"Dissemination of Education for Knowledge, Science and Culture"
-Shikshanmaharshi Dr. Bapuji Salunkhe

Shri Swami Vivekanand Shikshan Sanstha's
VIVEKANAND COLLEGE, KOLHAPUR
(An EMPOWERED AUTONOMOUS INSTITUTION)

Department of Statistics

B. Sc. Part – III

Syllabus with effect from July, 2025-2026
As Per NEP 1.0

Departmental Teaching and Evaluation scheme
(NEP-Phase-I)
Three/Four- Years UG Programme
Third Year Semester-V & VI

Sr. No.	Course Abbreviation	Course code	Course Name	Teaching Scheme Hours/Week		Examination Scheme and Marks				Course Credits
				TH	PR	ESE	CIE	PR	Marks	
Semester-V										
1	DSC-IX	DSC03STA51	Probability Distributions	2	-	40	10	-	50	2
2	DSC-X	DSC03STA52	Statistical Inference - I	2	-	40	10	-	50	2
3	DSC-XI	DSC03STA53	Sampling Theory	2	-	40	10	-	50	2
4	DSE-I	DSE03STA51	Operations Research	2	-	40	10	-	50	2
		DSE03STA52	Machine Learning							
		DSE03STA53	Reliability Theory							
5	VSC-PR-IV	VSC03STA59	Statistical Computing using Python I		4			25	25	2
6	FP	FPR03STA51	Field Project	-	2			50	50	2
7	DSC-PR-V	DSC03STA59	DSC Statistics Practical V	-	12	-	-	75	75	6
8	MIN-IX	MIN03STA51	Reliability Theory	2	-	40	10	-	50	2
9	MIN-PR-V	MIN03STA59	MIN Statistics Practical V	-	4	-	-	25	25	2
Semester –V Total				**10**	**20**	**200**	**50**	**175**	**425**	**22**
Semester-VI										
1	DSC-XII	DSC03STA61	Probability Theory	2	-	40	10	-	50	2
2	DSC-XIII	DSC03STA62	Statistical Inference -II	2	-	40	10	-	50	2
3	DSC-XIV	DSC03STA63	Design of Experiments	2	-	40	10	-	50	2
4	DSE-II	DSE03STA61	Quality Management	2	-	40	10	-	50	2
		DSE03STA62	Biostatistics							
		DSE03STA63	Stochastic Process							
5	VSC-PR-V	VSC03STA69	Statistical Computing using Python II		4			25	25	2
6	OJT	OJT03STA61	On Job Training	-	2	-	-	50	50	2
7	DSC-PR-VI	DSC03STA69	DSC Statistics Practical VI	-	12	-	-	75	75	6
8	MIN-X	MIN03STA61	Stochastic Process	2	-	40	10	-	50	2
9	MIN-PR-VI	MIN03STA69	MIN Statistics Practical VI	-	4	-	-	25	25	2
Semester –VI Total				**10**	**20**	**200**	**50**	**175**	**425**	**22**

Practical Examination Semester V
Practical Paper V

Section No.	Title of the Practical	Marks for Practical	Journal + Oral	Study Tour / Seminar	Total Marks
I	Probability Distributions	15	10	5	75
II	Statistical Inference I	15			
III	Sampling Theory	15			
IV	Operations Research / Reliability Theory/ Machine Learning	15			

Practical Examination Semester VI
Practical Paper VI

Section No.	Title of the Practical	Marks for Practical	Journal + Oral	Study Tour / Seminar	Total Marks
I	Probability Theory	15	10	5	75
II	Statistical Inference II	15			
III	Design of Experiments	15			
IV	Quality Management /Biostatistics/ Stochastic Process	15			

Evaluation Pattern for Practical Course:
Marks Distribution of Practical (LAB) course for each semester

Course	Experimental work	Oral+ Journal assessment	Total Marks
Minor / VSC	**20**	**05**	**25**

Semester V

Paper -IX: Probability Distributions

Course Code: DSC03STA51

Marks: 40 **Theory: 30 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 distributions.

CO2: Understand the knowledge of 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.	15
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	15

	(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.	

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-Graw Hill Series.
3. Lindgren B. W.: Statistical Theory (Third Edition), Collier Macmillan International 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.
5. Sanjay Arora and Bansilal: New Mathematical Statistics (First Edition), Satya Prakashan, 16/17698, New Market, New Delhi, 5 (1989).
6. Gupta S. C and Kapoor V. K.: Fundamentals of Mathematical Statistics, Sultan Chand and Sons, 88, Daryaganj, New Delhi 2.
7. Rohatgi V. K.: An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern Ltd., New Delhi.
8. Feller. W.: An Introduction of Probability Theory and its Applications, Wiley Eastern Ltd. Mumbai.

Paper -X: Statistical Inference – I
Course Code: DSC03STA52

Marks: 40 **Theory: 30 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: Learn various properties of good estimators.
CO4: Apply various methods of estimation.

Unit	Content	Hours Allotted
1	**Point Estimation, Likelihood and Sufficiency** **1.1** Notion of a parameter, parameter space, general problem of estimation, estimating an unknown parameter by point and interval estimation. **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. (c) Sample variance is a biased estimator of the population variance. Illustration of unbiased estimator for the parameter and parametric function. **1.3** 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. **1.4 Likelihood and Sufficiency** **1.4.1** Definition of likelihood function as a function of the parameter θ for a random sample from discrete and continuous distributions. Illustrative examples. **1.4.2** 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 statistic: (a) If T is sufficient for θ then $\Psi(T)$ is also sufficient for θ provided $\Psi(.)$ is a one-to-one function. (b) If T is sufficient for θ then T is sufficient for $\Psi(\theta)$ Examples. **1.4.3** 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, ..., xn) and in a sufficient statistic T, concept of minimal sufficient statistic. With illustrations to exponential family. Illustrative examples.	15

	1.5 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.	
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 θ then MVBUE exists for $\Psi(\theta)$, if $\Psi(.)$ is a linear function. (ii) If T is MVBUE for θ then T is sufficient for θ. 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.	**15**

Reference Books:

1. Kale, B. K.: A first Course on Parametric Inference second edition, Alpha Science International Ltd.
2. V. K. Rohatgi, and A. K. MD. E. Saleh (2015): Introduction to Probability Theory and MathematicalStatistics, John Wiley & sons, 3rd Edition.
3. E. L. Lehmann (1983): Theory of Point Estimation, John Wiley & sons.
4. C. R. Rao (1973): Linear Statistical Inference and its Applications, wiley, 2nd Edition.
5. B. K. Kale, and K. Muralidharan (2015): Parametric Inference: An Introduction, Alpha Science InternationalLtd.
6. P. Mukhopadhyay (2015): Mathematical Statistics, Books and Allied (p)Ltd.
7. E. J. Dudewicz and S. N. Mishra (1988): Modern Mathematical Statistics, John Wiley and Sons.
8. Casella and Berger (2002): Statistical Inference, Duxbury advanced series, IInd edition.

Paper -XI: Sampling Theory

Course Code: DSC03STA53

Marks: 40	**Theory: 30 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/ $\binom{N}{n}$. 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 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.	15

	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 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	**15**

	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. Daroga Singh and Choudhary F.S.; Theory and Analysis of Sample Survey Designs, Wiley Eastern Ltd., New Delhi.
4. Murthy, M.N: Sampling Methods, Indian Statistical Institute, Kolkata.
5. Mukhopadhyay Parimal: Theory and Methods of Survey Sampling, Prentice Hall.

DSE -I: Operations Research
Course Code: DSE03STA51

Marks: 40	**Theory: 30 Hours**	**Credits 2**

Course Outcomes:

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

CO1: Understand different optimization techniques & transform real life situations/problems to its mathematical form.

CO2: Formulate and solve linear programming, transportation, and assignment problems using suitable optimization methods.

CO3: Apply sequencing techniques to optimize job scheduling and minimize total elapsed and idle times in real-life situations.

CO4: Learn the concept of CPM & PERT.

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.	15

	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 machines. Computations of elapsed time and idle times. iv. Examples and problems.	
2	**CPM & PERT** **2.1: CPM & PERT** i. Introduction Basic differences between PERT and CPM. ii. Definition of (i) Events with Merge and Burst Events, (ii) Node, (iii) Activities – Predecessor, Successor, Dummy, (iv)Critical Activity, (v)Project Duration iii. CPM: Construction of network, Definitions of (i) earliest start time (ii) earliest finish time (iii) latest start time (iii) latest finish time for an activity. Types of floats - total floats, free float, independent float and their significance. Determination of critical path iv. PERT: Construction of network; (i) pessimistic time estimate, (ii) optimistic time estimate (iii) most likely time estimates, Determination of critical path, determination of mean and standard deviation of project duration, computations of probability of completing the project in a specified duration.	**15**

Reference Books:

1. Taha H. A.: Operation research – An Introduction, Fifth Edition, Prentice Hall of India, New Delhi.
2. Shrinath, L. S.: Linear Programming, Affiliated East-West Press Pvt. Ltd., New Delhi.
3. Phillips, D. T., Ravindra, A., Solberg, J.: Operations Research Principles and Practice, John Wiley and Sons Inc.
4. Sharma, J. K.: Mathematical Models in Operations Research, Tau McGraw Hill Publishing Company Ltd., New Delhi.
5. Kapoor, V. K.; Operations Research, Sultan Chand and Sons, New Delhi.
6. Gupta, P. K. and Hira, D. S.: Operations Research, S. Chand and Company Ltd., New Delhi.
7. Kanti Swaroop & Gupta M. M (1985): Operations Research, Sultan Chand & Co. ltd.
8. Hadley G. (1969): Linear Programming, Addison Wesley

DSE -II: Machine Learning
Course Code: DSE03STA52

Marks: 40 **Theory: 30 Hours** **Credits 2**

Course Outcomes:

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

CO1: Understand data preprocessing techniques, data cleaning, and types of machine learning.
CO2: Explain and apply different classification techniques.
CO3: Evaluate machine learning models using various performance measures.
CO4: Improve classification accuracy using ensemble methods.

Unit	Content	Hours Allotted
1	**Introduction to Data and Classification** **1.1 Understanding Data:** **Types of Data**: Structured vs. Unstructured Data, Categorical vs. Numerical Data, Continuous vs. Discrete Data **Data Cleaning**: Handling duplicates, dealing with inconsistent data, detecting and treating outliers **Data Transformation**: Normalization, Standardization, Feature Scaling **Data Discretization**: Binning techniques (Equal-width binning, Equal-frequency binning, Decision tree-based discretization) **Data Visualization**: Histograms, Boxplots, Scatterplots, Heatmaps, Correlation Matrices **Handling Missing Values**: Deletion methods, Mean/Median/Mode imputation, Predictive models for imputation **1.2 Supervised vs. Unsupervised Learning:** Definition and comparison of Supervised and Unsupervised learning, Applications of both learning paradigms, Examples of problems solved by each approach **1.3 Classification Problem:** Basics of classification: Binary vs. Multi-class classification Train-Test Split: Importance, Overfitting vs. Underfitting Cross-Validation: k-Fold Cross-Validation, Leave-One-Out Cross-Validation, Stratified Sampling **1.4 Classification Techniques:** K-Nearest Neighbors (KNN), Naïve Bayes Classifier.	**15**
2	**Model Evaluation and Accuracy Improvement** **2.1 Performance Measures** Accuracy: Definition, Limitations with imbalanced data Precision, Recall, and F1-score: Understanding the confusion matrix, Trade-offs between precision and recall ROC (Receiver Operating Characteristic) and AUC (Area Under Curve): Graphical interpretation, Threshold selection **2.2 Advanced Model Evaluation** Bootstrap Sampling: Concept, Application in model validation Cost-Benefit Analysis: Decision-making based on model performance **2.3** Cluster Analysis using K-Means	**15**

Reference Books:

1. Margret. H and Dunham: Data Mining- Introductory and Advanced Topics
2. G. K. Gupta: Introduction to Data Mining with case studies
3. R: Zhao: Data Mining Application.
4. Han, Kamber and Pei: Data Mining: Concepts and technique

DSE -III: Reliability Theory
Course Code: DSE03STA53

Marks: 40 **Theory: 30 Hours** **Credits 2**

Course Outcomes:

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

CO1: Understand the basic concepts of reliability.
CO2: Understand the different properties of ageing.
CO3: Interpret and apply survival functions, hazard functions, and mean residual life functions in reliability analysis.
CO4: Derive and utilize reliability measures for Exponential, Gamma, Weibull, and Pareto distributions.

Unit	Content	Hours Allotted
1	**Basic Terminology** 1.1 Structural properties of coherent system 1.2 Binary system of independent components, order of the system, different types of systems, concept of the structure function, structure function of series system, parallel system, k-out-of-n system, essentially series and parallel system, reliability block diagram 1.3 Path sets, cut sets, minimal path and cut set, representation of coherent system in terms of minimal path sets and cut sets. 1.4 Reliability of coherent system i. Reliability (h(p)) of system of independent components. ii. Computation of reliability of coherent system by using minimal path and cut set representation. iii. Reliability of Binary Components and Systems. 1.5 Coherent structure function (maximum 4 components), relevant component.	**15**
2	**Ageing Properties** 2.1 Ageing, survival function, probability density function, hazard function, cumulative hazard rate, mean residual life function, equilibrium residual life function, interrelation between all these functions. 2.2 Concept of distributions with increasing and decreasing failure rate (IFR, DFR, IFRA, DFRA) 2.3 Derivations of results i. Hazard rate of a series system of components having independent life times is summation of component hazard rates. ii. Life time of series system of independent components with independent IFR life times is IFR. 2.4 Ageing properties for exponential, gamma, weibull & pareto distribution.	**15**

Reference Books:

1. Barlow R. E. and Proschan Frank: Statistical Theory of Reliability and Life Testing. Holt Rinebart and Winston Inc., New York.
2. Sinha S. K.: Reliability and Life Testing, Second Edition, Wiley Eastern Publishers, New Delhi.
3. Trivedi R. S.: Probability and Statistics with Reliability and Computer Science Application, Prentice – Hall of India Pvt. Ltd., New Delhi.

B. Sc. Part – III Semester -V STATISTICS

DSC-PR-V: DSC03STA59: DSC Statistics Practical V (Credits: 06)

Course Outcomes:

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

CO1: Compute probabilities of standard probability distributions, expected frequencies and test the goodness of fit and understand the generation of random samples.

CO2: Understand the methods of point estimation.

CO3: Estimate population parameters using sampling distributions of estimator and compare different sampling methods.

CO4: Apply appropriate optimization technique to solve real life problems/ apply survival functions, hazard functions in reliability analysis/ apply transition probability matrices, state classifications, and stationary distributions to solve problems.

Sr. No.	Title of the Experiment
Section I: Probability Distributions	
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.
Section II: Statistical Inference I	
1	Sufficiency
2	Estimation of MVUE and MVBUE
3	Estimation of UMVUE
4	Point estimation by method of maximum likelihood (one parameter).
5	Point estimation by method of maximum likelihood (two parameters).
6	Point estimation by method of minimum chi-square.
7	Point estimation by method of moments for discrete distributions.
8	Point estimation by method of moment for continuous distributions.
9	Point estimation by method of moments using R
Section III: Sampling Theory	
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
Section IV: Operation Research (On Elective Paper I)	
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	CPM
8	PERT
	Section IV: Machine Learning (On Elective Paper II)
1	Understanding and Cleaning Data
2	Data Transformation and Discretization Techniques
3	Data Visualization: Histograms, Boxplots, Heatmap, Scatterplot, Correlation Matrix
4	Handling Missing Values and Imputation Methods
5	Supervised vs. Unsupervised Learning: A Comparison
6	Classification Problem and Train-Test Split
7	Classification Techniques: KNN, Decision Trees, Naïve Bays
8	Performance Measures and Model Evaluation
9	Ensemble Learning and K-Means Cluster Analysis
	Section IV: Reliability Theory (On Elective Paper III)
1	Structural Properties of Coherent Systems
2	Structure Function of Series, Parallel, and k-out-of-n Systems
3	Reliability Block Diagrams and Minimal Path/Cut Sets
4	Computation of System Reliability using Minimal Path and Cut Sets
5	Reliability of Binary Components and Systems
6	Ageing and Survival Analysis Functions
7	Hazard Function and its Interrelations
8	Increasing/Decreasing Failure Rate Distributions (IFR, DFR, etc.)
9	Reliability Analysis using Exponential, Gamma, Weibull & Pareto Distributions

B. Sc. Part III Semester V
VSC PR IV (VSC03STA59) (Credits 02)
Course Title: Statistical Computing using Python I

Course Outcomes:
At the end of the course, students will be able to:
CO1: Understand Python’s features, installation process, and different IDEs for programming.
CO2: Apply fundamental programming concepts such as variables, data types, operators, and expressions.
CO3: Implement control flow mechanisms using conditional statements and loops.
CO4: Develop programs using lists, tuples, and strings, utilizing their methods and built-in functions.

Sr. No.	Title of the Experiment
1	Python Basics
2	Variables and Operators
3	Control Flow Statements
4	Loops
5	Lists Operations
6	Tuple Manipulation
7	String Functions
8	Application of Data Structures

Reference Books:

1. Reema Thareja: Python Programming
2. Dr. R. Nageswara Rao: Core Python Programming
3. T. R. Padmanabhan: Programming in Python

MIN-IX: Reliability Theory
Course Code: MIN03STA51

Marks: 40 | **Theory: 30 Hours** | **Credits 2**

Course Outcomes:

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

- **CO1**: Understand the basic concepts of reliability.
- **CO2**: Understand the different properties of ageing.
- **CO3**: Interpret and apply survival functions, hazard functions, and mean residual life functions in reliability analysis.
- **CO4:** Derive and utilize reliability measures for Exponential, Weibull and Pareto distributions.

Unit	Content	Hours Allotted
1	**Basic Terminology** 1.1 Structural properties of coherent system 1.2 Binary system of independent components, order of the system, different types of systems, concept of the structure function, structure function of series system, parallel system, k-out-of-n system, essentially series and parallel system, reliability block diagram 1.3 Path sets, cut sets, minimal path and cut set, representation of coherent system in terms of minimal path sets and cut sets. 1.4 Reliability of coherent system i. Reliability (h(p)) of system of independent components. ii. Computation of reliability of coherent system by using minimal path and cut set representation. iii. Reliability of Binary Components and Systems. 1.5 Coherent structure function (maximum 4 components), relevant component.	15
2	**Ageing Properties** 2.1 Ageing, survival function, probability density function, hazard function, cumulative hazard rate, mean residual life function, equilibrium residual life function, interrelation between all these function 2.2 Concept of distributions with increasing and decreasing failure rate (IFR, DFR, IFRA, DFRA) 2.3 Derivations of results i. Hazard rate of a series system of components having independent life times is summation of component hazard rates. ii. Life time of series system of independent components with independent IFR life times is IFR. 2.4 Ageing properties for exponential, gamma, weibull & pareto distribution.	15

Reference Books:

1. Barlow R. E. and Proschan Frank: Statistical Theory of Reliability and Life Testing. Holt Rinebart and Winston Inc., New York.
2. Sinha S. K.: Reliability and Life Testing, Second Edition, Wiley Eastern Publishers, New Delhi.
3. Trivedi R. S.: Probability and Statistics with Reliability and Computer Science Application, Prentice – Hall of India Pvt. Ltd., New Delhi

MIN Statistics Practical V
Course Code: MIN03STA59

Sr. No.	Reliability Theory Practicals
1	Structural Properties of Coherent Systems
2	Structure Function of Series, Parallel, and k-out-of-n Systems
3	Reliability Block Diagrams and Minimal Path/Cut Sets
4	Computation of System Reliability using Minimal Path and Cut Sets
5	Reliability of Binary Components and Systems
6	Ageing and Survival Analysis Functions
7	Hazard Function and its Interrelations
8	Increasing/Decreasing Failure Rate Distributions (IFR, DFR, etc.)
9	Reliability Analysis using Exponential, Weibull & Pareto Distributions

Semester VI

Paper -XIII: Probability Theory
Course Code: DSC03STA61

Marks: 40 **Theory: 30 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 concept of simulation.
CO4: Generate real life scenario.

Unit	Content	Hours Allotted
1	**Order Statistics & Convergence** **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:** Chebychev'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 $X_n \overset{P}{\rightarrow} X$ then $g(X_n) \overset{P}{\rightarrow} g(X)$ 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.	15
2	**2.2: Simulation Techniques** 2.1Meaning of simulation, Monte Carlo simulation, advantages and disadvantages of simulation 2.2 Definition and properties of random numbers, generation of pseudo random numbers, Mid-Square method, Linear congruential method, 2.3Techniques of generating random numbers from uniform distribution 2.4Tests for randomness and uniformity distribution, random variate generation using inverse c.d.f method, random variate generation	15

	from Bernoulli, Binomial, Poisson, Geometric, Exponential and normal distributions.	

Reference Books:

1. Cramer H.: Mathematical Methods of Statistics, Asia Publishing House, Mumbai.
2. Lindgren B. W.: Statistical Theory (Third Edition), Collier Macmillan International Edition, Macmillan Publishing Co. Inc. New York.
3. 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. Parimal Mukhopadhyay: An Introduction to the Theory of Probability. World Scientific Publishing.
9. Gentle, J. E.: Random Number Generation and Monte Carlo Methods, Springer- Verlag.
10. Robert, C. P. and Casella, G.: Monte Carlo Statistical methods, Springer-Verlag.
11. Rubinstein, R. Y.: Simulation and Monte Carlo Method, John Wiley, New York

Paper -XIV: Statistical Inference – II

Course Code: DSC03STA62

Marks: 40 **Theory: 30 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 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 variance of normal population.	15
	Sequential Probability Ratio Tests (SPRT) & Non- Parametric Test **2.1: Sequential Probability Ratio Tests (SPRT)**	

2	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.	**15**

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. Cassella G. and Berger R. L.: Statistical Inference
6. Lehmann, E. L: Testing of Statistical Hypothesis
7. Rao, C. R.: Linear Statistical Inference
8. Dudewicz C. J. and Mishra S. N.: Modern Mathematical Statistics
9. Fergusson, T. S.: Mathematical statistics.
10. Gibbons J. D.: Non-parametric Statistical Inference.

Paper -XV: Design of Experiments
Course Code: DSC03STA63

Marks: 40 **Theory: 30 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: Analyze different real-life situations using appropriate designs.
CO3: Compare efficiency of different designs.
CO4: Understand concepts of 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 Cochran'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 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.	**15**

	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 and Factorial Experiments** **2.1: 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**: **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. iv) Box - cox power transformation **2.3: 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. 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.	**15**

Reference Books:

1. Cochran, W.G. and Cox, G.M.: Experimental Design, John Wiley and Sons, Inc., New York.
2. Montgomery, D.C.: Design and Analysis of Experiments, Wiley Eastern Ltd., New Delhi.
3. Das, M.N. and Giri, N.C.: Design and Analysis of Experiments, Wiley Eastern Ltd., New Delhi.
4. Kempthrone, O.: Design and Analysis of Experiments, Wiley Eastern Ltd., New Delhi.
5. Snedecor, G.W. and Cochran, W.G.: Statistical Methods, Affiliated East-West Press, New Delhi.
6. Goon, Gupta, Dasgupta: Fundamental of Statistics, Vol. I and II, The World Press Pvt. Ltd. Kolkata.
7. Gupta, S.C. and Kapoor, V.K.: Fundamentals of Applied Statistics, S. Chand & Sons, New Delhi.

DSE -I: Statistical Quality Control
Course Code: DSE03STA61

Marks: 40 **Theory: 30 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. Control chart for standard deviation (s chart) **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, V-mask technique, use of these charts for monitoring process means. Moving average and exponentially weighted moving average charts. Introduction to six-sigma methodology, DMAIC cycle.	**15**
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.	**15**

Books Recommended:

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

DSE -II: Biostatistics

Course Code: DSE03STA62

Marks: 40 **Theory: 30 Hours** **Credits 2**

Course Outcomes:

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

CO1: Understand need and ethics of any clinical trial.

CO2: Apply various designs of clinical trials to the data.

CO3: Compare different clinical trial designs.

CO4: Perform statistical analysis of categorical and survival data from clinical trials.

Unit	Content	Hours Allotted
1	1.1 Introduction to clinical trials: the need and ethics of clinical trials, bias and random error in clinical studies, conduct of clinical trials, overview of Phase I-IV trials, multi-center trials. 1.2 Data management: data definitions, case report forms, database design, data collection systems for good clinical practice 1.3 concept of blinding/masking in clinical trials. Bioavailability, pharmacokinetics and pharmaco-dynamics, two compartment model.	**15**
2	2.1 Design of clinical trials: parallel vs. cross-over designs, cross-sectional vs. Longitudinal designs 2.2 review of factorial designs, objectives and endpoints of clinical trials, design of Phase I trials, design of single-stage and multi-stage Phase II trials, design and monitoring of Phase III trials with sequential stopping. 2.3 Design of bio-equivalence trials, Inference for 2x2 crossover design: Classical methods of interval hypothesis testing for bioequivalence, Bayesian methods, nonparametric methods. 2.4 Reporting and analysis: analysis of categorical outcomes from Phase I - III trials, analysis of survival data from clinical trials.	**15**

Books Recommended:

1. C. Jennison and B. W. Turnbull (1999): Group Sequential Methods with Applications to Clinical Trials, CRC Press.
2. Chow S.C. and Liu J.P. (2004). Design and Analysis of Clinical Trials. 2nd Ed. Marcel Dekkar.
3. Chow S.C. and Liu J.P.(2009). Design and Analysis of Bioavailability and bioequivalence. 3rd Ed. CRC Press.
4. Clayton, D. and Hills, M. (2013). Statistical methods in Epidemiology, OUP.
5. Daniel, W. W. and Cross, C. L. (2012). Biostatistics: A Foundation for Analysis in the Health Sciences, 10th Edition, Wiley.
6. J. L. Fleiss (1989). The Design and Analysis of Clinical Experiments. Wiley and Sons.

DSE -III: Stochastic Process

Course Code: DSE03STA63

Marks: 40 **Theory: 30 Hours** **Credits 2**

Course Outcomes:

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

CO1: Understand basic concepts of stochastic processes and their applications.

CO2: Apply transition probability matrices, state classifications, and stationary distributions to solve problems.

CO3: Apply Queuing theory and its real-life situations.

CO4: Solve problems using probability distributions in queuing systems and analyze M/M/1 models.

Unit	Content	Hours Allotted
1	**Finite Markov Chains** **1.1: 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. **1.2: 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. **1.3: Markov Process:** Pure birth process, Poisson process, birth and death process. (Derivations not expected). Examples and problems.	15
2	**Queuing Theory** 2.1 Introduction, essential features of queuing system, input source, queue configuration, queue discipline, service mechanism. 2.2 Operating characteristics of queuing system, transient- state and steady state, queue length, general relationship among system characteristics. 2.3 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). 2.4 Types of queuing models: i. Solution of queuing Model: M/M/1, using FCFS queue discipline. ii. Problems and examples	15

Reference:

1. Medhi J: Stochastic Processes. Wiley Eastern Ltd. New Delhi.
2. Hoel, Port and Stone: Introduction to Stochastic Processes, Houghton Mifflin.
3. Bhat B. R.: Stochastic Models: Analysis and Applications. New Age International.

B. Sc. Part – III Semester -VI STATISTICS

DSC-PR-VI: DSC03STA69: DSC Statistics Practical VI (Credits: 06)

Course Outcomes:

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

CO1: Understand how to use test of goodness of fit and understand the generation of random samples using simulation.

CO2: Understand the methods of interval estimation and non-parametric tests.

CO3: Analyze the data by using different techniques of designs of experiment.

CO4: Construction of appropriate control charts/apply different classification techniques / apply various designs of clinical trials to the data.

Sr. No.	Title of the Experiment
Section I: Probability Theory	
1	Fitting of Laplace, Lognormal and Cauchy distribution using R
2	Fitting of Weibull, Pareto and Logistic distribution using R
3	Order Statistics
4	Chebychev's Inequality
5	Modes of Convergence
6	WLLN & CLT
7	Simulation I (Model Sampling from discrete distributions)
8	Simulation II (Model Sampling from Continuous distributions)
Section II: Statistical Inference II	
1	Interval estimation of location and scale parameters of normal distribution (single sample).
2	Interval estimation of difference of location and ratio of scale parameters of normal distribution (two samples).
3	Interval estimation for population proportion and difference between two population proportions.
4	Interval estimation for population median using order statistics.
5	Construction of MP and UMP test.
6	Construction of SPRT for binomial, Poisson distributions, graphical representation of procedure.
7	Construction of SPRT for exponential and normal distribution, graphical representation of procedure.
8	Run test (for one and two independent samples).
9	Sign test and Wilcoxon's signed rank test (for one and two samples paired observation).
10	Mann-Whitney U- test (for two independent samples).
11	Median test (for two large independent samples)
12	Kolmogorov - Smirnov test (for one and two independent samples).
Section III: Design of Experiments	
1	Analysis of CRD and RBD.
2	Analysis of Latin Square Design (LSD).
3	Analysis of Completely Randomized Design (CRD) & Randomized Block Design (RBD) using R-Software.
4	Missing Plot Technique for RBD and LSD with one missing observation.
5	Efficiency of i) RBD over CRD and ii) LSD over CRD and RBD.
6	Analysis of 2^2 and 2^3 Factorial Experiment.

7	Total Confounding.
8	Partial Confounding
9	Kruskal Wallis test for non-normal data. (CRD)
Section IV: Quality Management (On Elective Paper I)	
1	Construction of $\bar{X}$,R and s charts.
2	Construction of P and C charts.
3	EWMA-Chart
4	CUSUM chart.
5	Six sigma limits for mean.
6	Single sampling plan-I (Small sample).
7	Single sampling plan-II (Large sample).
8	Double sampling plan-I (Small sample).
9	Double sampling plan-II (Large sample).
	Section IV: Biostatistics (On Elective Paper II)
1	Construct Ethical Frameworks for Clinical Trials
2	Data Management in Clinical Trials: Case Reports and Database Design
3	Blinding and Masking in Clinical Trials
4	Pharmacokinetics and Pharmacodynamics: Two Compartment Model
5	Design of Clinical Trials: Parallel vs. Cross-Over, Cross-Sectional vs. Longitudinal
6	Factorial Designs and Design of Phase I and II Trials
7	Design and Monitoring of Phase III Trials with Sequential Stopping
8	Bio-Equivalence Trials: Inference and Methods for 2x2 Crossover Designs
9	Analyze Survival and Categorical Data
	Section IV: Stochastic Processes (On Elective Paper III)
1	Construction of TPM
2	Higher transition probabilities using Chapman-Kolmogorov Equation
3	Classification of States in a Markov Chain
4	Stationary Probability Distribution of Markov Chains
5	Continuous-Time Markov Chains – Poisson Process & Birth-Death Process
6	Simulation of a Simple Queuing System (M/M/1)
7	Calculation of Queuing System Parameters
8	Probability Distributions in a Queuing System

B. Sc. Part III Semester VI STATISTICS
VSC PR V (VSC03STA69) (Credit 02)
Course Title: Statistical Computing using Python II

Course Outcomes:

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

CO1: Understand the concept of dictionaries, their properties, and basic operations.

CO2: Utilize various dictionary methods.

CO3: Define and apply functions, including argument passing, return values, and modular programming techniques.

CO4: Implement advanced function concepts like lambda functions and recursion to solve complex problems.

Practical No.	Title of the Experiment
1	Creating and Accessing Dictionaries
2	Dictionary Methods
3	Function Basics
4	Function Arguments
5	Return Statements in Functions
6	Lambda Functions
7	Recursive Functions
8	Dictionary-Based Application

Reference Books:

1. Martin C. Brown: Python: The Complete Reference
2. Sheetal Taneja & Naveen Kumar: Python Programming: A Modular Approach
3. Ashok Namdev Kamthane & Amit Ashok Kamthane: Problem Solving and Python Programming

MIN Paper -X: Stochastic Process

Course Code: MIN03STA61

Marks: 40 **Theory: 30 Hours** **Credits 2**

Course Outcomes:

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

CO1: Understand basic concepts of stochastic processes and their applications.

CO2: Apply transition probability matrices, state classifications, and stationary distributions to solve problems.

CO3: Apply Queuing theory and its real-life situations.

CO4: Solve problems using probability distributions in queuing systems and analyze M/M/1 models.

Unit	Content	Hours Allotted
1	**Finite Markov Chains** **1.1: 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. **1.2: 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. **1.3: Markov Process:** Pure birth process, Poisson process, birth and death process. (Derivations not expected). Examples and problems.	**15**
2	**Queuing Theory** **2.1** Introduction, essential features of queuing system, input source, queue configuration, queue discipline, service mechanism. **2.2** Operating characteristics of queuing system, transient- state and steady state, queue length, general relationship among system characteristics. **2.3** 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). **2.4 Types of queuing models:** Solution of queuing Model: M/M/1, using FCFS queue discipline. Problems and examples	**15**

Reference Books:

1. Medhi J: Stochastic Processes. Wiley Eastern Ltd. New Delhi.
2. Hoel, Port and Stone: Introduction to Stochastic Processes, Houghton Mifflin.
3. Bhat B. R.: Stochastic Models: Analysis and Applications. New Age International.
4. Taha H. A.: Operation research – An Introduction, Fifth Edition, Prentice Hall of India, New Delhi.
5. Kanti Swaroop & Gupta M. M (1985): Operations Research, Sultan Chand & Co. ltd.

MIN Statistics Practical VI
Stochastic Process
Course Code: MIN03STA69

Practical No.	Title of the Experiment
1	Construction of TPM
2	Higher transition probabilities using Chapman-Kolmogorov Equation
3	Classification of States in a Markov Chain
4	Stationary Probability Distribution of Markov Chains
5	Continuous-Time Markov Chains – Poisson Process & Birth-Death Process
6	Simulation of a Simple Queuing System (M/M/1)
7	Calculation of Queuing System Parameters
8	Probability Distributions in a Queuing System

Assessment Structure
Structure of Question Paper
Nature of Theory Question Paper

Instructions:

1) **All questions are compulsory.**
2) **Figures to the right indicate full marks.**
3) **Use of scientific calculator is allowed.**

Time: 2-hour **Total Marks: 40**

Que. No.	Question Pattern	Marks
Q.1.	Choose correct alternative.	(8x1=8)
Q.2	Attempt any two. i) ii) iii)	(8x2=16)
Q.3.	Attempt any four. a) b) c) d) e) f)	(4x4=16)

Internal Evaluation

Semester	Evaluation	Marks
V& VI	Unit test /Multiple choice questions/Assignment	10

Nature of Practical Paper

For 25 marks:

1) Each practical question paper must contain three questions each carry 10 marks.
2) Each question should contain two bits from different units.
3) Student should attempt any two questions.
4) Complete and certified journal is of 3 marks and oral will be of 2 marks.

For 75 marks:

1) This practical consists of 4 sections each carrying 15 marks.
2) Each section contains four questions carrying 5 marks.
3) Student should attempt any three questions.
4) Complete, certified journal and oral will be of 10 marks.
5) Seminar/ study tour will carry 5 marks.

Evaluation Pattern for practical Course:
Marks Distribution of Practical (LAB) course

Course	Experimental work	Journal + Oral	Seminar/ Study Tour	Total Marks
Major	60	10	05	75
Minor / VSC	20	05	-	25