"Education for knowledge, science and culture"
-Shikshanmaharshi Dr. Bapuji Salunkhe

Shri Swami Vivekanand Shikshan Sanstha's

VIVEKANAND COLLEGE, KOLHAPUR (EMPOWERED AUTONOMOUS)

Department of Statistics

B. Sc. Part – III

CBCS Syllabus with effect from July, 2023-24

Department of Statistics

Semester V and VI, CBCS

Semester	Paper No.	Paper code	Title of Paper	Marks for Term end Exam	Internal Marks	No. of Credits
Sem-V	IX	DSE 1004E1	Probability Distributions	35	15	2
	X	DSE 1004E2	Statistical Inference - I	35	15	2
	XI	DSE 1004E3	Sampling Theory	35	15	2
	XII	DSE 1004E4	Operations Research	35	15	2
		SEC 3	Database Management System	-	50	2
Sem-VI	XIII	DSE 1004F1	Probability Theory	35	15	2
	XIV	DSE 1004F2	Statistical Inference -II	35	15	2
	XV	DSE 1004F3	Design of Experiments	35	15	2
	XVI	DSE 1004F4	Quality Management	35	15	2
		SEC 4	Project Work	-	50	2

Note:

1. SEC - Examination will be conducted annually. (50 marks each)

2. Project will be conducted in a group of 5 students.

Practical

Paper No	Title of the Practical	Marks for Practical	Journal	Oral	Study Tour & Report	Total Marks
IV	Probability Distributions & R Software	40	04	04	08	50
V	Statistical Inference	40	04	04		50
VI	Sampling Theory & Design of Experiments	40	04	04		50
VII	Operations Research & Quality Management	40	04	04		50

Semester V

Paper -IX: Probability Distributions

Course Code: DSE 1004E1

Marks: 35 **Theory: 36 Hours** **Credits 2**

Course Outcomes:

At the end of the course students will be able to:

CO1: Understand the knowledge of important univariate distributions such as Laplace, Cauchy, Lognormal, Weibull, Logistic, Pareto, Power series distributions.

CO2: Understand the knowledge of multinomial distribution and bivariate normal distribution.

CO3: Understand the knowledge of truncated distributions**.**

CO4: Apply standard continuous probability distributions to different real-life situations.

Unit	Content	Hours Allotted
1	**Univariate and Multivariate Probability Distributions** **1.1 Laplace (Double Exponential) Distribution** P. d. f. with parameters (μ, λ), Nature of the probability curve, Distribution function, quartiles, m. g. f., mean, variance, moments, β_1, β_2, γ_1 and γ_2, Laplace distribution as the distribution of the difference of two i. i. d. exponential variates with parameter θ, examples and problems. **1.2 Lognormal Distribution** P.d.f. with parameters (μ, σ^2), Nature of the probability curve, mean, variance, median, mode, moments, β_1, β_2, γ_1 and γ_2 coefficients, Relation with N (μ, σ^2) **1.3 Cauchy Distribution** P. d. f. with parameters (μ, λ), nature of the probability curve, distribution function, quartiles, non-existence of moments, additive property for two independent Cauchy variates (statement only), statement of distribution of the sample mean, relationship with uniform and Students' t distribution, distribution of X/Y where X and Y are i. i. d. N (0, 1), examples and problems. **1.4 Weibull Distribution** P. d. f. with parameters (α, β), distribution function, quartiles, mean and variance, coefficient of variation, relation with gamma and exponential distribution, examples and problems. **1.5 Logistic distribution:** P.d.f. with parameters (μ, σ), c.d.f., mean, mode , variance, skewness using mode, applications. **1.6 Pareto distribution**: P.d.f. with parameters (α, β), mean, variance, mode, skewness using mode, applications. **1.7 Power series distribution**: P.m.f. mean, mode, variance, Binomial, Poisson, Geometric and negative binomial distribution as particular cases of power series distribution.	18

	1.8 Multinomial distribution: P.m.f, m.g.f., marginal distribution, mean, variance, covariance, variance and covariance matrix, correlation coefficient, additive property, Trinomial distribution as particular case of multinomial distribution.	
2	**Truncated Distributions & Bivariate Normal Distribution** **2.1 Truncated Distributions** Truncated distribution as conditional distribution, truncation to the right, left and on both sides. Binomial distribution B(n, p) left truncated at X = 0 (value zero not observable), its p.m.f, mean, variance. Poisson distribution P(m), left truncated at X = 0 (value zero not observable), its p.m.f., mean and variance. Normal distribution N (μ, σ^2) truncated (i) to the left below a (ii) to the right above b (iii) to the left below a and to the right above b, its p.d.f. and mean. Exponential distribution with parameter θ left truncated below a, its p.d.f., mean and variance. Examples and problems. **2.2 Bivariate Normal Distribution** p. d. f. of a bivariate normal distribution, BN $(\mu_1,\mu_2,\sigma_1^2,\sigma_2^2,\rho)$ marginal and conditional distributions, identification of parameters, conditional expectation and conditional variance, regression of Y on X and of X on Y., independence and uncorrelated-ness imply each other, m. g. f and moments. Distribution of aX + bY + c, where a, b and c are real numbers. Cauchy distribution as the distribution of Z = X/Y where (X, Y)~BN(0,0,$\sigma^2{}_1$,$\sigma^2{}_2$, ρ), Examples and problems.	18

Reference Books:

1. Cramer H.: Mathematical Methods of Statistics, Asia Publishing House, Mumbai.
2. Mood, A. M., Graybill K, Bose. D. C.: Introduction to Theory of Statistics. (Third edition) Mc-GrawHiil Series.
3. Lindgren B. W.: Statistical Theory (Third Edition), Collier MacmillanInternational Edition, Macmillan Publishing Co. Inc. New York. 4. Hogg, R. V. and Craig A. T. : Introduction to Mathematical Statistics (Third Edition), Macmillan Publishing Company, Inc. 866, 34d Avenue, New York, 10022.
4. Sanjay Arora and BansiLal: New Mathematical Statistics (First Edition), Satya Prakashan, 16/17698, New Market, New Delhi, 5 (1989).
5. Gupta S. C and Kapoor V. K.: Fundamentals of Mathematical Statistics, Sultan Chand and Sons, 88, Daryaganj, New Delhi 2.
6. Rohatgi V. K.: An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern Ltd., New Delhi.
7. Feller. W.: An Introduction of Probability Theory and its Applications, Wiley Eastern Ltd. Mumbai.
8. Jhonson and Kotz: Continuous Univariate Distributions I and II
   : Discrete Distributions : Multivariate Distributions
9. Bhat B. R.: Modern Probability Theory. New Age International.

Paper -X: Statistical Inference – I

Course Code: DSE 1004E2

Marks: 35 **Theory: 36 Hours** **Credits 2**

Course outcomes:

At the end of the course students will be able to:

CO1: Understand the notion of parameter and estimator.

CO2: Understand the concept of point estimation

CO3: Recall various properties of good estimators.

CO4: Apply various methods of estimation.

Unit	Content	Hours Allotted
1	**Point Estimation, Likelihood and Sufficiency** **1.1 Point Estimation** **1.1.1** Notion of a parameter, parameter space, general problem of estimation, estimating an unknown parameter by point and interval estimation. **1.1.2** Point estimation: Definition of an estimator (statistic) & its S.E., distinction between estimator and estimate, illustrative examples. Properties of estimator: Unbiased estimator, biased estimator, positive and negative bias, examples of unbiased and biased estimators. Proofs of the following results regarding the unbiased estimators: (a) Two distinct unbiased estimators of $\Psi(\theta)$ give rise to infinitely many unbiased estimators of $\Psi(\theta)$ (b) If T is unbiased estimator of θ then $\Psi(T)$ is an unbiased estimator of $\Psi(\theta)$ provided $\Psi(.)$ is a linear function. Sample variance is a biased estimator of the population variance. Illustration of unbiased estimator for the parameter and parametric function. **1.1.3** Relative efficiency of T_1 with respect to T_2, where T_1 and T_2 are unbiased estimators. Use of mean square error to modify the above definition for biased estimator. Minimum Variance Unbiased Estimator (MVUE) and Uniformly Minimum Variance Unbiased Estimator (UMVUE), uniqueness of UMVUE whenever it exists. Illustrative examples. **1.1.4** Consistency: Definition, proof of the following (a) Sufficient condition for consistency, (b) If T is consistent for θ and $\Psi(.)$ is a continuous function then $\Psi(T)$ is consistent for $\Psi(\theta)$. Illustrative examples. **1.2 Likelihood and Sufficiency** **1.2.1** Definition of likelihood function as a function of the parameter θ for a random sample from discrete and continuous distributions. Illustrative examples. **1.2.2** Sufficiency: Concept of sufficiency, definition of sufficient statistic through (i) conditional distribution of the sample given the statistic (ii) Neyman factorization criterion. Pitman Koopmans form and sufficient statistic. Proof of the following properties of sufficient	18

	statistic: a) If T is sufficient for ɵ then Ψ (T) is also sufficient for θ provided Ψ (.) is a one-to-one function. b) If T is sufficient for ɵ then T is sufficient for $\Psi(\theta)$ Examples. **1.2.3** Fisher information function: Definition of information function, amount of information contained in a sample. Statement regarding equality of the information in (x_1, x_2, ... ,x_n) and in a sufficient statistic T, concept of minimal sufficient statistic. With illustrations to exponential family. Illustrative examples.	
2	**Cramer Rao Inequality and Methods of Estimation** **2.1 Cramer Rao Inequality** Statement and proof of Cramer Rao inequality. Definition of Minimum Variance Bound Unbiased Estimator (MVBUE) of $\Psi(\theta)$. Proof of the following results: (i) If MVBUE exists for ɵ then MVBUE exists for $\Psi(\theta)$, if $\Psi(.)$ is a linear function. (ii) If T is MVBUE for ɵ then T is sufficient for ɵ. Examples and problems. **2.2 Methods of Estimation:** Method of maximum likelihood, derivation of maximum likelihood estimators for parameters of standard distributions. Use of iterative procedure to derive MLE of location parameter μ of Cauchy distribution, properties of MLE: i) invariance property (with proof) ii) MLE is a function of sufficient statistic iii)Non uniqueness property of MLE (with counter example) iv) MLE's are asymptotically Normally distributed (without proof) Illustrative examples. **2.3 Method of moments:** Derivation of moment estimators for standard distributions. Illustrations of situations where MLE and moment estimators are distinct and their comparison using mean square error (for uniform distribution). Illustrative examples. **2.4 Method of minimum chi-square:** Definition, derivation of minimum chi-square estimator for the parameter. Illustrative examples.	18

Reference Books:

1. Kale, B. K.: A first Course on Parametric Inference
2. Rohatgi, V. K.: Statistical Inference
3. Rohatgi, V. K.: An introduction to Probability Theory and Mathematical Statistics
4. Saxena H. C. and Surenderan : Statistical Inference
5. Kendall M. G. and Stuart A.: An advanced Theory of Statistics
6. Lindgren, B. W.: Statistical Theory
7. Lehmann, E. L.: Theory of Point Estimation
8. Rao, C. R.: Linear Statistical Inference

9. Dudewicz C. J. and Mishra S. N. : Modern Mathematical Statistics
10. Fergusson, T. S.: Mathematical statistics.
11. Zacks, S.: Theory of Statistical Inference.
12. Cramer, H.: Mathematical Methods of Statistics.
13. Cassela G. and Berger R. L.: Statistical Inference

Paper -XI: Sampling Theory
Course Code: DSE 1004E3

Marks: 35 **Theory: 36 Hours** **Credits 2**

Course Outcomes:

At the end of the course students will be able to:

CO1: Understand basic concepts in sampling theory.
CO2: Learn different sampling methods.
CO3: Estimate population parameters using sampling distributions of estimator.
CO4: Compare different sampling methods.

Unit	Content	Hours Allotted
1	**Basic Terminology ,SRS and Stratified Sampling** **1.1 Basic Terminology** Concept of distinguishable elementary units, sampling units, sampling frame, random sampling and non-random sampling. Advantages of sampling method over census method, objectives of a sample survey, Designing a questionnaire, Characteristics of a good questionnaire, Concept of sampling and non-sampling errors. Handling of non- response cases. **1.2 Simple random sampling** i. Simple random sampling from finite population of size N with replacement (SRSWR) and without replacement (SRSWOR): Definitions, population mean and population total as parameters, inclusion probabilities. ii. Following results with proof. a) In SRSWOR, the probability of a specified unit being selected in sample at any given draw is equal to 1/N. b) In SRSWOR, the probability of a specific unit included in the sample is n/N. c) In SRSWOR, the probability of drawing a sample of size 'n' from a population of size N units is 1/ $\left(\frac{N}{n}\right)$. d) In SRSWR, the probability of a specific unit included in the sample is 1- $\left(1-\frac{1}{N}\right)^n$ e) In SRSWR, the probability of drawing a sample of size 'n' from a population of size N units is $1/\ N^n$ iii. Sample mean $\bar{y}$ as an estimator of population mean $\bar{Y}_N$, derivation of its expectation, standard error and estimator of standard error under SRSWOR and SRSWR. iv. $N\bar{y}$ as an estimator of population total, derivation of its expectation, standard error and estimator of standard error under SRSWOR and SRSWR. v. Sampling for dichotomous attributes. Estimation of population proportion Sample proportion (p) as an estimator of population	18

	proportion (P), derivation of its expectation, standard error and estimator of standard error using SRSWOR. Np as an estimator of total number of units in the population possessing the attribute of interest, derivation of its expectation, standard error and estimator of standard error. **1.3 Determination of the sample size.** Determination of the sample size (n) under SRSWOR for variables and attributes given: i. Margin of error and confidence coefficient. ii. Coefficient of variation of the estimator and confidence coefficient. **1.4 Stratified Sampling** Real life situations where stratification can be used. i. Description of stratified sampling method where sample is drawn from individual stratum using SRSWOR method. a) $\underline{y}_{st}$ as an estimator of population mean $\bar{Y}_N$, derivation of its expectation, standard error and estimator of standard error. b) $N\underline{y}_{st}$ as an estimator of population total, derivation of its expectation, standard error and estimator of standard error. ii. Problem of allocation: Proportional allocation, Neyman's allocation and optimum allocation, derivation of the expressions for the standard errors of the above estimators when these allocations are used. iii. Comparison amongst SRSWOR, stratification with proportional allocation and stratification with optimum allocation. iv. Cost and variance analysis in stratified random sampling, minimization of variance for fixed cost, minimization of cost for fixed variance, optimum allocation as a particular case of optimization in cost and variance analysis. v. Real life examples.	
2	**Other Sampling Methods** **2.1 Systematic Sampling** i. Real life situations where systematic sampling is appropriate. Technique of drawing a sample using systematic sampling (when the population size is multiple of sample size). ii. Estimation of population mean and population total, standard error of these estimators. iii. Comparison of systematic sampling with SRSWOR. iv. Comparison of systematic sampling with SRSWOR and stratified sampling in the presence of linear trend. v. Idea of Circular Systematic Sampling. **2.2 Cluster Sampling** i. Real life situations where cluster sampling is appropriate. Technique of drawing a sample using cluster sampling. ii. Estimation of population mean and population total (with equal	18

	size clusters), standard error of these estimators. iii. Systematic sampling as a particular case of cluster sampling. **2.3 Two Stage and Multi Stage Sampling** Idea of two-stage and multistage sampling. **2.4 Sampling Methods using Auxiliary variables** **2.4.1 Ratio Method** i. Concept of auxiliary variable and its use in estimation ii. Situations where Ratio method is appropriate. iii. Ratio estimators of the population mean and population total and their standard errors (without derivations), estimators of these standard errors. iv. Relative efficiency of ratio estimators with that of SRSWOR **2.4.2 Regression Method** i. Situations where Regression method is appropriate. ii. Regression estimators of the population mean and population total and their standard errors (without derivations), estimators of these standard errors. iii. Comments regarding bias in estimation iv. Relative efficiency of regression estimators with that of a) SRSWOR b) Ratio estimator. **v:** Real life examples.	

Reference Books:

1. Cochran, W.G: Sampling Techniques, Wiley Eastern Ltd., New Delhi.
2. Sukhatme, P.V. and Sukhatme, B.V.: Sampling Theory of Surveys with Applications, Indian Society of Agricultural Statistics, New Delhi.
3. Des Raj: Sampling Theory.
4. Daroga Singh and Choudhary F.S.; Theory and Analysis of Sample Survey Designs, Wiley Eastern Ltd., New Delhi.
5. Murthy, M.N: Sampling Methods, Indian Statistical Institute, Kolkata.
6. Mukhopadhay, Parimal: Theory and Methods of Survey Sampling, Prentice Hall.

Paper -XII: Operations Research
Course Code: DSE 1004E4

Marks: 35 **Theory: 30 Hours** **Credits 2**

Course Outcomes:

At the end of the course students will be able to:

CO1: Understand different optimization techniques.

CO2: Transform real life situations/problems to its mathematical form.

CO3: Apply appropriate optimization technique to solve real life problems.

CO4: Generate real life scenario.

Unit	Content	Hours Allotted
1	**Linear programming, Transportation, Assignment and Sequencing Problems** **1.1 Basic concepts** Statement of the Linear Programming Problem (LPP), formulation of problem as Linear programming problem. Definition of (i) a slack variable, (ii) a surplus variable. L.P. problem in (i) canonical form, (ii) standard form. Definition of (i) a solution, (ii) a feasible solution, (iii) basic variable and non-basic variable, (iv) a basic feasible solution, (v) a degenerate and a non-generate solution, (vi) an optimal solution. **1.2 Solution of L.P.P.** i. Graphical Method: Solution space, obtaining an optimal solution, unique and non- unique optimal solutions. ii. Simplex Method: a) Initial basic feasible solution (IBFS) is readily available: obtaining an IBFS, criteria for deciding whether obtained solution is optimal, criteria for unbounded solution, more than one optimal solution. b) IBFS not readily available: introduction of artificial variable, Big-M method, modified objective function, modifications and applications of simplex method to L.P.P., criterion for no solution. **1.3 Duality Theory**: Writing dual of a primal problem, solution of L.P.P. with artificial variable. Examples and problems. **1.4 Transportation problem** i. Transportation problem (T. P.), statement of T. P., balanced and unbalance T. P. ii. Methods of obtaining initial basic feasible solution of T.P. (a) North West corner rule (b)Method of matrix minima (least cost method), (c) Vogel's approximation (VAM). iii. MODI method of obtaining Optimal solution of T. P, uniqueness and non- uniqueness of optimal solutions, degenerate solution. iv. Examples and problems. **1.5 Assignment Problem** i. Statement of an assignment problem, balanced and unbalanced assignment problem, relation with T.P, optimal solution of an assignment problem using Hungarian method. ii. Examples and problems. **1.6 Sequencing Problem** i. Introduction. Statement of problem. ii. Procedure of processing n jobs on two machines. iii. Procedure of processing n jobs on three machines and m	18

	machines. Computations of elapsed time and idle times. iv. Examples and problems.	
2	**Decision Theory and Simulation Techniques** **2.1: Decision Theory** i. Introduction, steps in decision theory approach. ii. Type of decision-making environments. iii. Decision making under uncertainty: Criteria of optimism, criteria of pessimism, equally likely decision criterion, criterion of regret. iv. Decision making under risk: Expected monetary value, expected opportunity loss, expected value of perfect information. v. Examples and problems. **2.2: Simulation Techniques** Meaning of simulation, Monte Carlo simulation, advantages and disadvantages of simulation, definition and properties of random numbers, generation of pseudo random numbers, Mid-Square method, Linear congruential method, Techniques of generating random numbers from uniform distribution, Tests for randomness and uniformity distribution, random variate generation using inverse cdf method, random variate generation from Bernoulli, Binomial, Poisson, Geometric, Exponential and normal distributions.	18

Reference Books:

1. Gass E.: Linear Programming Method and Applications, Narosa Publishing House, New Delhi.
2. Shrinath L. S.: Linear Programming.
3. Taha H. A.: Operation research – An Introduction, Fifth Edition, Prentice Hall of India, New Delhi.
4. Saceini, Yaspan, Friedman: Operations Research Method and Problems, Wiley International Edition.
5. Shrinath, L. S.: Linear Programming, Affiliated East-West Press Pvt. Ltd., New Delhi.
6. Phillips, D. T., Ravindra, A., Solberg, J.: Operations Research Principles and Practice, John Wiley and Sons Inc.
7. Sharma, J. K.: Mathematical Models in Operations Research, Tau McGraw Hill Publishing Company Ltd., New Delhi.
8. Kapoor, V. K.; Operations Research, Sultan Chand and Sons, New Delhi.
9. Gupta, P. K. and Hira, D. S.: Operations Research, S. Chand and Company Ltd., New Delhi.
10. Luc Devroye:Non-Uniform Random Variate Generation, Springer – Verlag, New York.
11. Gentle, J. E.: Random Number Generation and Monte Carlo Methods, Springer- Verlag.
12. Robert, C. P. and Casella, G.: Monte Carlo Statistical methods, Springer-Verlag.
13. Rubinstien, R. Y.: Simulation and Monte Carlo Method, John Wiley, New York.

Semester VI

Paper -XIII: Probability Theory

Course Code: DSE 1004F1

Marks: 35 **Theory: 36 Hours** **Credits 2**

Course Outcomes:

At the end of the course students will be able to:

CO1: Understand necessity of order statistics and its distributions.

CO2: Implement various laws of probability to get solution for different problems in Statistics.

CO3: Understand basic concepts of stochastic processes and their applications.

CO4: Apply Queuing theory and its real-life situations.

Unit	Content	Hours Allotted
1	**Order Statistics, Chebychev's Inequality, Convergence, WLLN & CLT** **1.1: Order Statistics** Order statistics for a random sample of size n from a continuous distribution, Joint distribution, definition, derivation of distribution function and density function of the i- th order statistic, particular cases for i=1 and i=n. Derivation of joint p. d. f. of i -th and j- th order statistics, statement of distribution of the sample range. Distribution of the sample median when n is odd. Examples and Problems. **1.2: Chebychev's Inequality:** Chebycheve's inequality for discrete and continuous distributions. Examples **1.3: Convergence** i. Definition of convergence of sequence of random variables (a) in probability, (b) in distribution, (c) in quadratic mean. ii. If $X_n^p \to X$ then $g(X_n^p) \to g(X)$ where g is continuous function without proof. Examples and Problems. **1.4: Weak Law of Large Numbers (WLLN):** Weak law of large numbers (WLLN)- statement and proof for i. i. d. random variables with finite variance. **1.5: Central limit theorem:** Statement and proof for i. i. d. random variables with finite variance, proof based on m. g. f. Simple examples based on Bernoulli, Binomial, Poisson and chi-square distribution.	18
2	**Finite Markov Chains & Queuing Theory** **2.1: Basic concepts:** Definition and examples of stochastic process, State Space, index set, classification of general stochastic process into	

	discrete – continuous time, discrete – continuous state space, problems and examples. **2.2: Markov chain:** Definition and examples of Markov chain, Homogenous and non-homogenous Markov chain, stochastic matrix, transition probability matrix, Chapman - Kolmogorov equation (statement only), n step transition probability matrix, Accessible state, Communicating States, Closed Class, Absorbing States, Reducible and irreducible Markov chain, classification of states, simple problems. Stationary probability distribution, applications. Examples and problems. **2.3: Continuous Markov chain:** Pure birth process, Poisson process, birth and death process. (Derivations not expected). Examples and problems. **2.4 Queuing Theory** i. Introduction, essential features of queuing system, input source, queue configuration, queue discipline, service mechanism. ii. Operating characteristics of queuing system, transient- state and steady state, queue length, general relationship among system characteristics. iii. Probability distribution in queuing system: Distribution of arrival, distribution of inter arrival time, distribution of departure and distribution of service time (Derivations are not expected). iv. Types of queuing models: v. Solution of queuing Model: M/M/1, using FCFS queue discipline. vi. Problems and examples.	18

Reference Books:

3. Cramer H.: Mathematical Methods of Statistics, Asia Publishing House, Mumbai.
4. Lindgren B. W.: Statistical Theory (Third Edition), Collier Macmillan International Edition, Macmillan Publishing Co. Inc. New York.
5. Hogg, R. V. and Craig A. T. : Introduction to Mathematical Statistics (Third Edition), Macmillan Publishing Company, Inc. 866, 34d Avenue, New York, 10022.
6. Sanjay Arora and BansiLal: New Mathematical Statistics (First Edition), Satya Prakashan, 16/17698, New Market, New Delhi, 5 (1989).
7. Gupta S. C and Kapoor V. K.: Fundamentals of Mathematical Statistics, Sultan Chand and Sons, 88, Daryaganj, New Delhi 2.
8. Rohatgi V. K.: An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern Ltd., New Delhi.
9. MedhiJ : Stochastic Processes. Wiley Eastern Ltd. New Delhi.
10. Hoel, Port and Stone: Introduction to Stochastic Processes, Houghton Mifflin.
11. Feller. W.: An Introduction of Probability Theory and its Applications. Wiley Eastern Ltd. Mumbai.
12. Bhat B. R.: Modern Probability Theory.
13. Karlin and Taylor: Stochastic process.
14. Ross S: Probability Theory.

15. Bhat B. R.: Stochastic Models: Analysis and Applications. New Age International.
16. 16.Zacks S.: Introduction to Reliability Analysis, Probability Models and Statistical
17. Methods, Springer Verlag.
18. Taha H. A.: Operation research – An Introduction, Fifth edition, Prentice Hall of India, New Delhi
19. Parimal Mukhopadhyaya: An Introduction to the Theory of Probability. World Scientific Publishing.

Paper -XIV: Statistical Inference – II

Course Code: DSE 1004F2

Marks: 35 **Theory: 36 Hours** **Credits 2**

Course Outcomes:

At the end of the course students will be able to:

CO1: Construct confidence intervals for population parameters.

CO2: Understand concept of testing of hypothesis.

CO3: Develop test procedures for testing hypothesis.

CO4: Implement appropriate nonparametric tests for real life testing of hypothesis problems.

Unit	Content	Hours Allotted
1	**Interval Estimation & Parametric Tests** **1.1 Interval Estimation** **1.1.1** Notion of interval estimation, definition of confidence interval, length of confidence interval, confidence bounds. Definition of Pivotal quantity and its use in obtaining confidence intervals and bounds. **1.1.2** Interval estimation for the following cases: i. Mean μ of normal distribution (σ^2known and σ^2 unknown). ii. Variance σ^2 of normal distribution (μ known and μ unknown). iii. Difference between two means μ_1- μ_2, a) for a sample from bivariate normal population, b) for samples from two independent normal populations. iv. Ratio of variances for samples from two independent normal populations. v. Mean of exponential distribution. vi. Population proportion and difference of two population proportions of two independent large samples. vii. Population median using order statistics. viii. Illustrative examples. **1.2 Parametric Tests** **1.2.1:** Statistical hypothesis, problems of testing of hypothesis, definitions and illustrations of simple hypothesis composite hypothesis, critical region, type I and type II error, probabilities of type I & type II errors. Power of a test, p-value, size of a test, level of significance, problem of controlling probabilities of type I & type II errors. **1.2.2:** Definition of Most Powerful (MP) test , Neyman-Pearson (NP) lemma (only Statement) for simple null hypothesis against simple alternative hypothesis for construction of MP test. Examples of construction of MP test of level α. **1.2.3:** Power function of a test, power curve, definition of uniformly most powerful (UMP) level α test. Use of NP lemma for constructing UMP level α test for one-sided alternative. Computation of powers for standard probability distributions, Illustrative examples. **1.2.4:** Likelihood Ratio Test: Procedure of likelihood ratio test, properties (only statements) , Likelihood Ratio test involving mean and	18

	variance of normal population.	
2	**Sequential Probability Ratio Tests (SPRT) & Non- parametric Test** **2.1: Sequential Probability Ratio Tests (SPRT)** General theory of sequential analysis and its comparison with fixed sample procedure. Wald's SPRT of strength (α, β) for simple null hypothesis against simple alternative hypothesis. Illustrations for standard distributions like Binomial, Poisson, exponential and normal distributions. Graphical and tabular procedure for carrying out the test. Illustrative examples. **2.2: Non- parametric Test** Notion of non-parametric statistical inference (test) and its comparison with parametric statistical inference. Concept of distribution free statistic. Test procedure of: i. Run test for one sample (i.e. test for randomness) and run test for two independent sample problems. ii. Sign test for one sample and two sample observations. iii. Wilcoxon's signed rank test for one sample and two sample paired observations. iv. Mann-Whitney U - test (two independent samples) v. Median test vi. Kolmogorov Smirnov test for one and for two independent samples.	18

Books Recommended

1. Kale, B. K.: A first Course on Parametric Inference
2. Rohatgi, V. K.: Statistical Inference
3. Rohatgi, V. K.: An introduction to Probability Theory and Mathematical Statistics
4. Saxena H. C. and Surendran : Statistical Inference
5. Kendall M. G. and Stuart A.: An advanced Theory of Statistics
6. Lindgren, B. W.: Statistical Theory
7. Cassela G. and Berger R. L.: Statistical Inference
8. Lehmann, E. L: Testing of Statistical Hypothesis
9. Rao, C. R.: Linear Statistical Inference
10. Dudewicz C. J. and Mishra S. N.: Modern Mathematical Statistics
11. Fergusson, T. S.: Mathematical statistics.
12. Zacks, S.: Theory of Statistical Inference.
13. Cramer, H.: Mathematical Methods of Statistics.
14. Gibbons, J. D.: Non-parametric Statistical Inference.
15. Doniel: Applied Non-parametric Statistics
16. Siegel, S.: Non-parametric Methods for the behavioral sciences.
17. Kunte, S.: Purophit, S. G. and Wanjale, S.K.: Lecture notes on Non-parametric Tests.

Paper -XV: Design of Experiment
Course Code: DSE 1004F3

Marks: 35 **Theory: 36 Hours** **Credits: 2**

Course outcomes:

At the end of the course students will be able to:

CO1: Understand the basic terminology in design of experiments.

CO2: Analyse different real life situations using appropriate designs.

CO3: Compare efficiency of different designs.

CO4: Understand concepts of ANOCOVA, factorial experiment and Confounding.

Unit	Content	Hours Allotted
1	**Simple Designs of Experiments:** **1.1: Basic Concepts:** i. Basic terms in design of experiments: Experimental unit, treatment, layout of an experiment. ii. Basic principles of design of experiments: Replication, randomization and local control. iii. Choice of size and shape of a plot for uniformity trials, the empirical formula for the variance per unit area of plots. **1.2: Completely Randomized Design (CRD)** i. Application of the principles of design of experiments in CRD, layout, mathematical model, assumptions and interpretations: ii. Estimation of parameters, expected values of mean sum of squares, components of variance. iii. Breakup of total sum of squares in to components. iv. Visual inspection of treatment effects using treatment wise Box plots. v. Technique of one-way analysis of variance (ANOVA) and its applications to CRD. vi. Statement of Chochran's theorem (without proof) for justification of F-test. vii. Tests for equality for treatment effects and its interpretation. Test for equality of two specified treatment effects using Critical Difference (CD) viii. Model adequacy check using residual analysis. **1.3: Randomized Block Design (RBD):** i. Application of the principles of design of experiments in RBD, layout, mathematical model, assumptions and interpretations: ii. Estimation of parameters, expected values of mean sum of squares, components of variance. iii. Breakup of total sum of squares into components. iv. Visual inspection of treatment effects using treatment wise Box plots. v. Technique of two-way analysis of variance (ANOVA) and its	18

	applications to RBD. Residual analysis for model adequacy checking. vi. Tests and their interpretations, test for equality of two specified treatment effects, vii. comparison of treatment effects using critical difference (C.D.). viii. Idea of missing plot technique. ix. Situations where missing plot technique is applicable. x. Analysis of RBD with single missing observation. **1.4: Latin Square Design (LSD)** i. Application of the principles of design of experiments in LSD, layout, mathematical model, assumptions and interpretations. ii. Breakup of total sum squares into components. iii. Estimation of parameters, expected values of mean sum of squares, components of variance. preparation of analysis of variance (ANOVA) table. iv. Visual inspection of treatment effects, row and column effects using BOX-PLOT's. xi. Tests and their interpretations, test for equality of two specified treatment effects, comparison of treatment effects using critical difference (C.D.). Residual analysis for model adequacy checking. v. Analysis of LSD with single missing observation. vi. Identification of real-life situations where CRD, RBD and LSD are used.	
2	**Efficiency of design, ANOCOVA and Factorial Experiments** **2.1: Efficiency of design** Efficiency of design i. Concept and definition of efficiency of a design. ii. Efficiency of RBD over CRD. iii. Efficiency of LSD over CRD and LSD over RBD. **2.2**: **ANOCOVA** Analysis of Covariance (ANOCOVA) with one concomitant variable iv. Purpose of analysis of covariance. v. Practical situations where analysis of covariance is applicable. vi. Modelfor analysis of covariance in CRD and RBD. Estimation of parameters (derivations are not expected). vii. Preparation of analysis of covariance (ANOCOVA) table, **2.3**: **Analysis of non- normal data in CRD, RBD, LSD using** i)Square root transformation for counts. ii)Sin-1 (.) transformation for proportions. iii)Kruskal Wallis test. **2.4: Factorial Experiments** i. General description of factorial experiments, 2^2 and 2^3 factorial experiments arranged in RBD. ii. Definitions of main effects and interaction effects in 2^2 and 2^3 factorial experiments.	18

	iii. Model, assumptions and its interpretation. iv. Preparation of ANOVA table by Yate's procedure, test for main effects and interaction effects and plots v. General idea and purpose of confounding in factorial experiments. vi. Total confounding (Confounding only one interaction): ANOVA table, testing main effects and interaction effects. vii. Partial Confounding (Confounding only one interaction per replicate): ANOVA table, testing main effects and interaction effects. viii. Construction of layout in total confounding and partial confounding in 2^3factorial experiment.	

Reference Books:

1. Federer, W.T.: Experimental Design, Oxford and IBH publishing Company, New Delhi.
2. Cochran, W.G. and Cox, G.M.: Experimental Design, John Wiley and Sons, Inc., New York.
3. Montgomery, D.C.: Design and Analysis of Experiments, Wiley Eastern Ltd., New Delhi.
4. Das, M.N. and Giri, N.C.: Design and Analysis of Experiments, Wiley Eastern Ltd., New Delhi.
5. Goulden, G.H.: Methods of Statistical Analysis, Asia Publishing House, Mumbai.
6. Kempthrone, O.: Design and Analysis of Experiments, Wiley Eastern Ltd., New Delhi.
7. Snedecor, G.W. and Cochran, W.G.: Statistical Methods, Affiliated East-West Press, New Delhi.
8. Goon, Gupta, Dasgupta: Fundamental of Statistics, Vol. I and II, The World Press Pvt. Ltd. Kolkata.
9. Gupta, S.C. and Kapoor, V.K.: Fundamentals of Applied Statistics, S. Chand & Sons, New Delhi.
10. C.F. Jeff Wu, Michael Hamada: Experiments, Planning Analysis and Parameter Design Optimization.

B. Sc. III Semester VI- Statistics
Paper -XVI: Quality Management
Course Code: DSE 1004F4

Marks: 35 **Theory: 36 Hours** **Credits: 2**

Course outcomes:

At the end of the course students will be able to:

CO1: Understand concept of quality and dimensions of quality.

CO2: Construct various types of control charts for quality control problems.

CO3: Apply acceptance sampling plan for monitoring quality of products.

CO4: Learn different sampling schemes used in SQC.

Unit	Content	Hours Allotted
1	**Quality Tools and Process Control** **1.1: Quality Tools:** Meaning and dimensions of quality, quality philosophy, magnificent tools of quality: Histogram, Check sheet, Pareto diagram, cause and effect diagram, scatter diagram, control chart, flow chart. Deming's PDCA cycle for continuous improvements and its applications. **1.2: Process Control** **i)** Meaning and purpose of S.Q.C., Process control, Product control, chance causes, assignable causes, Shewhart's control chart construction &working, lack of control situation. **ii)** Control charts for variables - control chart for mean, control chart for range, construction and working of mean & range charts for unknown standards, revised control limits. **iii)** Control charts for Attributes – Defects, defectives, fraction defective, control chart for fraction defective (p-chart) for fixed sample size and unknown standards, construction and working of chart. Control charts for number of defects (C-chart), for unknown standards, construction and working of C-chart. **iv)** CUSUM chart, tabular form, use of these charts for monitoring process mean. Moving average and exponentially weighted moving average charts. Introduction to six-sigma methodology, DMAIC cycle and case studies.	18
2	**Product Control** Sampling Inspection plans for attribute inspection: Concept of AQL, LTPD, Consumer's risk, producer's risk, AOQ, AOQL, OC, ASN and ATI. Description of Single and double sampling plans with determination of above constants. Sequential Sampling, Continuous sampling plans, skip-lot sampling plans.	18

Books Recommended

1. Introduction to quality Control – Montgomery D. C.
2. Quality Control and Industrial statistics Duncan A J
3. Statistical Quality Control by E L Grant

Practical Paper IV

Probability Distributions and R – Software

1. Model sampling from Laplace and Cauchy distributions
2. Model sampling from Lognormal & Weibull distribution
3. Model sampling from pareto & Logistic distribution
4. Model sampling from truncated binomial and poison distributions.
5. Model sampling from truncated normal and exponential distributions.
6. Model sampling from bivariate normal distribution.
7. Fitting of Lognormal & Weibull distribution.
8. Fitting of Logistic distribution.
9. Fitting of truncated Binomial & truncated Poisson distribution.
10. Application of multinomial distribution.
11. Application of bivariate normal distribution.
12. Computation of probabilities of type I and type II errors and power of a test using R- Software.
13. Model sampling from log-normal and Weibull distributions using R-Software.
14. Model sampling from logistic distribution using R-Software.
15. Fitting of Binomial and Poisson distribution using R-Software.
16. Fitting of Normal distribution using R-Software.
17. Fitting of log-normal distribution using R-Software.
18. Analysis of Completely Randomized Design (CRD) & Randomized Block Design (RBD using R-Software.

PRACTICAL PAPER – V

Statistical Inference

1. Point estimation by method of moments for discrete distributions.
2. Point estimation by method of moment for continuous distributions.
3. Point estimation by method of maximum likelihood (one parameter).
4. Point estimation by method of maximum likelihood (two parameters).
5. Point estimation by method of minimum chi-square.
6. Interval estimation of location and scale parameters of normal distribution (single sample).
7. Interval estimation of difference of location and ratio of scale parameters of normal distribution (two samples).
8. Interval estimation for population proportion and difference between two population proportions.
9. Interval estimation for population median using order statistics.
10. Construction of MP test.
11. Construction of UMP test.
12. Construction of SPRT for binomial, Poisson distributions, graphical representation of procedure.
13. Construction of SPRT for exponential and normal distribution, graphical representation of procedure.
14. NP test- -Run test (for one and two independent samples).
15. NP test –Sign test and Wilcoxon's signed rank test (for one and two samples paired observation).
16. NP test-- Mann-Whitney U- test (for two independent samples).
17. NP test –Median test (for two large independent samples)
18. NP test—Kolmogorov - Smirnov test (for one and two independent samples).

PRACTICAL PAPER – VI

Sampling Theory and Design of Experiments

1. Simple Random Sampling for Variables.
2. Simple Random Sampling for Attributes.
3. Determination of Sample Size in SRS for Variables and Attributes.
4. Stratified Random Sampling – I
5. Stratified Random Sampling – II
6. Ratio Method of Estimation.
7. Regression Method of Estimation.
8. Systematic Sampling.
9. Cluster Sampling.
10. Analysis of CRD and RBD.
11. Analysis of Latin Square Design (LSD).
12. Missing Plot Technique for RBD and LSD with one missing observation.
13. Efficiency of i) RBD over CRD and ii) LSD over CRD and RBD.
14. Analysis of Covariance in CRD and RBD.
15. Analysis of 2^2 and 2^3 Factorial Experiment.
16. Total Confounding.
17. Partial Confounding
18. Kruskal Wallis test for non-normal data. (CRD)

PRACTICAL PAPER VII

Operations Research and Quality Management

1. Graphical method
2. L.P.P. by simplex method I (Slack variable)
3. L.P.P. by simplex method II (Big M method)
4. Transformation problem
5. Assignment problem.
6. Sequencing Problem.
7. Decision Theory.
8. Simulation I (Discrete distribution)
9. Simulation II (Continuous distribution)
10. Construction of R and $\bar{X}$ charts.
11. Construction of P and C charts.
12. EWMA-Chart
13. CUSUM chart.
14. Six sigma limits for mean.
15. Single sampling plan-I (Small sample).
16. Single sampling plan-II (Large sample).
17. Double sampling plan-I (Small sample.
18. Double sampling plan-II (Large sample).

Skill Enhancement Course I

Database Management System (DBMS)

Course Outcomes:

At the end of the course students will be able to:

CO1: Enhance database handling, data manipulation and data processing skills through SQL.

CO2: Develop data centric computer applications.

UNIT I:

Introduction: Overview of Database Management System, Introduction to Database Languages, advantages of DBMS over file processing systems.

UNIT II

Relational Database Management System: The Relational Model, Introduction to SQL: Basic Data Types, working with relations of RDBMS: Creating relations e.g., Bank, College Database (create table statement)

UNIT III:

Modifying relations (alter table statement), Integrity constraints over the relation like Primary Key, Foreign key, NOT NULL to the tables, advantages and disadvantages of relational Database System.

UNIT IV:

Database Structure: Introduction, Levels of abstraction in DBMS, View of data, Role of Database users and administrators, Database Structure: DDL, DML, Data Manager (Database Control System). Types of Data Models Hierarchical databases, Network databases, Relational databases, Object oriented databases

Reference:

1. Gruber, M (1990): Understanding SQL, BPB publication

2. Silberschatz, A, Korth, H and Sudarshan,S(2011) “Database System and Concepts”, 6th Edition McGraw-Hill.

3. Desai, B. (1991): Introduction to Database Management system, Galgotia Publications

Skill Enhancement Course II
Project Work

The main objective of this course is to acquaint students with the following concepts.

- To apply different methods of collection of data if any
- To analyze the data using statistical tools
- To prepare the report of the project
- To make the presentation of the project work

The students are supposed to carry out project work during this semester. This project work should be done in a group of not more than 5 students. The project will be evaluated on the following parameters:

Sr. No.	Distribution of work	Marks
1	Initial presentation of the problem	10
2	Data collection/ Methods to be used / layout of project	10
3	Submission of the project & final presentation in scheduled time	20
4	Attendance & active participation for project work	10

Note: Viva would be conducted individually. Viva will be taken for 15 minutes for each candidate.

Nature of Practical Examination B.Sc.III (as per BoS guidelines)

1. Nature of practical papers:

(i) Each practical question paper must contain **four** questions.

(ii) Each question should contain **two** bits from different units.

(iii) Student should attempt **Any Two** questions.

(iv) Each question should carry 20 marks and to be distributed according to following points:

(a) Aim of the Experiment: 2 Marks

(b) Statistical formulae: 4 Marks

(c) Observation Tables: 6 Marks

(d) Calculations: 6 Marks

(e) Conclusion/ result of the experiment :2 Marks.

v) Practical examination is of 4 hours duration which includes oral as well as online demonstration.

vi) There should be two subject experts at the time of practical examination.

2. Instructions:

i. While attempting questions based on R-software students have to write the commands of R-software on their Answer-book. Final result should be shown to the examiner online or the printout may be attached.

ii. Duration of each practical paper should be of four hours.

Nature of Theory Question Paper:

Nature of Question Paper (Except English)

Time: 2 hours **Total Marks: (35)**

Instructions: (1) **All** questions are **compulsory**.
(2) Figures to the **right** indicate **full** marks.
(3) Draw **neat**, labeled diagrams **wherever** necessary.
(Paper setter may add or delete any instruction if required)

Q.1. A) Select correct alternative. **(05)**

(i) .....
a) b) c) d)
(ii) .....
a) b) c) d)
(iii) .....
a) b) c) d)
(iv) .....
a) b) c) d)
(v) .....
a) b) c) d)

B) Fill in the blanks **(02)**

i) .....
ii) .....

Q. 2. Attempt any two **(16)**

(i)
(ii)
(iii)

Q.3. Attempt any three **(12)**

(i)
(ii)
(iii)
(iv)
(v)

Assessment Structure
Structure of Question Paper
Internal Evaluation

Semester	Evaluation	Marks
V	1. Unit test	10
	2. MCQ Test	10
	3. Seminar/Oral/Assignment	10
VI	1. Unit test	10
	2. MCQ Test	10
	3. Seminar/Oral/ Assignment	10

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