** **Calculus** **Credit 6** **[Marks:100** IA: 20 + End Sem:80]	**UNIT I Students learn** Differential Calculus**:** Limits of function, continuous functions, and properties of continuous functions, partial differentiation and total differentiation. Indeterminate forms: L-Hospital's rule, Leibnitz rule for successive differentiation. Euler's theorem on homogeneous functions. Maxima and minima of functions of one and two variables, constrained optimization techniques (with Lagrange multiplier) along with some problems. Jacobian, concavity and convexity, points of inflexion of function, singular points.
		UNIT II Gives knowledge of Integral Calculus**:** Review of integration and definite integral. Differentiation under integral sign, double integral, changes of order of integration, transformation of variables. Beta and Gamma functions:

		properties and relationship between them.
		UNIT III Students able to sove Differential Equations**:** Exact differential equations, Integrating factors, change of variables, Total differential equations, Differential equations of first order and first degree, Differential equations of first order but not of first degree, Equations solvable for x, y, q, Equations of the first degree in x and y, Clairaut's equations. Higher Order Differential Equations**:** Linear differential equations of order n, Homogeneous linear differential equations of order n with constant coefficients, Different forms of particular integrals, Linear differential equations with non-constant coefficients, Reduction of order method.
		UNIT IV: Students learn Formation and solution of a partial differential equations**.** Equations easily integrable. Linear partial differential equations of first order. Non-linear partial differential equation of first order and their different forms. Charpit's method. Homogeneous linear partial differential equations with constant coefficients. Different cases for complimentary functions and particular integrals. Non-homogeneous partial differential equations with constant coefficients .Classification of second order linear partial differential equations.
2	**STS-CC-T4-201** **Probability and Probability Distributions** **Credit 4** **Marks:70** IA: 14 + End Sem:56	**UNIT I Gives idea of** Probability: Introduction, random experiments, sample space, events and algebra of events. Definitions of Probability – classical, statistical, and axiomatic. Conditional Probability, laws of addition and multiplication, independent events, theorem of total probability, Bayes' theorem and its applications.
		UNIT II Students learn Random variables: discrete and continuous random variables, p.m.f., p.d.f. and c.d.f., illustrations and properties of random

		variables, univariate transformations with illustrations. Two dimensional random variables: discrete and continuous type, joint, marginal and conditional p.m.f, p.d.f., and c.d.f., independence of variables, bivariate transformations with illustrations.
		UNIT III Students understands Mathematical Expectation and Generating Functions: Expectation of single and bivariate random variables and its properties. Moments and Cumulants, moment generating function, cumulant generating function and characteristic function. Uniqueness and inversion theorems (without proof) along with applications. Conditional expectations.
		UNIT IV Students get the knowledge of Standard probability distributions: Binomial, Poisson, geometric, negative binomial, hypergeometric, uniform, normal, exponential, Cauchy, beta and gamma along with their properties and limiting/approximation cases.
2	**STS-CC-P2-201 PRACTICAL/LAB. WORK**: Credit:2 **[Marks:30** IA:6+ End Sem:24]	**Students learn numerically** 1. Fitting of binomial distributions for n and p = q = ½. 2. Fitting of binomial distributions for given n and p. 3. Fitting of binomial distributions after computing mean and variance. 4. Fitting of Poisson distributions for given value of lambda. 5. Fitting of Poisson distributions after computing mean. 6. Fitting of negative binomial. 7. Fitting of suitable distribution. 8. Application problems based on binomial distribution. 9. Application problems based on Poisson distribution. 10. Application problems based on negative binomial distribution. 11. Problems based on area property of normal distribution. 12. To find the ordinate for a given area for normal distribution. 13. Application based problems using

		normal distribution. 14. Fitting of normal distribution when parameters are given. 15. Fitting of normal distribution when parameters are not given.
2	**STS-CC-T6-202** **Algebra** **Credit 6** **[Marks:100** IA: 20 + End Sem:80]	**UNIT I Students learn** Theory of equations, statement of the fundamental theorem of algebra and its consequences. Relation between roots and coefficients or any polynomial equations. Solutions of cubic and biquadratic equations when some conditions on roots of equations are given. Evaluation of the symmetric polynomials and roots of cubic and biquadratic equations. Vector spaces, Subspaces, sum of subspaces, Span of a set, Linear dependence and independence, dimension and basis.
		UNIT II Students understands Algebra of matrices - A review, theorems related to triangular, symmetric and skew symmetric matrices, idempotent matrices, Hermitian and skew Hermitian matrices, orthogonal matrices, singular and non-singular matrices and their properties. Trace of a matrix, unitary, involutory and nilpotent matrices. Adjoint and inverse of a matrix and related properties.
		UNIT III Students understands Determinants of Matrices: Definition, properties and applications of determinants for 3rd and higher orders, evaluation of determinants of order 3 and more using transformations. Symmetric and Skew symmetric determinants, Circulant determinants and Vandermonde determinants for nth order, Jacobi's Theorem, product of determinants. Use of determinants in solution to the system of linear equations, row reduction and echelon forms, the matrix equations AX=B, solution sets of linear equations, linear independence, Applications of linear equations, inverse of a matrix.
		UNIT IV Students know Rank of a matrix, row-rank, column-rank,

		standard theorems on ranks, rank of the sum and the product of two matrices. Generalized inverse (concept with illustrations).Partitioning of matrices and simple properties. Characteristic roots and Characteristic vector, Properties of characteristic roots, Cayley Hamilton theorem, Quadratic forms, Linear orthogonal transformation and their digitalization.
2	**STS-CC-T4-301** **Sampling Distributions** **Credit 4** **[Marks:70** IA: 14 + End Sem:56]	**UNIT I Students understand** Limit laws: convergence in probability, almost sure convergence, convergence in mean square and convergence in distribution and their inter relations, Chebyshev's inequality, W.L.L.N., S.L.L.N. and their applications, De-Moivre Laplace theorem, Central Limit Theorem (C.L.T.) for i.i.d. variates, applications of C.L.T. and Liapunov Theorem (without proof). **Order Statistics**: Introduction, distribution of the rth order statistic, smallest and largest order statistics. Joint distribution of rth and sth order statistics, distribution of sample median and sample range.
		UNIT II Students understand Definitions of random sample, parameter and statistic, sampling distribution of a statistic, sampling distribution of sample mean, standard errors of sample mean, sample variance and sample proportion. Null and alternative hypotheses, level of significance, Type I and Type II errors, their probabilities and critical region. 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 by classical and p-value approaches.
		UNIT III Student learn Exact sampling distribution: Definition and derivation of p.d.f. of $\chi 2$ with n degrees of freedom (d.f.) using m.g.f.,

		nature of p.d.f. curve for different degrees of freedom, mean, variance, m.g.f., cumulant generating function, mode, additive property and limiting form of $\chi 2$ distribution. Tests of significance and confidence intervals based on distribution.
		UNIT IV Student learn Exact sampling distributions: Student's and Fishers t-distribution, Derivation of its p.d.f., nature of probability curve with different degrees of freedom, mean, variance, moments and limiting form of t distribution. Snedecore's F-distribution: Derivation of p.d.f., nature of p.d.f. curve with different degrees of freedom, mean, variance and mode. Distribution of 1/F(n1,n2). Relationship between t, F and $\chi 2$ distributions. Test of significance and confidence Intervals based on t and F distributions.
3	**STS-CC-P2-301 PRACTICAL/LAB. WORK**: Credit: 2 **[Marks:30** IA:6+ End Sem:24]	**Students understand practical applications of** Testing of significance and confidence intervals for single proportion and difference of two proportions, single mean and difference of two means and paired tests, difference of two standard deviations. Exact Sample Tests based on Chi-Square Distribution. Testing if the population variance has a specific value and its confidence intervals, of goodness of fit, of independence of attributes, based on 2 X 2 contingency table without and with Yates' corrections, of significance and confidence intervals of an observed sample correlation coefficient and of equality of two population variances
3	**STS-CC-T4-302 Survey Sampling and Indian Official Statistics** **Credit 4** **[Marks:70** IA: 14 + End Sem:56]	**UNIT I Students get idea of** Concept of population and sample, complete enumeration versus sampling, sampling and non-sampling errors. Types of sampling: non-probability and probability sampling, basic principle of sample survey, simple random sampling with and without replacement, definition

		and procedure of selecting a sample, estimates of: population mean, total and proportion, variances of these estimates, estimates of their variances and sample size determination.
		UNIT II Students understand Stratified random sampling: Technique, estimates of population mean and total, variances of these estimates, proportional and optimum allocations and their comparison with SRS.Practical difficulties in allocation, estimation of gain in precision, post stratification and its performance. Systematic Sampling: Technique, estimates of population mean and total, variances of these estimates (N=nxk). Comparison of systematic sampling with SRS and stratified sampling in the presence of linear trend and corrections.
		UNIT III Students learn Introduction to Ratio and regression methods of estimation, first approximation to the population mean and total (for SRS of large size), variances of these estimates and estimates of these variances, variances in terms of correlation coefficient for regression method of estimation and their comparison with SRS. Cluster sampling (equal clusters only) estimation of population mean and its variance, comparison (with and without randomly formed clusters). Relative efficiency of cluster sampling with SRS in terms of intra class correlation. Concept of sub sampling.
		UNIT IV Students know Present official statistical system in India, Methods of collection of official statistics, their reliability and limitations. Role of Ministry of Statistics & Program Implementation (MoSPI), Central Statistical Office (CSO), National Sample Survey Office (NSSO), and National Statistical Commission. Government of India's Principal publications containing data on the

		topics such as population, industry and finance.
3	**STS-CC-P2-302 PRACTICAL/LAB. WORK:** Credit: 2 **[Marks:30** IA:6+ End Sem:24]	**Students learn practically** To select a SRS with and without replacement. To estimate population mean, population mean square and To enumerate all possible samples of size 2 by WR and WOR and establish all properties relative to SRS. Stratified Sampling: allocation of sample to strata by proportional and Neyman's methods Compare the efficiencies of above two methods relative to SRS Ratio and Regression estimation Cluster sampling: estimation of mean or total, variance of the estimate
3	**STS-CC-T6- 303 Mathematical Analysis** **Credit 6** **[Marks:100** IA: 20 + End Sem:80]	**UNIT-I Students get idea of** Real Analysis: Representation of real numbers as points on the line and the set of real numbers as complete ordered field. Bounded and unbounded sets, neighborhoods and limit points, Superimum and infimum, derived sets, open and closed sets, sequences and their convergence, limits of some special sequences such as and Cauchy's general principle of convergence, Cauchy's first theorem on limits, monotonic sequences, limit superior and limit inferior of a bounded sequence.
		UNIT-II Students understands Infinite series, positive termed series and their convergence, Comparison test, D'Alembert's ratio test, Cauchy's nth root test, Raabe's test. Gauss test, Cauchy's condensation test and integral test (Statements and Examples only). Absolute convergence of series, Leibnitz's test for the convergence of alternating series, Conditional convergence. Indeterminate form, L' Hospital's rule.
		UNIT-III Students learns Review of limit, continuity and differentiability, uniform Continuity and

		boundedness of a function. Rolle's and Lagrange's Mean Value theorems. Taylor's theorem with lagrange's and Cauchy's form of remainder(without proof). Taylor's and Maclaurin's series expansions of sinx, cosx, log (1+x).
		UNIT-IV Students learns Numerical Analysis: Factorial, finite differences and interpolation. Operators, E and divided difference. Newton's forward, backward and divided differences interpolation formulae. Lagrange's interpolation formulae. Central differences, Gauss and Stirling interpolation formulae. Numerical integration. Trapezoidal rule, Simpson's one-third rule, three-eights rule, Weddle's rule with error terms. Stirling's approximation to factorial n. Solution of difference equations of first order.
4	**STS-CC-T4-401** **Statistical Inference** **Credit 4** **[Marks:70** IA: 14 + End Sem:56]	**UNIT I Students get idea of** Estimation: Concepts of estimation, unbiasedness, sufficiency, consistency and efficiency. Factorization theorem. Complete statistic, Minimum variance unbiased estimator (MVUE), Rao-Blackwell and Lehmann-Scheffe theorems and their applications. Cramer-Rao inequality and MVB estimators(statement and applications).
		UNIT II Students learns Methods of Estimation: Method of moments, method of maximum likelihood estimation, method of minimum Chi-square, basic idea of Bayes estimators.
		UNIT III Students learns Principles of test of significance: Null and alternative hypotheses (simple and composite), Type-I and Type-II errors, critical region, level of significance, size and power, best critical region, most powerful test, uniformly most powerful test, Neyman Pearson Lemma (statement and applications to construct most powerful test). Likelihood ratio test, properties of likelihood ratio tests (without proof).

		UNIT IV Students learns Sequential Analysis: Sequential probability ratio test (SPRT) for simple vs simple hypotheses. Fundamental relations among α, β, A and B, determination of A and B in practice. Wald's fundamental identity and the derivation of operating characteristics (OC) and average sample number (ASN) functions, examples based on normal, Poisson, binomial and exponential distributions.
4	**STS-CC-P2-401** **PRACTICAL/LABWORK:** Credit: 2 **[Marks:30** IA:6+ End Sem:24]	**Students get practical knowledge of** 1. Unbiased estimators (including unbiased but absurd estimators) 2. Consistent estimators, efficient estimators and relative efficiency of estimators. 3. Cramer-Rao inequality and MVB estimators 4. Sufficient Estimators – Factorization Theorem, Rao-Blackwell theorem, Complete Sufficient estimators 5. Lehman-Scheffe theorem and UMVUE 6. Maximum Likelihood Estimation 7. Asymptotic distribution of maximum likelihood estimators 8. Estimation by the method of moments, minimum Chi-square 9. Type I and Type II errors 10. Most powerful critical region (NP Lemma) 11. Uniformly most powerful critical region 12. Unbiased critical region 13. Power curves 14. Likelihood ratio tests for simple null hypothesis against simple alternative hypothesis 15. Likelihood ratio tests for simple null hypothesis against composite alternative hypothesis 16. Asymptotic properties of LR tests 17. SPRT procedure 18. OC function and OC curve 19. ASN function and ASN curve 22

4	**STS-CC-T4-402** **Linear Models** **Credit 4** **[Marks:70** IA: 14 + End Sem:56]	**UNIT I Students learns** Gauss-Markov set-up: Theory of linear estimation, Estimability of linear parametric functions, Method of least squares, Gauss-Markov theorem, Estimation of error variance.
		UNIT II Students learns Regression analysis: Simple regression analysis, Estimation and hypothesis testing in case of simple and multiple regression models, Concept of model matrix and its use in estimation.
		UNIT III Students learns Analysis of variance: Definitions of fixed, random and mixed effect models, analysis of variance and covariance in one-way classified data for fixed effect models, analysis of variance and covariance in two-way classified data with one observation per cell for fixed effect models.
		UNIT IV Students learns Model checking: Prediction from a fitted model, Violation of usual assumptions concerning normality, Homoscedasticity and collinearity, Diagnostics using quantile-quantile plots
4	**STS-CC-P2-402** **PRACTICAL/LAB. WORK**: Credit: 2 **[Marks:30** IA:6+ End Sem:24]	**Students learn practicals of** 1. Estimability when X is a full rank matrix and not a full rank matrix 2. Distribution of Quadratic forms 3. Simple Linear Regression 4. Multiple Regression 5. Tests for Linear Hypothesis 6. Bias in regression estimates 7. Lack of fit 8. Orthogonal Polynomials 9. Analysis of Variance of a one way classified data 10. Analysis of Variance of a two way classified data with one observation per cell 11. Analysis of Covariance of a one way

		classified data 12. Analysis of Covariance of a two way classified data
4	**STS-CC-T4-403** **Statistical Quality Control** **Credit 4** **[Marks:70** IA: 14 + End Sem:56]	**UNIT I Students get idea of** Quality: Definition, dimensions of quality, historical perspective of quality control and improvements starting from World War II, historical perspective of Quality Gurus and Quality Hall of Fame. Quality system and standards: Introduction to ISO quality standards, Quality registration. Statistical Process Control - Seven tools of SPC, chance and assignable Causes of quality variation. Statistical Control Charts-Construction and Statistical basis of 3-σ Control charts, Rational Sub-grouping.
		UNIT II Students learn Control charts for variables: X-bar & R-chart, X-bar & s-chart. Control charts for attributes: np-chart, p-chart, c-chart and u-chart. Comparison between control charts for variables and control charts for attributes. Analysis of patterns on control chart, estimation of process capability.
		UNIT III Students learn Acceptance sampling plan: Principle of acceptance sampling plans. Single and Double sampling plan their OC, AQL, LTPD, AOQ, AOQL, ASN, ATI functions with graphical interpretation, use and interpretation of Dodge and Romig's sampling inspection plan tables.
		UNIT IV Students learn Introduction to Six-Sigma: Overview of Six Sigma, Lean Manufacturing and Total Quality Management (TQM). Organizational Structure and Six Sigma training plans- Selection Criteria for Six-Sigma roles and training plans. Voice of customers (VOC): Importance and VOC data collection. Critical to Quality (CTQ).Introduction to DMAIC using one case study: Define Phase, Measure Phase, Analyse Phase, Improve Phase and Control Phase.

4	**STS-CC-P2-403** **PRACTICAL/LAB. WORK**: Credit: 2 **[Marks:30** IA:6+ End Sem:24]	**Students get practical learning of** 1. Construction and interpretation of statistical control charts □ X-bar & R-chart □ X-bar & s-chart □ np-chart □ p-chart □ c-chart □ u-chart 2. Single sample inspection plan: Construction and interpretation of OC, AQL, LTPD, ASN, ATI, AOQ, AOQL curves 3. Calculation of process capability and comparison of 3-sigma control limits with specification limits.
5	**STS-CC-T4-501** **Stochastic Processes and Queuing Theory** **Credit 4** **[Marks:70** IA: 14 + End Sem:56]	**UNIT I Students learn** Probability Distributions: Generating functions, Bivariate probability generating function. Stochastic Process: Introduction, Stationary Process.
		UNIT II Students learn Markov Chains: Definition of Markov Chain, transition probability matrix, order of Markov chain, Markov chain as graphs, higher transition probabilities. Generalization of independent Bernoulli trials, classification of states and chains, stability of Markov system, graph theoretic approach.
		UNIT III Students learn Poisson Process: postulates of Poisson process, properties of Poisson process, inter-arrival time, pure birth process, Yule Furry process, birth and death process, pure death process.
		UNIT IV Students learn Queuing System: General concept, steady state distribution, queuing model, M/M/1 with finite and infinite system capacity, waiting time distribution (without proof). Gambler's Ruin Problem: Classical ruin

		problem, expected duration of the game.
5	**STS-CC-P2-501 PRACTICAL/LAB. WORK** Credit: 2 **[Marks:30** IA:6+ End Sem:24]	**Students get practical learning of** 1. Calculation of transition probability matrix 2. Identification of characteristics of reducible and irreducible chains. 3. Identification of types of classes 4. Identification of ergodic transition probability matrix 5. Stationarity of Markov chain and graphical representation of Markov chain 6. Computation of probabilities in case of generalizations of independent Bernoulli trials 7. Calculation of probabilities for given birth and death rates and vice versa 8. Calculation of probabilities for Birth and Death Process 9. Calculation of probabilities for Yule Furry Process 10. Computation of inter-arrival time for a Poisson process. 11. Calculation of Probability and parameters for (M/M/1) model and change in behaviour of queue as N tends to infinity. 12. Calculation of generating function and expected duration for different amounts of stake. 13. Computation of probabilities and expected duration between players.
5	**STS-CC-P2-502 PRACTICAL/ LAB WORK**(Using C/C++ Programming Language) Credit: 2 **[Marks:30** IA:6+ End Sem:24]	**Students get hands on practical application of C/C++** 1. Plot of a graph y = f(x) 2. Roots of a quadratic equation (with imaginary roots also) 3. Sorting of an array and hence finding median 4. Mean, Median and Mode of a Grouped Frequency Data 5. Variance and coefficient of variation of a Grouped Frequency Data 6. Preparing a frequency table 7. Value of n! using recursion 8. Random number generation from uniform, exponential, normal(using CLT) and gamma

		distribution, calculate sample mean and variance and compare with population parameters. 9. Matrix addition, subtraction, multiplication Transpose and Trace 10. Fitting of Binomial, Poisson distribution and apply Chi-square test for goodness of fit 11. Chi-square contingency table 12. t-test for difference of means 13. Paired t-test 14. F-ratio test 15. Multiple and Partial correlation. 16. Compute ranks and then calculate rank correlation(without tied ranks) 17. Fitting of lines of regression
6	**STS-CC-T4-601** **Design of Experiments** **Credit 4** **[Marks:70** IA: 14 + End Sem:56]	**UNIT I Students get knowledge of** Experimental designs: Role, historical perspective, terminology, experimental error, basic principles, uniformity trials, fertility contour maps, choice of size and shape of plots and blocks. Basic designs: Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD) – layout, model and statistical analysis, relative efficiency, analysis with missing observations.
		UNIT II Students learn Incomplete Block Designs: Balanced Incomplete Block Design (BIBD) – parameters, relationships among its parameters, incidence matrix and its properties, Symmetric BIBD, Resolvable BIBD, Affine Resolvable BIBD, Intra Block analysis, complimentary BIBD, Residual BIBD, Dual BIBD, Derived BIBD.
		UNIT III Students learn Factorial experiments: advantages, notations and concepts, 2^2, $2^3 \ldots 2^n$ and 3^2 factorial experiments, design and analysis, Total and Partial confounding for 2^n ($n \leq 5$),

		3^2 and 3^3. Factorial experiments in a single replicate.
		UNIT IV Students learn Fractional factorial experiments: Construction of one-half and one-quarter fractions of 2n ($n \leq 5$) factorial experiments, Alias structure, Resolution of a design.
6	**STS-CC-P2-601** **PRACTICAL/LAB. WORK**: Credit: 2 **[Marks:30** IA:6+ End Sem:24]	**Students get practical knowledge of** 1. Analysis of a CRD 2. Analysis of an RBD 3. Analysis of an LSD30 4. Analysis of an RBD with one missing observation 5. Analysis of an LSD with one missing observation 6. Intra Block analysis of a BIBD 7. Analysis of 22 and23 factorial in CRD and RBD 8. Analysis of 22 and23 factorial in LSD 9. Analysis of a completely confounded two level factorial design in 2 blocks 10. Analysis of a completely confounded two level factorial design in 4 blocks 11. Analysis of a partially confounded two level factorial design 12. Analysis of a single replicate of a 2n design 13. Analysis of a fraction of 2n factorial design
6	**STS-CC-T4-602** **Multivariate Analysis and Nonparametric Methods** **Credit 4** **[Marks:70** IA: 14 + End Sem:56]	**UNIT I Students learn** Bivariate Normal Distribution (BVN): p.d.f. of BVN, properties of BVN, marginal and conditional p.d.f. of BVN. Multivariate Data: Random Vector: Probability mass/density functions, Distribution function, Mean vector & Dispersion matrix, Marginal & Conditional distributions.
		UNIT II Students learn Multivariate Normal distribution and its properties. Sampling distribution for mean vector and variance- covariance matrix. Multiple and partial correlation coefficient and their properties.

		UNIT III Students learn Applications of Multivariate Analysis: Discriminant Analysis, Principal Components Analysis and Factor Analysis.
		UNIT IV Students learn Nonparametric Tests: Introduction and Concept, Test for randomness based on total number of runs, Empirical distribution function, Kolmogrov Smirnov test for one sample, Sign tests- one sample and two samples, Wilcoxon-Mann-Whitney test, Kruskal-Wallis test.
6	**STS-CC-P2-602 PRACTICALS/ LAB WORK**: Credit: 2 **[Marks:30** IA:6+ End Sem:24]	**Sudents get practical knowledge of** 1. Multiple Correlation 2. Partial Correlation 3. Bivariate Normal Distribution, 4. Multivariate Normal Distribution 5. Discriminant Analysis 6. Principal Components Analysis 7. Factor Analysis 8. Test for randomness based on total number of runs, 9. Kolmogrov Smirnov test for one sample. 10. Sign test: one sample, two samples, large samples. 11. Wilcoxon-Mann-Whitney U-test 12. Kruskal-Wallis test

Course outcome of GE

Semester	Code of paper, title of the paper	Course Outcome
	STS-GE-T4-101 Statistical Methods **Credit 4** **[Marks:70** IA: 14 + End Sem:56]	UNIT I **Gives introduction to** Definition and scope of Statistics, concepts of statistical population and sample. Data: quantitative and qualitative, attributes, variables, scales of measurement - nominal, ordinal, interval and ratio. Presentation: tabular and graphic, including histogram and ogives.
		UNIT I **Gives an understanding of** Definition and scope of Statistics, concepts of statistical population and sample. Data: quantitative and qualitative, attributes, variables, scales of measurement - nominal, ordinal, interval and ratio. Presentation: tabular and graphic, including histogram and ogives.
		UNIT III Students learn Bivariate data: Definition, scatter diagram, simple, partial and multiple correlation (3 variables only), rank correlation. Simple linear regression, principle of least squares and fitting of polynomials and exponential curves.
		UNIT IV Students learn Theory of attributes, consistency of data, independence and association of attributes, measures of association and contingency.
	STS-GE-P2-101 PRACTICAL/ LAB WORK Credit: 2 **[Marks:30** IA:6+ End Sem:24]	Students learn practicals of 1. Graphical representation of data

		2. Problems based on measures of central tendency 3. Problems based on measures of dispersion 4. Problems based on combined mean and variance and coefficient of variation 5. Problems based on moments, skewness and kurtosis 6. Fitting of polynomials, exponential curves 7. Karl Pearson correlation coefficient 8. Partial and multiple correlations 9. Spearman rank correlation with and without ties. 10. Correlation coefficient for a bivariate frequency distribution 11. Lines of regression, angle between lines and estimated values of variables. 12. Checking consistency of data and finding association among attributes.
	STS-GE-T4-201 Introductory Probability **Credit 4** **[Marks:70** IA: 14 + End Sem:56]	UNIT I Students get idea of Probability: Introduction, random experiments, sample space, events and algebra of events. Definitions of Probability – classical, statistical, and axiomatic. Conditional Probability, laws of addition and multiplication, independent events, theorem of total probability, Bayes' theorem and its applications.
		UNIT II Students gets understanding of Random Variables: Discrete and continuous random variables, p.m.f., p.d.f. ,c.d.f. Illustrations of random variables and its properties. Expectation, variance, moments and moment generating function.

		UNIT III Students learn Convergence in probability, almost sure convergence, Chebyshev's inequality, weak law of large numbers, De-Moivre Laplace and Lindeberg-Levy Central Limit Theorem (C.L.T.).
		UNIT IV Students learn Standard probability distributions: Binomial, Poisson, geometric, negative binomial, hypergeometric, uniform, normal, exponential, beta, gamma.
	STS-GE-P2-201 PRACTICAL/LAB. WORK: Credit: 2 **[Marks:30** IA:6+ End Sem:24]	Students learn 1. Fitting of binomial distributions for n and p = q = ½ given 2. Fitting of binomial distributions for n and p given 3. Fitting of binomial distributions computing mean and variance 4. Fitting of Poisson distributions for given value of lambda 5. Fitting of Poisson distributions after computing mean 6. Application problems based on binomial distribution 7. Application problems based on Poisson distribution 8. Problems based on area property of normal distribution 9. To find the ordinate for a given area for normal distribution48 10. Application based problems using normal distribution 11. Fitting of normal distribution when parameters are given 12. Fitting of normal distribution when parameters are not given

	Generic Elective STS-GE-T4-301 Basics of Statistical Inference **Credit 4** **[Marks:70** IA: 14 + End Sem:56]	UNIT I Students get idea of Estimation of population mean, confidence intervals for the parameters of a normal distribution (one sample and two sample problems). The basic idea of significance test. Null and alternative hypothesis. Type I & Type II errors, level of significance, concept of p-value. Tests of hypotheses for the parameters of a normal distribution (one sample and two sample problems).
		UNIT II Students learn Categorical data: Tests of proportions, tests of association and goodness-of-fit using Chisquare test, Yates' correction.
		UNIT III Students learn Tests for the significance of correlation coefficient. Sign test for median, Sign test for symmetry, Wilcoxon two-sample test.
		UNIT IV Students learn Analysis of variance, one-way and two-way classification. Brief exposure of three basic principles of design of experiments, treatment, plot and block. Analysis of completely randomized design, randomized complete block design. Bioassay.
	STS-GE-P2-301 PRACTICAL/LAB WORK Credit: 2 **[Marks:30** IA:6+ End Sem:24]	Students learn practicals of 1. Estimators of population mean. 2. Confidence interval for the parameters of a normal distribution (one sample and two sample problems).

		3. Tests of hypotheses for the parameters of a normal distribution (one sample and two sample problems). 4. Chi-square test of proportions.50 5. Chi-square tests of association. 6. Chi-square test of goodness-of-fit. 7. Test for correlation coefficient. 8. Sign test for median. 9. Sign test for symmetry. 10. Wilcoxon two-sample test. 11. Analysis of Variance of a one way classified data 12. Analysis of Variance of a two way classified data. 13. Analysis of a CRD. 14. Analysis of an RBD.
	STS-GE-T4-401 (Optional) Introduction to Operations Research Credit 4 **[Marks:70** IA: 14 + End Sem:56]	UNIT I Students get idea of Introduction to Operations Research, phases of O.R., model building, various types of O.R. problems. Linear Programming Problem, Mathematical formulation of the L.P.P, graphical solutions of a L.P.P.
		UNIT II Students learn Optimum solution to a L.P.P: Simplex method, concept of artificial variables and Charne's big M-technique. Graphically identifying special cases of L.P.P. Concept of duality in L.P.P.
		UNIT III Students learn Transportation Problem: Initial solution by North West corner rule, Least cost method and Vogel's approximation method (VAM), MODI's method to find the optimal solution. Assignment problem: Hungarian method to find optimal assignment.

		UNIT IV Students learn Game theory: Rectangular game, minimax-maximin principle, solution to rectangular game using graphical method, dominance property to reduce the game matrix and solution to rectangular game with mixed strategy. Networking: Shortest route problem
	STS-GE-P2-401 **(Optional)** PRACTICAL/LAB WORK: Using TORA/WINQSB/LINGO Credit: 2 **[Marks:30** IA:6+ End Sem:24]	Students learn practicals of 1. Mathematical formulation of L.P.P and solving the problem using graphical method 2. Simplex technique to solve L.P.P and reading dual solution from the optimal table 3. Charne's Big M method involving artificial variables. 4. Identifying Special cases: Degenerate solution, Unbounded solution, Alternate solution and Infeasible solution by Graphical method and interpretation 5. Allocation problem using Transportation model 6. Allocation problem using Assignment model 7. Networking : Shortest route problem 8. Problems based on game matrix: mx2 / 2xn rectangular and Mixed strategy
	Generic Elective **STS-GE-T4-401 (Optional)** Applied Statistics **Credit 4** **[Marks:70** IA: 14 + End Sem:56]	UNIT I Students learn Economic Time Series: Components of time series, Decomposition of time series-Additive and multiplicative model with their merits and demerits, Illustrations of time series. Measurement of trend by method of free-hand curve, method of semi-averages and method of least squares

		(linear, quadratic and modified exponential).Measurement of seasonal variations by method of ratio to trend.
		UNIT II Students learn Index numbers: Definition, Criteria for a good index number, different types of index numbers. Construction of index numbers of prices and quantities, consumer price index number. Uses and limitations of index numbers.
		UNIT III Students learn Statistical Quality Control: Importance of statistical methods in industrial research and practice. Determination of tolerance limits. Causes of variations in quality: chance and assignable. General theory of control charts, process & product control, Control charts for variables: X- bar and R-charts. Control charts for attributes: p and c-charts
		UNIT IV Students learn Demographic Methods: Introduction, measurement of population, rates and ratios of vital events. Measurement of mortality: CDR, SDR (w.r.t. Age and sex), IMR, Standardized death rates. Life (mortality) tables: definition of its main functions and uses. Measurement of fertility and reproduction: CBR, GFR, and TFR. Measurement of population growth: GRR, NRR.
	STS-GE-P2-401 (Optional) PRACTICAL/LAB WORK Credit: 2 **[Marks:30** IA:6+ End Sem:24]	Students learn application of Statistics to applied problems of society. 1. Measurement of trend: Fitting of linear, quadratic

		trend, exponential curve and plotting of trend values and comparing with given data graphically. 2. Measurement of seasonal indices by Ratio-to-trend method and plotting of trend values and comparing with given data graphically. 3. Construction of price and quantity index numbers by Laspeyre's formula, Paasche's formula, Marshall-Edgeworth's formula, Fisher's Formula. Comparison and interpretation. 4. Construction of wholesale price index number, fixed base index number and consumer price index number with interpretation 5. Construction and interpretation of X bar & R-chart 6. Construction and interpretation p-chart (fixed sample size) and c-chart 7. Computation of measures of mortality 8. Completion of life table 9. Computation of measures of fertility and population growth
	STS-GE-T4-401 (Optional) Research Methodology **Credit 4** **[Marks:70** IA: 14 + End Sem:56]	UNIT I Students learn Introduction to research, meaning of research, role of research in important areas, process of research, types of research, Unit of analysis, characteristics of interest. Research problem as a hypothesis testing Sampling Techniques: Introduction to sampling, advantage of sampling over census, simple random sampling, sampling frame, probabilistic aspects of sampling, stratified random sampling, other methods of sampling, sampling design,

		non probability sampling methods
		UNIT II Students learn Data: Introduction, primary and secondary data, methods of collecting primary data, merits and demerits of different methods of collecting primary data, designing a questionnaire, pretesting a questionnaire, editing of primary data, technique of interview, collection of secondary data, scrutiny of secondary data, Data Processing: Introduction, editing of data, coding of data, classification of data, tables as data presentation devices, graphical presentation of data
		UNIT III Students learn Data Analysis: An overview on techniques in univariate, bivariate and multivariate data Models and Model Building: role of models, types of models, objectives of modeling, model building/ model development, model validation, simulation models.
		UNIT IV Students learn Formats of Reports: introduction, parts of a report, cover and title page, introductory pages, text, reference section, typing instructions, copy reading, proof reading. Presentation of a report: introduction, communication dimensions, presentation package, audio-visual aids, presenter's poise.
	STS-GE-P2-401 **(Optional)** PRACTICAL/LAB WORK Credit: 2 **[Marks:30** IA:6+ End Sem:24]	**Students learn report writing on real life problem.** Submit a Research Report based on empirical study on some real life situation. The student will personally collect, analyse, interpret the data and prepare a

		report under the supervision of a faculty.

After completing the degree programme in Statistics a student will:

- Be able to work in broad field of analytic, scientific, government, financial, health, technical and other positions.
- Be able to grasp the interrelation of Statistics to other cotemporary branches of knowledge.
- Be able to recognise the value of statistical thinking , training and approach to problem solving on a diverse variety of disciplines.
- Be able to explain variety of abstract or physical phenomena with a variety of examples.
- Be able to establish connections between theory and applications.
- Be able to go through independently various statistical materials.
- Be a lifelong learner.