AC: 02.06.2025 ITEM NO: 24.3

Deccan Education Society's

Kirti M. Doongursee College of Arts, Science and Commerce (AUTONOMOUS)

Affiliated to

UNIVERSITY OF MUMBAI

Syllabus for
Program: Bachelor of Science
Course: T.Y.B.Sc.
Subject: Statistics

Choice Based Credit System (CBCS)
with effect from
Academic Year 2025-2026
(NEP 2020)

PROGRAM SPECIFIC OUTCOMES

PSO	Description
A student completing **B.Sc. Statistics** Program will be able to:	
PSO1	Demonstrate the ability to recall and explain scientific knowledge clearly and thoroughly. Apply learned skills effectively within the chosen field of study, and understand the links between scientific concepts across various disciplines.
PSO2	Critically evaluate scientific ideas, identify and analyze problems, explore practical solutions through experimentation or demonstrations, plan and implement tasks, manage data efficiently, and draw logical conclusions.
PSO3	Access, evaluate, and utilize digital information to enhance subject knowledge. Apply appropriate digital tools for data analysis, presentation, and scientific communication.
PSO4	Formulate relevant scientific questions, recognize their significance, develop hypotheses, design and execute research plans, and analyze outcomes in a structured manner.
PSO5	Approach complex tasks with responsibility, work independently or collaboratively as required, and communicate ideas and results effectively, confidently, and with clarity.
PSO6	Use scientific knowledge with an awareness of cultural diversity and social values. Share scientific information meaningfully to contribute to societal development and well-being.
PSO7	Adhere to ethical standards in all scientific practices. Maintain objectivity and integrity in data interpretation, and address environmental concerns by promoting sustainable practices.
PSO8	Stay informed about current developments in the field of science. Embrace technological advancements and commit to continuous learning for personal and professional growth.
PSO9	Demonstrate proficiency in mathematical and statistical reasoning to interpret scientific data, build models, and support evidence-based decision-making across interdisciplinary domains.
PSO10	Develop innovative and creative thinking to address scientific challenges, adapt to emerging trends, and propose original solutions through logical reasoning and experimental validation.
PSO11	Engage effectively with scientific literature and scholarly resources. Critically review research articles, synthesize information, and contribute constructively to academic discussions and scientific documentation.
PSO12	Participate in outreach activities, science communication, and public engagement to foster scientific temper among peers and the community, promoting inclusive and informed dialogue on science-related issues.

PROGRAM OUTCOMES

PO	Description
A student completing Bachelor's Degree in **Science** Program will be able to	
PO1	**Disciplinary Knowledge:** Demonstrate comprehensive knowledge of the disciplines that form a part of a graduate Programme. Execute strong theoretical and practical understanding generated from the specific graduate Programme in the area of work.
PO2	**Critical Thinking and Problem solving:** Exhibit the skills of analysis, inference, interpretation and problem-solving by observing the situation closely and design the solutions.
PO3	**Social competence:** Display the understanding, behavioral skills needed for successful social adaptation, work in groups, exhibits thoughts and ideas effectively in writing and orally.
PO4	**Research-related skills and Scientific temper:** Develop the working knowledge and applications of instrumentation and laboratory techniques. Able to apply skills to design and conduct independent experiments, interpret, establish hypothesis and inquisitiveness towards research.
PO5	**Trans-disciplinary knowledge:** Integrate different disciplines to uplift the domains of cognitive abilities and transcend beyond discipline-specific approaches to address a common problem.
PO6	**Personal and professional competence:** Performing dependently and collaboratively as a part of team to meet defined objectives and carry out work across interdisciplinary fields. Execute interpersonal relationships, self-motivation and adaptability skills and commit to professional ethics.
PO7	**Effective Citizenship and Ethics:** Demonstrate empathetic social concern and equity centered national development, and ability to act with an informed awareness of moral and ethical issues and commit to professional ethics and responsibility.
PO8	**Environment and Sustainability:** Understand the impact of the scientific solutions in societal and environmental contexts and demonstrate the knowledge of and need for sustainable development.

Deccan Education Society's

Kirti M. Doongursee College (Autonomous)

Proposed Curriculum as per NEP 2020

Year of implementation- 2025-26

Name of the Department: Statistics

Semester	Course Code	Course Title	Vertical	Credit
V	25STAMJ511	Multivariate Analysis	Major	2
	25STAMJ512	Theory of Estimation	Major	2
	25STAMJ513	Regression Analysis	Major	2
	2STAMAJ514	Introduction To Statistics and Research Methodology	Major IKS Specific	2
	25STAMJP51	Practical-5	Major	2
	25STAMR521	Testing of Hypothesis	Minor	2
	25STAMRP51	Statistics Practical-4	Minor	2
	25STAEL531	Biostatistics	Elective I	2
	25STAELP51	Elective Practical-1	Elective I Practical	2
	25STAEL532	Operations Research - I	Elective II	2
	25STAELP52	Elective Practical- 1	Elective II Practical	2
	25STAVS541	Data Analysis Using R-software	VSC	2
	25STAFP551	Field Project	FP	2
VI	25STAMJ611	Probability and Stochastic Processes	Major	2
	25STAMJ612	Parametric and Non-parametric Tests	Major	2
	25STAMJ613	Actuarial Science	Major	2
	2STAMAJ614	Probability Distribution Theory	Major	2
	25STAMJP61	Practical-6	Major	2
	25STAMR621	Analysis of Variance	Minor	2
	25STAMRP61	Statistics Practical-5	Minor	2
	25STAEL631	Annuities and Assurance Benefits	Elective I	2
	25STAELP61	Elective Practical- 2	Elective I Practical	2
	25STAEL632	Operations Research - II	Elective II	2
	25STAELP62	Elective Practical- 2	Elective II Practical	2
	25STAOJ551	On Job Training	OJT	4

Course Code	MAJOR SEM – V	Credits	Lectures /Week
25STAMJ511	**Paper I - Multivariate Analysis**	**2**	**2**

Course Outcomes:

After successful completion of this course, students would be able to:

CO1: Recall the definitions and properties of Moment Generating Functions (MGFs), joint and marginal distributions, and correlation coefficients for both discrete and continuous random variables, including Trinomial, Multinomial, and Bivariate Normal distributions.

CO2: Explain the concepts of independence using MGFs, interpret marginal and conditional distributions, and describe the significance of correlation and Trinomial, Multinomial and Fisher's Z-transformation in the context of Bivariate Normal distributions.

CO3: Apply the concepts of joint MGFs to compute means, variances, and probabilities for Trinomial, Multinomial, and Bivariate Normal distributions, including tests for the significance of correlation.

CO4: Evaluate independence and correlation through hypothesis testing and confidence intervals.

Unit	Topics	No of Lectures
I	**Joint Moment Generating Function, Trinomial Distribution and Multinomial Distribution** 1. Definition and properties of Moment Generating Function (MGF) of two random variables of discrete and continuous type. Necessary and Sufficient condition for independence of two random variables. Concept and definition of Bivariate MGF. 2. Trinomial distribution: Definition of joint probability distribution of (X, Y). Joint moment generating function, moments $\mu_{rs}$where r=0, 1, 2 and s=0, 1, 2. Marginal & Conditional distributions. Their Means & Variances. Correlation coefficient between (X, Y). 3. Distribution of the Sum X+Y Extension to Multinomial distribution with parameters $(n, p_1, p_2, \ldots\ldots\ldots, p_{k-1})$. where $p_1 + p_2 + \cdots\cdots + p_k = 1$, Expression for joint MGF. Derivation of: joint probability distribution of (X_i, X_j). Conditional probability distribution of X_i.	**15**

II	**Bivariate Normal Distribution** 1. Definition of joint probability distribution (X, Y). Joint Moment Generating function, moments μ_{rs}, where r=0, 1, 2 and s=0, 1. 2. Marginal & Conditional distributions. Their Means & Variances. Correlation coefficient between the random variables. Necessary and sufficient condition for the independence of X and Y. Distribution of aX + bY, where 'a' and 'b' are constants. 3. Distribution of sample correlation coefficient when $\rho = 0$. Testing the significance of a correlation coefficient. 4. Fisher's z – transformation. 5. Tests for: i) $H_0: \rho = \rho_0$ ii) $H_0: \rho_1 = \rho_2$ 6. Confidence interval for ρ.	**15**

References:

1. Feller W: An introduction to probability theory and it's applications, Volume: 1, Third edition, Wiley Eastern Limited.
2. Hogg R. V. & Craig A.T.: Introduction to Mathematical Statistics, Fifth edition, Pearson Education (Singapore) Pvt Ltd.
3. Mood A M, Graybill F A, Bose D C: Introduction to the theory of statistics, Third edition, Mcgraw- Hill Series.
4. Hogg R. V. and Tanis E.A.: Probability and Statistical Inference, Fourth edition, McMillan Publishing Company.
5. Gupta S C & Kapoor V K: Fundamentals of Mathematical statistics, Eleventh edition, Sultan Chand & Sons. Kapur J. N., Saxena H. C.: Mathematical Statistics, Fifteenth edition, S. Chand and Company.

Course Code	MAJOR SEM – V	Credits	Lectures /Week
25STAMJ512	**Paper II – Theory of Estimation**	**2**	**2**

Course Outcomes:

After successful completion of this course, students would be able to:

CO1: Recall fundamental definitions and concepts such as estimator, estimate, unbiasedness, consistency, sufficiency, likelihood function, prior and posterior distributions, pivotal quantity, and confidence interval in classical estimation theory.

CO2: Explain the properties of good estimators, including unbiasedness, consistency, and efficiency; describe the principles behind the methods of estimation—MLE, Method of Moments, Minimum Chi-Square, Bayesian estimation, and interval estimation techniques.

CO3: Apply various estimation methods to derive point and interval estimators for parameters of standard distributions and compute Maximum Likelihood Estimators (MLEs), Moment Estimators, and Bayesian Estimators under standard loss functions.

CO4: Analyze and compare different estimators using criteria like Mean Square Error (MSE), Cramer-Rao Lower Bound (CRLB), and Bayes Risk; evaluate the efficiency and optimality of estimators in different scenarios, and interpret the significance of confidence intervals in statistical inference.

Unit	Topics	No of Lectures
I	**Point Estimation** **Properties of Estimators** 1. Notion of a Parameter and Parameter Space. 2. Problem of Point estimation. 3. Definitions: Statistic, Estimator and Estimate. 4. Properties of a good estimator: a) Unbiasedness: Definition of an unbiased estimator, Illustrations and examples. Proofs of the following results: (i) Two distinct unbiased estimators of U(θ) give rise to infinitely many unbiased estimators. (ii) If T is an unbiased estimator of then U(T) is an unbiased estimator of U(θ) provided U( ) is a linear function. b) Consistency: Definition of Consistency. Sufficient condition for consistency, proof & Illustrations. c) Sufficiency: Concept and Definition of sufficient statistic. Neyman's Factorization theorem (without proof). Exponential family of probability distributions and sufficient statistics.	**15**

	d) Relative efficiency of an estimator & illustrative examples. 5. Minimum variance unbiased estimator (MVUE) and Cramer Rao Inequality: Definition of MVUE. 6. Uniqueness property of MVUE (proof). 7. Fisher's information function 8. Regularity conditions. 9. Statement and proof of Cramer-Rao inequality. 10. Cramer-Rao lower bound (CRLB), Efficiency of an estimator using CRLB. 11. Condition when equality is attained in Cramer Rao Inequality and its use in finding MVUE. **Methods of Point Estimation** **Method of Maximum Likelihood Estimation (M.L.E.):** 1. Definition of likelihood as a function of unknown parameter for a random sample from: Discrete distribution & Continuous distribution. 2. Derivation of Maximum likelihood estimator (M.L.E.) for parameters of Standard distributions (case of one and two unknown parameters). 3. Properties of MLE (without proof). **Method of Moments:** 1. Derivation of Moment estimators for standard distributions (case of one and two unknown parameters. 2. Illustrations of situations where MLE and Moment Estimators are distinct and their comparison using Mean Square error. **Method of Minimum Chi-square and Modified Minimum Chi-Square.**	
II	**Bayesian Estimation Method and Interval Estimation** **Bayes Estimation:** 1. Prior distribution, Posterior distribution 2. Loss function, Risk function 3. Types of Loss function: Squared error Loss function. (SELF), Absolute error Loss function (AELF) 4. Bayes' risk. 5. Bayes' method of finding Point estimator (assuming SELF). Examples:(i) Binomial- Beta (ii) Poisson- Gamma (iii) Gamma-Gamma (iv) Normal-Normal. **Interval Estimation:** 1. Concept of confidence interval & confidence limits.	**15**

	2. Definition of Pivotal quantity and its use in obtaining confidence limits. 3. Derivation of 100(1-α) % equal tailed confidence interval for: a) The population mean: μ, μ1-μ2 (population variance (known/ unknown), σ^2 b) the population variance: σ^2, $\frac{1}{\sigma_2^2}$ (Normal distribution). Confidence interval for the parameters of Binomial, Poisson and Exponential distributions.	

References:

1. Hogg R.V., Craig A.T.: Introduction to Mathematical Statistics, Fourth Edition; Collier McMillan Publishers.
2. Hogg R.V., Tannis E. A.: Probability and Statistical Inference, Third Edition; Collier McMillan Publishers.
3. Rohatgi, V. K, Ehsanes Saleh A.K. Md.: An introduction to Probability Theory and Mathematical Statistics, Second Edition, Wiley series in Probability and Statistics.
4. John E. Freund's Mathematical Statistics: I. Miller, M. Miller; Sixth Edition; Pearson Education Inc.
5. Hoel P.G.: Introduction to Mathematical Statistics; Fourth Edition; John Wiley & Sons Inc.
6. Gupta S.C., Kapoor V.K.: Fundamentals of Mathematical Statistics; Eighth Edition; Sultan Chand & Sons.
7. Kapur J. N., Saxena H.C.: Mathematical Statistics; Fifteenth Edition; S. Chand & Company Ltd.
8. Arora Sanjay and Bansi La:: New Mathematical Statistics, Satya Prakashan, New Market, New Delhi,5(1989).

Course Code	MAJOR SEM – V	Credits	Lectures /Week
25STAMJ513	**Paper III – Regression Analysis**	**2**	**2**

Course Outcomes:

After successful completion of this course, students would be able to:

CO1: Recall the assumptions, definitions, and concepts related to simple and multiple linear regression, including OLS estimators, coefficient of determination and multicollinearity.

CO2: Explain the principles of model fitting, significance testing, and interpretation of regression outputs, as well as the implications of assumption violations such as autocorrelation, heteroscedasticity, and multicollinearity.

CO3: Perform tests for overall significance of the model, significance of individual coefficients, and confidence intervals for regression coefficients.

CO4: Analyze the validity and reliability of regression models by evaluating residuals, interpreting diagnostic plots, and assessing model assumptions using statistical tests.

Unit	Topics	No of Lectures
I	**Simple & Multiple Regression Analysis** **Simple Linear Regression Model** 1. Assumptions of the model, Derivation of ordinary least square (OLS) estimators of regression coefficients for simple, Properties of least square estimators (without proof), Coefficient of determination R^2 and adjusted R^2. 2. Procedure of testing: a) Overall significance of the models b) Significance of individual coefficients c) Confidence intervals for the regression coefficients. 3. Data Pre-processing: Detection and treatment of missing value(s)and outliers, Variable selection and Model building, Interpretation of output produced by lm command in R. Weighted Least Square Method. **Multiple Linear Regression Model** 1. Derivation of ordinary least square (OLS) estimators of regression coefficients for multiple regression models, Coefficient of determination R^2 and adjusted R^2. 2. Procedure of testing: a) Overall significance of the models b) Significance of individual coefficients	**15**

	c) Confidence intervals for the regression coefficients. 3. Data Pre-processing: Detection and treatment of missing value(s) and outliers, Variable selection and Model building, Interpretation of output produced by lm command in R.	
II	**Validity of Assumptions** 1. Residual Diagnostics: Standardized residuals, Studentized residuals, residual plots, Interpretation of four plots of Interpretation output produced by plot command in R and corrective measures such as transformation of response variable, testing normality of data. 2. Autocorrelation: Concept and detection using Durbin Watson Test, Interpretation of output produced by DW-test function in R. 3. Heteroscedasticity: Concept and detection using Breusch –Pagan-Godfrey Test, Interpretation of output produced by bptest function in R. 4. Multicollinearity: a. Concept and detection using R2 and t-ratios b. pairwise correlation between repressors, Variance Inflation Factor (VIF) c. Interpretation of output produced by mctest function in R. 5. Consequences of using OLS estimators in presence of Autocorrelation, Heteroscedasticity and Multicollinearity, Remedial measures. 6. Ridge Regression: Concept and case study using R.	**15**

References:

1. Draper, N. R. and Smith, H. (1998), Applied Regression Analysis (John Wiley), Third Edition.
2. Montgomery, D. C., Peck, E. A. and Vining, G. G. (2003), Introduction to Linear Regression Analysis (Wiley).
3. Neter, J., W., Kutner, M. H. Nachtsheim, C.J. and Wasserman, W.(1996), Applied Linear Statistical Models, fourth edition, Irwin USA.
4. Damodar Gujrati, Sangetha,Basic Econometrics, fourth edition, McGraw Hill Companies.
5. William Geene (1991), Econometrics Analysis, first edition, Mc Millan Publishing Company.

Course Code	MAJOR SEM – V	Credits	Lectures /Week
25STAMJ514	Paper IV – Introduction To Statistics and Research Methodology.	2	2

Course Outcomes:

After successful completion of this course, students would be able to:

CO1: Recall the origin, development, and definition of statistics, and understand its importance and scope in research and decision-making.

CO2: Explain the fundamental concepts of statistics and research methodology, highlighting the origin, development, scope, and application of both fields in practical research contexts.

CO3: Apply basic research concepts and methodologies to select appropriate research types and formulate research problems in practical scenarios.

CO4: Analyze different types of research methods and evaluate their applications in real-world research scenarios, comparing methodologies and approaches.

Unit	Topics	No of Lectures
I	**Introduction to Statistics** 1. Origin and development of Statistics 2. Statistics Defined 3. Importance and scope of statistics 4. Statistical Organizations in India.	15
II	**Introduction to Research Methodology** 1. Basic Research Concepts: -Research definition; Objectives of Research; Research methods vs Methodology; Criteria of Good Research 2. Types of Research: - Basic Research, Applied Research Descriptive Research, Analytical Research, Empirical Research, Qualitative and Quantitative approaches. 3. Research methodology: - Stages in Scientific Research process, Identification and Selection of Research Problem, Formulation of Research problem, Review of Literature. Pilot Study.	15

References:

1. Agresti, A. and Franklin, C. (2013), Statistics: The Art and Science of Learning from Data (Pearson), 3rd Edition.
2. Gupta, D. N. S. (2010), The Indian Statistical System (Indian Statistical Institute), 1st Edition.
3. Kothari, C. R. (2004), Research Methodology: Methods and Techniques (New Age

International Publishers), 2nd Edition.
4. Kumar, R. (2014), Research Methodology: A Step-by-Step Guide for Beginners (Sage Publications), 4th Edition.
5. Babbie, E. (2010), The Practice of Social Research (Cengage Learning), 12th Edition.
6. Trochim, W. M. K. (2006), Research Methods Knowledge Base (Atomic Dog Publishing), 2nd Edition.
7. Flick, U. (2015), Introducing Research Methodology: A Beginner's Guide to Doing a Research Project (Sage Publications), 1st Edition.
8. Creswell, J. W. (2014), Research Design: Qualitative, Quantitative, and Mixed Methods Approaches (Sage Publications), 4th Edition.

Course Code	MAJOR SEM V	Credits	Lectures /Week
25STAMJP51	**Practical - 5**	**2**	**4**

Course Outcomes:

After successful completion of this course, students would be able to:

CO1: Recall key definitions and properties related to moment generating functions, bivariate distributions, unbiased estimators, and regression models including assumptions.

CO2: Explain the procedures for deriving joint and marginal distributions, selecting estimation methods, and evaluating regression models, including significance tests and confidence intervals.

CO3: Estimate parameters using MLE, Method of Moments, and Bayes Estimation; fit simple, multiple, and ridge regression models.

CO4: Analyze and interpret the efficiency of estimators, the validity of regression assumptions.

Paper I	Title	No. of lectures
1	Trinomial Distribution	**60**
2	Multinomial Distribution	
3	Bivariate Normal Distribution	
4	Tests for correlation and Interval estimation	
Paper II		
1	MVUE and MVBUE	
2	Methods of Estimation – I	
3	Methods of Estimation – II	
4	Baye's Estimation	
5	Confidence Interval	
Paper III		
1	Simple Linear Regression	
2	Multiple Linear Regression	
3	Weighted Least Square	
4	Ridge Regression	
5	Validity of Assumptions	

References:

1. Feller W: An introduction to probability theory and it's applications, Volume: 1, Third edition, Wiley Eastern Limited.
2. Hogg R. V. & Craig A.T.: Introduction to Mathematical Statistics, Fifth edition, Pearson Education (Singapore) Pvt Ltd.

3. Mood A M, Graybill F A, Bose D C: Introduction to the theory of statistics, Third edition, Mcgraw- Hill Series.
4. Hogg R. V. and Tanis E.A.: Probability and Statistical Inference, Fourth edition, McMillan Publishing Company.
5. Gupta S C & Kapoor V K: Fundamentals of Mathematical statistics, Eleventh edition, Sultan Chand & Sons. Kapur J. N., Saxena H. C.: Mathematical Statistics, Fifteenth edition, S. Chand and Company.
6. Kapur J. N., Saxena H.C.: Mathematical Statistics; Fifteenth Edition; S. Chand & Company Ltd.
7. Arora Sanjay and Bansi La:: New Mathematical Statistics, Satya Prakashan, New Market, New Delhi,5(1989**).**
8. Draper, N. R. and Smith, H. (1998), Applied Regression Analysis (John Wiley), Third Edition.
9. Montgomery, D. C., Peck, E. A. and Vining, G. G. (2003), Introduction to Linear Regression Analysis (Wiley).
10. Neter, J., W., Kutner, M. H. Nachtsheim, C.J. and Wasserman, W.(1996), Applied Linear Statistical Models, fourth edition, Irwin USA.
11. Damodar Gujrati, Sangetha,Basic Econometrics, fourth edition, McGraw Hill Companies.
12. William Geene (1991), Econometrics Analysis, first edition, Mc Millan Publishing Company.

Course Code	MINOR SEM – V	Credits	Lectures /Week
25STAMR521	**Paper I – Testing of Hypothesis**	**2**	**2**

Course Outcomes:

After successful completion of this course, students would be able to:

CO1: Recall and define fundamental concepts related to hypothesis testing and estimation.

CO2: Explain the concepts and interpret the significance of hypothesis testing procedures and sampling distributions.

CO3: Apply large sample tests to test hypotheses concerning population mean, difference of means, population proportion, and difference of proportions using appropriate statistical procedures.

CO4: Differentiate between various hypothesis testing scenarios and assess the appropriateness of estimation techniques for interpreting population characteristics from sample data in large samples.

Unit	Topics	No of Lectures
I	**Introduction to Statistical tests** 1. Concept of hypothesis 2. Null and alternate hypothesis, 3. Types of errors 4. Critical region 5. Level of significance.	**15**
II	**Concept of estimation and Large sample test:** 1. Concept of statistics, estimate and its sampling distribution. 2. Parameter and it's estimator. 3. Concept of standard error of an estimator. 4. Central Limit theorem (statement only). 5. Sampling distribution of sample mean and sample proportion. (For large sample only) 6. Standard errors of sample mean and sample proportion. Large Sample Test: a) For testing specified value of population mean b) For testing specified value in difference of two means c) For testing specified value of population proportion d) For testing specified value of difference of population proportion	**15**

References:

1. Hogg R.V. and Craig A.T: Introduction to Mathematical Statistics, Fourth edition London Macmillan Co. Ltd.
2. Hogg R.V. and Tanis E.A.: Probability and Statistical Inference, Third edition Delhi Pearson Education.
3. Lehmann, E. L: Testing of Statistical Hypothesis, Wiley & Sons.
4. Rao, C. R.: Linear Statistical Inference and its applications, Second Edition Wiley Series in Probability and Statistics.
5. Wald A.: Sequential Analysis, First edition New York John Wiley & Sons.
6. Gupta S.C. and Kapoor V.K.: Fundamentals of Mathematical Statistics, Tenth edition New Delhi S. Chand & Company Ltd.
7. Sanjay Aroraand BansiLal: New Mathematical Statistics, SatyaPrakashan, New Market, New Delhi, 5(1989).
8. A. Mood, F. Graybill& D. Boes: Introduction to the theory of Statistics- McGraw Hil.

Course Code	MINOR SEM - V	Credits	Lectures /Week
25STAMRP51	Statistics Practical - 4	2	4

Course Outcomes:

After successful completion of this course, students would be able to:

CO1: Recall and tabulate values from the standard normal distribution table to support hypothesis testing procedures.

CO2: Interpret the formulation of null and alternative hypotheses and explain the outcome of hypothesis tests based on calculated test statistics and critical regions.

CO3: Apply appropriate large sample tests for means and proportions using real or simulated data, and make data-driven decisions.

CO4: Analyze different testing situations by selecting suitable statistical procedures and evaluating the validity of test results through practical examples.

Practical No.	Title	No. of lectures
1	Use of Standard Normal tables	**60**
2	Testing of Hypothesis-I	
3	Testing of Hypothesis-II	
4	Testing of Hypothesis-III	
5	Testing of Hypothesis-IV	
6	Estimation and Sampling distribution	
7	Large sample test-I	
8	Large sample test-II	
9	Large sample test-III	
10	Large sample test-IV	
11	Data analysis using Testing of Hypothesis	
12	Data analysis using Large sample test.	

References:

1. Hogg R.V. and Craig A.T: Introduction to Mathematical Statistics, Fourth edition London Macmillan Co. Ltd.
2. Hogg R.V. and Tanis E.A.: Probability and Statistical Inference, Third edition Delhi Pearson Education.
3. Lehmann, E. L: Testing of Statistical Hypothesis, Wiley & Sons.
4. Rao, C. R.: Linear Statistical Inference and its applications, Second Edition Wiley Series in Probability and Statistics.
5. Wald A.: Sequential Analysis, First edition New York John Wiley & Sons.
6. Gupta S.C. and Kapoor V.K.: Fundamentals of Mathematical Statistics, Tenth edition New Delhi S. Chand & Company Ltd.
7. Sanjay Aroraand BansiLal: New Mathematical Statistics, SatyaPrakashan, New Market, New Delhi, 5(1989).
8. A. Mood, F. Graybill& D. Boes: Introduction to the theory of Statistics- McGraw Hil.

Course Code	ELECTIVE SEM – V	Credits	Lectures /Week
25STAEL531	Elective –1: Bio-Statistics	2	2

Course Outcomes:

After successful completion of this course, students would be able to:

CO1: Recall and define key terminologies related to epidemic models and bioassays.

CO2: Explain the structure and assumptions of deterministic and stochastic epidemic models such as the Reed-Frost and Greenwood models, and describe the dose-response relationship and conditions of validity in bioassays.

CO3: Apply chain binomial models to estimate the probability of infection using maximum likelihood estimation and compute relative potency in direct and indirect assays using Fieller's theorem and linearized models.

CO4: Analyze and validate bioassay data using orthogonal contrasts, interpret probit and logit analysis results, and evaluate model fit and assumptions in both epidemic modeling and quantal response assays.

Unit	Topics	No of Lectures
I	**Epidemic Models** 1. The features of Epidemic spread. Definitions of various terms involved. Simple mathematical models for epidemics: Deterministic model without removals (for 'a' introductions), Carrier model. 2. Chain binomial models. Reed-Frost and Greenwood models. Distribution of individual chains and total number of cases. Maximum likelihood estimator of `p' and its asymptotic variance for households of sizes up to 4.	15
II	**Bioassays** 1. Meaning and scope of bioassays. Relative potency. Direct assays. Fieller's theorem. 2. Indirect assays. Dose-response relationship. Conditions of similarity and Monotony.	15

	Linearizing transformations. Parallel line assays. Symmetrical (2, 2) and (3, 3) parallel line assays. Validity tests using orthogonal contrasts. Point Estimate and Interval Estimate of Relative potency. 3. Quantal Response assays. Tolerance distribution. Median effective dose ED50 and LD50. Probit and Logit analysis.	

References:

1. Bailey N.TJ.: The Mathematical theory of infectious diseases, Second edition, Charles Griffin and Co. London.
2. Das M.N. and Giri N. C.: Design and Analysis of Experiments, Second edition, Wiley Eastern.
3. Finney D. J.: Statistical Methods in Biological Assays, First edition, Charles Griffin and Co. London.
4. Sanford Boltan and Charles Bon: Pharmaceutical Statistics, Fourth edition, Marcel Dekker Inc.
5. Zar Jerrold H.: Biostatistical Analysis, Fourth edition, Pearson's education.
6. Daniel Wayne W.: Biostatistics. A Foundation for Analysis in the Health Sciences, 7th Edition, Wiley Series in Probability and Statistics.

Course Code	ELECTIVE SEM - V	Credits	Lectures /Week
25STAELP51	Elective Practical - 1	2	4

Course Outcomes:

After successful completion of this course, students would be able to:

CO1: Identify and define fundamental concepts involved in epidemic modeling and various types of bioassays.

CO2: Interpret the mechanisms of epidemic spread using mathematical models and explain the significance of response curves in direct and indirect bioassays.

CO3: Fit Reed-Frost and Greenwood chain binomial models to real or simulated epidemic data and compute maximum likelihood estimators. Calculate point and interval estimates of relative potency in bioassay experiments.

CO4: Analyze the validity of (2,2) and (3,3) parallel line assays using orthogonal contrasts, and evaluate the effectiveness of treatments using probit and logit analysis in quantal response assays.

Practical No.	Title	No. of lectures
1	Epidemic Models - I	60
2	Epidemic Models - II	
3	Epidemic Models - III	
4	Epidemic Models - IV	
5	Bioassay-I	
6	Bioassay-II	
7	Bioassay-III	
8	Bioassay-IV	
9	Bioassay-V	
10	Data analysis using Epidemic Models – I & II	
11	Data analysis using Epidemic Models – III & IV	
12	Data analysis using Bioassay – I & II	
13	Data analysis using Bioassay – IIII & IV	
14	Data analysis using Bioassay –V	

References:

1. Bailey N.TJ.: The Mathematical theory of infectious diseases, Second edition, Charles Griffin and Co. London.
2. Das M.N. and Giri N. C.: Design and Analysis of Experiments, Second edition, Wiley Eastern.
3. Finney D. J.: Statistical Methods in Biological Assays, First edition, Charles Griffin and Co. London.
4. Sanford Boltan and Charles Bon: Pharmaceutical Statistics, Fourth edition, Marcel Dekker Inc.
5. Zar Jerrold H.: Biostatistical Analysis, Fourth edition, Pearson's education.
6. Daniel Wayne W.: Biostatistics. A Foundation for Analysis in the Health Sciences, 7th Edition, Wiley Series in Probability and Statistics.

Course Code	ELECTIVE SEM – V	Credits	Lectures /Week
25STAEL532	**Elective – 1: Operations Research - I**	**2**	**2**

Course Outcomes:

After successful completion of this course, students would be able to:

CO1: Recall and define fundamental concepts and terminologies of Game Theory and Decision Theory.

CO2: Explain the theoretical framework of Game Theory and Decision Theory models and interpret strategies, decision-making criteria.

CO3: Apply appropriate strategies and decision-making techniques to solve problems in two-person zero-sum games and under conditions of risk and uncertainty.

CO4: Analyze and compare decision-making alternatives and game strategies using critical evaluation of outcomes, regret values, and optimal solutions under different scenarios.

Unit	Topics	No of Lectures
I	**Game Theory** 1. Definitions of Two persons 2. Zero Sum Game, Saddle Point, Value of the Game 3. Pure and Mixed strategy 4. Optimal solution of two person zero sum games 5. Dominance property 6. Derivation of formulae for (2 2) game 7. Graphical solution of (2 n) and (m 2) games 8. Reduction of game theory to LPP.	**15**
II	**Decision Theory** 1. Decision making under uncertainty: a) Laplace criterion b) Maximax (Minimin) criterion c) Maximin (Minimax) criterion d) Hurwitz α criterion e) Minimax Regret criterion. 2. Decision making under risk: a) Expected Monetary Value criterion b) Expected Opportunity Loss criterion c) EPPI d) EVPI 3. Bayesian Decision rule for Posterior analysis. 4. Decision tree analysis along with Posterior probabilities.	**15**

References:

1. Mathematical Models in Operations Research: J K Sharma, (1989), Tata McGraw Hill Publishing Company Ltd. 17
2. Operations Research: S. D. Sharma.11th edition, KedarNath Ram Nath& Company.
3. Operations Research: Kantiswaroop and Manmohan, Gupta. 12thEdition; S Chand & Sons. Schaum Series book in O.R. Richard Bronson. 2nd edition Tata Mcgraw Hill Publishing Company Ltd.
4. Bronson R.: Theory and problems of Operations research, First edition, Schaum's Outline series Operations Research: Methods and Problems: Maurice Sasieni, Arthur Yaspan and Lawrence Friedman, (1959), John Wiley & Sons.
5. Operations Research: H. A.Taha., 6th edition, Prentice Hall of India.
6. Vora N. D.: Quantitative Techniques in Management, Third edition, McGraw Hill Companies. Bannerjee B. : Operation Research Techniques for Management, First edition, Business Books.

Course Code	ELECTIVE SEM - V	Credits	Lectures /Week
25STAELP52	**Elective Practical - 1**	**2**	**4**

Course Outcomes:

After successful completion of this course, students would be able to:

CO1: Recall and describe key concepts of Game Theory and Decision Theory.

CO2: Explain how to formulate and simplify game-theoretic and decision problems using appropriate theoretical models.

CO3: Apply solution techniques such as pure and mixed strategies, graphical methods, decision-making criteria under uncertainty and risk, and Bayesian rules to solve real-life decision problems.

CO4: Analyze and evaluate different strategies and decisions using game theory models and decision tree analysis to recommend optimal solutions in uncertain and risky business environments.

Practical No.	Title	No. of lectures
1	Game Theory - I	**60**
2	Game Theory - II	
3	Game Theory - III	
4	Game Theory - IV	
5	Decision Theory - I: Decisions Under Uncertainty	
6	Decision Theory - II : Decisions Under Risk	
7	Decision Theory - III : Decision Tree analysis	
8	Data analysis using Game Theory I & II	
9	Data analysis using Game Theory III & IV	
10	Data analysis using Decision Theory I	
11	Data analysis using Decision Theory II	

References:

1. Mathematical Models in Operations Research: **J** K Sharma, (1989), Tata McGraw Hill Publishing Company Ltd. 17
2. Operations Research: S. D. Sharma.11th edition, KedarNath Ram Nath& Company.
3. Operations Research: Kantiswaroop and Manmohan, Gupta. 12thEdition; S Chand & Sons. Schaum Series book in O.R. Richard Bronson. 2nd edition Tata Mcgraw Hill Publishing Company Ltd.
4. Bronson R.: Theory and problems of Operations research, First edition, Schaum's Outline Series Operations Research: Methods and Problems: Maurice Sasieni, Arthur Yaspan and Lawrence Friedman, (1959), John Wiley & Sons.
5. Operations Research: H. A.Taha., 6th edition, Prentice Hall of India.
6. Vora N. D.: Quantitative Techniques in Management, Third edition, McGraw Hill Companies. Bannerjee B. : Operation Research Techniques for Management, First edition, Business Books.

Course Code	VOCATIONAL SKILL COURSE SEM – V	Credits	Lectures /Week
25STAVS541	Data Analysis Using R-Software	2	4

Course Outcomes:

After successful completion of this course, students would be able to:

CO1: Recall fundamental R commands and functions used for data input, manipulation, and basic statistical operations.

CO2: Interpret and visualize statistical data using appropriate graphs and diagrams in R, and explain the outputs of various descriptive and inferential statistical procedures.

CO3: Apply R programming to perform calculations for central tendency, dispersion, probability distributions, regression analysis, ANOVA, and hypothesis testing (parametric and non-parametric).

CO4: Analyze datasets using R to draw meaningful inferences through regression modeling, ANOVA, and hypothesis testing, and critically evaluate the suitability of parametric vs non-parametric tests.

Practical No.	Title	No. of lectures
1	Fundamentals of R - I	60
2	Fundamentals of R - II	
3	Graphs and Diagrams using R	
4	Measures of Central Tendency using R - I	
5	Measures of Central Tendency using R - II	
6	Measures of Dispersion using R	
7	Discrete Probability distributions using R	
8	Continuous Probability distributions using R	
9	Parametric Tests using R	
10	Non-Parametric Tests using R	
11	Regression Analysis using R	
12	ANOVA using R	

References:

1. Dalgaard, Peter: Introductory Statistics with R, Springer.
2. Wickham, Hadley & Grolemund, Garrett: R for Data Science, O'Reilly Media.
3. Verzani, John: Using R for Introductory Statistics, CRC Press.
4. Crawley, Michael J.: The R Book, Wiley.
5. Bruce, Peter, Bruce, Andrew, & Gedeck, Peter: Practical Statistics for Data Scientists: 50 Essential Concepts with R and Python, O'Reilly Media.

Course Code	MAJOR SEM – VI	Credits	Lectures /Week
25STAMJ611	**Paper I – Probability & Stochastic Processes**	**2**	**2**

Course Outcomes:

After successful completion of this course, students would be able to:

CO1: Recall and explain key definitions and foundational theorems in probability, inequalities, and stochastic processes.

CO2: Classify and illustrate various probabilistic events, inequality bounds, and stochastic models to gain conceptual clarity on uncertainty and time-dependent random processes.

CO3: Apply probability theorems, inequalities, and stochastic process equations to solve real-world problems involving randomness and uncertainty.

CO4: Analyze probabilistic systems using inequalities and stochastic processes.

Unit	Topics	No of Lectures
I	**Probability & WLLN** **Probability** 1. Basic definitions: Random Experiment, Outcome, Event, Sample Space, Complementary, Mutually Exclusive, Exhaustive and Equally Likely Events. 2. Mathematical, Statistical, Axiomatic and Subjective probability. 3. Addition Theorem for (a) two (b) three events. 4. Conditional Probability: Multiplication Theorem for two, three events. 5. Bayes' theorem. 6. Theorems on Probability of realization of: (a) At least one (b) Exactly m (b) At least m of N Events A_1, A_2, A_3...A_N. 7. Classical occupancy problems, Matching and Guessing problems. Problems based on them. **Inequalities and Law of Large Numbers** 1. Markov Inequality 2. Tchebyshev's Inequality	**15**
	3. Boole's Inequality 4. Cauchy Schwartz's Inequality 5. Weak law of large numbers.	

II	**Stochastic Processes** 1. Definition of stochastic process. 2. Postulates and difference differential equations for: a) Pure birth process b) Poisson process with initially 'a' members, for a =0 and a >0 c) Yule Furry process d) Pure death process e) Death process with $\mu_n=\mu$ f) Death process with $\mu_n= n\mu$ g) Birth and death process h) Linear growth model. Derivation of Pn(t), mean and variance where ever applicable.	**15**

References:

1. Feller W: An introduction to probability theory and it's applications, Volume: 1, Third edition, Wiley Eastern Limited.
2. Hogg R. V. and Tanis E.A.: Probability and Statistical Inference, Fourth edition, McMillan Publishing Company.
3. Chandra T.K. & Chatterjee D.: A First Course in Probability, Second Edition, Narosa Publishing House.
4. S.C. Gupta and V. K. Kapoor: Fundamental of Mathematical Statistics, Sultan Chand and Sons V K Rohatgi: An Introduction to probability and Mathematical Statistics.
5. Medhi J: Stochastic Processes, Second edition, Wiley Eastern Ltd.
6. Biswas S.: Topics in Statistical Methodology (1992), First edition, Wiley Eastern Ltd.
7. Kapur J. N., Saxena H. C.: Mathematical Statistics, Fifteenth edition, S. Chand and Company.

Course Code	MAJOR SEM – VI	Credits	Lectures /Week
25STAMJ612	Paper II – Parametric & Non-Parametric Tests	2	2

Course Outcomes:

After successful completion of this course, students would be able to:

CO1: Define and recall key concepts of hypothesis testing.

CO2: Explain the principles and procedures of constructing most powerful and uniformly most powerful tests, and differentiate between fixed sample size and sequential test methods.

CO3: Apply parametric and non-parametric tests to real-life problems.

CO4: Analyze the appropriateness and effectiveness of different test procedures (parametric vs. non-parametric) by evaluating their assumptions, power, and suitability for small or large sample sizes.

Unit	Topics	No of Lectures
I	**Parametric Tests:** **Most Powerful Tests** 1. Problem of testing of hypothesis. 2. Definitions and illustrations of: a) Simple hypothesis b) Composite hypothesis c) Null Hypothesis d) Alternative Hypothesis e) Test of hypothesis f) Critical region g) Type I and Type II errors h) Level of significance i) p-value x) Size of the test j) Power of the test k) Power function of a test l) Power curve. 3. Definition of most powerful test of size α for a simple hypothesis against a simple alternative hypothesis. Neyman-Pearson fundamental lemma. Randomised test. 4. Definition, Existence and Construction of Uniformly most powerful (UMP) test.	15

	Sequential Probability Ratio Tests 1. Sequential test procedure for testing a simple null hypothesis against a simple alternative hypothesis. Its comparison with fixed sample size (Neyman-Pearson) test procedure. 2. Definition of Wald's SPRT of strength (α, β). Graphical/Tabular procedure for carrying out SPRT. 3. Problems based on Bernoulli, Binomial. Poisson, Normal & Exponential distributions.	
II	**Non-parametric Tests** 1. Need for non-parametric tests. 2. Distinction between a parametric and a non-parametric test. 3. Concept of a distribution free statistic. 4. Single sample and two sample Nonparametric test: (i) Sign test (ii) Wilcoxon's signed rank test (iii) Median test (iv) Mann–Whitney test (v) Run test (vi) Fisher exact test (vii) Kruskal -Wallis test (viii) Friedman test 5. Assumptions, justification of the test procedure for small & large samples.	**15**

References:

1. Hogg R.V., Craig A.T.: Introduction to Mathematical Statistics, Fourth Edition; Collier McMillan Publishers.
2. Hogg R.V., Tannis E. A.: Probability and Statistical Inference, Third Edition; Collier McMillan Publishers.
3. Rohatgi, V. K, Ehsanes Saleh A.K. Md.: An introduction to Probability Theory and Mathematical Statistics, Second Edition, Wiley series in Probability and Statistics.
4. John E. Freund's Mathematical Statistics: I. Miller, M. Miller; Sixth Edition; Pearson Education Inc.
5. Hoel P.G.: Introduction to Mathematical Statistics; Fourth Edition; John Wiley & Sons Inc.
6. Gupta S.C., Kapoor V.K.: Fundamentals of Mathematical Statistics; Eighth Edition; Sultan Chand & Sons.
7. Kapur J. N., Saxena H.C.: Mathematical Statistics; Fifteenth Edition; S. Chand & Company Ltd.
8. Arora Sanjay and Bansi La:: New Mathematical Statistics, Satya Prakashan, New Market, New Delhi,5(1989).
9. Sidney Siegal& N John Castellan Jr.:Non parametric test for behavioral sciences, McGraw Hill c-1988.
9. A. Mood, F. Graybill& D. Boes: Introduction to the theory of Statistics- McGraw Hil.

Course Code	MAJOR SEM – VI	Credits	Lectures /Week
25STAMJ613	**Paper III – Acturial Science**	**2**	**2**

Course Outcomes:

After successful completion of this course, students would be able to:

CO1: Recall and describe the basic components and types of mortality tables, annuities, and related mortality laws used in actuarial science.

CO2: Understand and explain key concepts in mortality functions, annuities, and mortality laws

CO3: Apply mortality functions, mortality laws, and commutation functions to compute present values of various annuities.

CO4: Analyze mortality patterns, calculate life expectancy, and evaluate the present value of various life annuities using commutation functions.

Unit	Topics	No of Lectures
I	**Mortality Tables** 1. Various mortality functions. Probabilities of living and dying. 2. The force of mortality. Estimation of μ_x from the mortality table. Central Mortality Rate. 3. Laws of mortality: Gompertz's and Makeham's first law. 4. Select, Ultimate and Aggregate mortality tables. 5. Stationary population. Expectation of life and Average life at death.	**15**
II	**Simple interest and Compound Interest** 1. Concept of Simple interest and Compound interest. 2. Accumulated value and present value. 3. Nominal and Effective rates of interest. 4. Varying rates of interest. 5. Equation of value. Equated time of payment.	**15**

References:

1. Neill A.: Life Contingencies, First edition, Heineman educational books London.
2. Dixit S.P., Modi C.S., Joshi R.V.: Mathematical Basis of Life Assurance, First edition Insurance Institute of India.
3. Gupta S. C. &. Kapoor V. K.: Fundamentals of Applied Statistics, Fourth edition, Sultan Chand & Sons.

Course Code	MAJOR SEM – VI	Credits	Lectures /Week
25STAMJ614	**Paper IV – Probability Distribution Theory**	**2**	**2**

Course Outcomes:

After successful completion of this course, students would be able to:

CO1: Recall definitions, fundamental formulas, and properties related to order statistics and generating functions used in probability.

CO2: Illustrate the derivation of distributions of order statistics and explain the use of generating functions in computing statistical moments.

CO3: Apply the principles of order statistics and generating functions to compute probabilities, moments, and solve real-life problems.

CO4: Analyze differential equations for various processes like pure birth, Poisson, Yule Furry, pure death, and birth-death processes.

Unit	Topics	No of Lectures
I	**Order Statistics** 1. Definition of Order Statistics based on a random sample. 2. Derivation of: a) Cumulative distribution function of r^{th} order statistic. b) Probability density functions of the r^{th} order statistic. c) Joint Probability density function of the r^{th} and the s^{th} order statistic (r<s). d) Joint Probability density functions of all n ordered statistics. e) Distribution of Maximum observation (nth order statistic) and Minimum observation (first order statistic) in case of uniform and Exponential distribution. f) Probability density function of the difference between r^{th} and s^{th} order statistic (r<s) in case of uniform and Exponential distribution.	**15**
II	**Generating Functions** 1. Definitions of generating function and probability generating function. Expression for mean and variance in terms of generating functions. 2. Definition of a convolution of two or more sequences. Generating function of a convolution. Generating functions of the standard discrete distributions. 3. Relation between: a) Bernoulli and Binomial	**15**

	distributions b) Geometric and Negative Binomial distributions in terms of convolutions.	

References:

1. Feller W: An introduction to probability theory and it's applications, Volume: 1, Third edition, Wiley Eastern Limited.
2. Biswas S.: Topics in Statistical Methodology (1992), First edition, Wiley Eastern Ltd.
3. Hogg R V. & Craig Allen T.: Introduction to Mathematical Statistics, Fifth edition, Pearson Education (Singapore) Pvt. Ltd.
4. Mood A. M., Graybill F. A., Boes D. C.: Introduction to the theory of statistics, Third edition, Mcgraw- Hill Series.
5. Kapur J. N. & Saxena H. C.: Mathematical Statistics, Fifteenth edition, S. Chand and Company.
6. S.C. Gupta and V. K. Kapoor: Fundamental of Mathematical Statistics, Sultan Chand and Sons V K Rohatgi: An Introduction to probability and Mathematical Statistics.

Course Code	MAJOR SEM VI	Credits	Lectures /Week
25STAMJP61	Practical - 6	2	4

Course Outcomes:

After successful completion of this course, students would be able to:

CO1: Recall key definitions, formulas, and foundational concepts in probability, stochastic processes, parametric & non-parametric tests, mortality models, and generating functions used in statistical applications.

CO2: Recall and explain fundamental probability principles, test procedures, mortality measures, and statistical functions.

CO3: Apply appropriate statistical tests, stochastic models, and actuarial functions to analyze sample data and compute life expectancy.

CO4: Analyze complex statistical problems involving probability models, inferential testing, mortality data, and actuarial functions to evaluate the underlying distributions and make informed predictions.

Paper I	Title	No. of lectures
1	Probability – I	**60**
2	Probability – II	
3	Inequalities & WLLN	
4	Stochastic Processes	
Paper II		
1	Most Powerful Test	
2	Uniformly Most Powerful Test	
3	Sequential Probability Ratio Test	
4	Non-Parametric Test	
Paper III		
1	Mortality Table - I	
2	Mortality Table - I	
3	Simple interest and Compound interest – I	
4	Simple interest and Compound interest – II	
Paper IV		
1	Order Statistics - I	

2	Order Statistics - II	
3	P.G.F. – I	
4	P.G.F. – II	

References:

1. Feller W: An introduction to probability theory and it's applications, Volume: 1, Third edition, Wiley Eastern Limited.
2. Hogg R. V. & Craig A.T.: Introduction to Mathematical Statistics, Fifth edition, Pearson Education (Singapore) Pvt Ltd.
3. Mood A M, Graybill F A, Bose D C: Introduction to the theory of statistics, Third edition, Mcgraw- Hill Series.
4. Hogg R. V. and Tanis E.A.: Probability and Statistical Inference, Fourth edition, McMillan Publishing Company.
5. Gupta S C & Kapoor V K: Fundamentals of Mathematical statistics, Eleventh edition, Sultan Chand & Sons. Kapur J. N., Saxena H. C.: Mathematical Statistics, Fifteenth edition, S. Chand and Company.
6. Kapur J. N., Saxena H.C.: Mathematical Statistics; Fifteenth Edition; S. Chand & Company Ltd.
7. Sidney Siegal& N John Castellan Jr.:Non parametric test for behavioral sciences, McGraw Hill c-1988.
8. A. Mood, F. Graybill& D. Boes:Introduction to the theory of Statistics- McGraw Hil.
9. Neill A.: Life Contingencies, First edition, Heineman educational books London.
10. Dixit S.P., Modi C.S., Joshi R.V.: Mathematical Basis of Life Assurance, First edition Insurance Institute of India.
11. Gupta S. C. &. Kapoor V. K.: Fundamentals of Applied Statistics, Fourth edition, Sultan Chand & Sons.

Course Code	MINOR SEM – VI	Credits	Lectures /Week
25STAMR621	Paper I – Analysis of Variance	2	2

Course Outcomes:

After successful completion of this course, students would be able to:

CO1: Define and explain the basic concepts of One-way and Two-way ANOVA, including their uses and assumptions.

CO2: Calculate least square estimators for the parameters in One-way and Two-way ANOVA models.

CO3: Apply One-way and Two-way ANOVA to analyze data with equal and unequal observations per class.

CO4: Analyze the results of ANOVA models, including interpreting the sums of squares, F-statistic, and the significance of the results.

Unit	Topics	No of Lectures
I	**One-way ANOVA** 1. Introduction, Uses, Cochran's Theorem (Statement only). 2. One-way classification with equal & unequal observations per class. 3. Mathematical Model, Assumptions, Mathematical analysis, F-test, Analysis of variance table.	15
II	**Two-way ANOVA** 1. Two-way classification with one observation per cell, with replication. 2. Mathematical Model, Assumptions, Mathematical analysis, F-test, Analysis of variance table.	15

References:

1. Experimental Designs: W.G. Cochran and G.M.Cox; Second Edition;John Wiley and Sons.
2. The Design and Analysis of Experiments: Oscar Kempthorne, John Wiley and Sons.
3. Design and Analysis of Experiments: Douglas C Montgomery; 6th Edition;John Wiley & Sons.
4. Design and Analysis of Experiments: M.N.Das and N.C.Giri, 2nd Edition; New Age International (P) Limited;1986.
5. Experimental Design, Theory and Application: Walter T Federer; Oxford & IBH Publishing Co. Pvt. Ltd.
6. Fundamentals of Applied Statistics: S.C.Gupta and V.K.Kapoor; 3rd Edition; Sultan Chand and Sons (2001).
7. Statistical Principles in Experimental Design: B.J. Winer, McGraw Hill Book Company.

Course Code	MINOR SEM - VI	Credits	Lectures /Week
25STAMRP61	Statistics Practical - 5	2	4

Course Outcomes:

After successful completion of this course, students would be able to:

CO1: Recall the key concepts and definitions related to One-way ANOVA and Two-way ANOVA, including the assumptions, the mathematical models, and the structure of the ANOVA table.

CO2: Explain the purpose and process of performing One-way and Two-way ANOVA.

CO3: Apply the One-way and Two-way ANOVA techniques to real-world data sets, perform the necessary calculations, and draw conclusions based on the results.

CO4: Analyze the results of One-way and Two-way ANOVA, evaluate the significance of the output.

Practical No.	Title	No. of lectures
1	One-way ANOVA -I	**60**
2	One-way ANOVA -II	
3	One-way ANOVA -III	
4	Two-way ANOVA-I	
5	Two-way ANOVA-II	
6	Two-way ANOVA-III	
7	Data analysis using One-way ANOVA-I	
8	Data analysis using One-way ANOVA-II	
9	Data analysis using Two-way ANOVA-I	
10	Data analysis using One-way ANOVA-II	

References:

1. Experimental Designs: W.G. Cochran and G.M.Cox; Second Edition;John Wiley and Sons.
2. The Design and Analysis of Experiments: Oscar Kempthorne, John Wiley and Sons.
3. Design and Analysis of Experiments: Douglas C Montgomery; 6th Edition;John Wiley & Sons.
4. Design and Analysis of Experiments: M.N.Das and N.C.Giri, 2nd Edition; New Age International (P) Limited;1986.
5. Experimental Design, Theory and Application: Walter T Federer; Oxford & IBH Publishing Co. Pvt. Ltd.
6. Fundamentals of Applied Statistics: S.C.Gupta and V.K.Kapoor; 3rd Edition; Sultan Chand and Sons (2001).
7. Statistical Principles in Experimental Design: B.J. Winer, McGraw Hill Book Company.

Course Code	ELECTIVE SEM – VI	Credits	Lectures /Week
25STAEL631	Elective – 2: Annuities, Life Annuities and Assurance Benefits	2	2

Course Outcomes:

After successful completion of this course, students would be able to:

CO1: Recall the basic concepts of life annuities and assurance benefits, including the definition and calculation of present values using commutation functions.

CO2: Understand the calculation of present values and accumulated values of life annuities and assurance benefits using commutation functions.

CO3: Apply the principles of commutation functions to calculate the present value of various life annuities and assurance benefits, including variable, increasing annuities, and different types of assurance plans.

CO4: Analyze and compare the present values of various life annuities and assurance benefits, understanding the impact of deferment periods and types of assurance plans on premium calculations.

Unit	Topics	No of Lectures
I	**Annuities and Life Annuities** 1. Concept of annuity and types of annuities. 2. Present and accumulated values of annuity certain (immediate and due) with and without deferment period. Present value for perpetuity (immediate and due) with and without deferment Period. 3. Present and accumulated values of: a) increasing annuity b) increasing annuity when successive instalments form arithmetic progression c) annuity with frequency different from that with which interest is convertible. 4. Life annuities: . a) Present value in terms of commutation functions of Life annuities and Temporary life annuities (immediate and due) with and without deferment period. b) Present values of Variable, increasing life annuities and increasing Temporary life annuities (immediate and due).	15

II	**Assurance Benefits** 1. Present value of Assurance benefits in terms of commutation functions of: a) pure endowment assurance b) temporary assurance c) endowment assurance d) whole life assurance e) double endowment assurance f) special endowment assurance g) deferred temporary assurance. 2. Net premiums: Net level annual premiums (including limited period of payment) for various assurance plans. Natural and Office premiums.	15

References:

1. Neill A.: Life Contingencies, First edition, Heineman educational books London.
2. Dixit S.P., Modi C.S., Joshi R.V.: Mathematical Basis of Life Assurance, First edition Insurance Institute of India.
3. Gupta S. C. &. Kapoor V. K.: Fundamentals of Applied Statistics, Fourth edition, Sultan Chand & Sons.

Course Code	ELECTIVE SEM - VI	Credits	Lectures /Week
25STAELP61	**Elective-2: Practical - II**	**2**	**4**

Course Outcomes:

After successful completion of this course, students would be able to:

CO1: Recall and define key concepts related to life annuities, assurance benefits, and net premiums, including types of annuities and assurance benefits.

CO2: Explain the relationship between commutation functions, present values of life annuities, and assurance benefits, and the process of calculating net premiums for different assurance plans.

CO3: Apply commutation functions to calculate the present value of life annuities and various assurance benefits, and determine net premiums for practical actuarial scenarios.

CO4: Analyze and compare the impact of different life annuity structures and assurance benefit plans on the present value and net premium calculations.

Practical No.	Title	No. of lectures
1	Annuities - I	
2	Annuities - II	
3	Annuities - III	
4	Life Annuities - I	**60**
5	Life Annuities - II	
6	Life Annuities - III	
7	Assurance Benefits - I	
8	Assurance Benefits - II	
9	Net Premiums	
10	Revision practical-I	
11	Revision practical-II	
12	Revision practical-III	

References:

1. Neill A.: Life Contingencies, First edition, Heineman educational books London.
2. Dixit S.P., Modi C.S., Joshi R.V.: Mathematical Basis of Life Assurance, First edition Insurance Institute of India.
3. Gupta S. C. &. Kapoor V. K.: Fundamentals of Applied Statistics, Fourth edition, Sultan Chand & Sons.

Course Code	ELECTIVE SEM – VI	Credits	Lectures /Week
25STAEL632	**Elective – II: Operations Research - II**	**2**	**2**

Course Outcomes:

After successful completion of this course, students would be able to:

CO1: Define and recall key concepts and models related to inventory control, replacement policies, and reliability theory.

CO2: Explain the structure and logic behind deterministic and probabilistic inventory models, replacement strategies, and the behavior of different failure time distributions.

CO3: Apply deterministic and probabilistic inventory models to solve real-world inventory control problems and use replacement policies to optimize decision-making for deteriorating and failing items.

CO4: Analyze and compare the effectiveness of different inventory control models, replacement policies, and reliability configurations by evaluating cost efficiency, demand-replenishment scenarios, failure rates, and system performance.

Unit	Topics	No of Lectures
I	**Inventory Control** 1. Introduction to Inventory Problem 2. **Deterministic Models:** Single item static EOQ models for: a) Constant rate of demand with instantaneous replenishment, with and without shortages. b) Constant rate of demand with uniform rate of replenishment, with and without shortages. c) Constant rate of demand with instantaneous replenishment without shortages, with at most two price breaks. 3. **Probabilistic models:** Single period with: a) Instantaneous demand (discrete and continuous) without setup cost. b) Uniform demand (discrete and continuous) without set up cost.	**15**
II	**Replacement** 1. Replacement of items that deteriorate with time and value of money: 2. remains constant 3. changes with time.	**15**

	4. 2. Replacement of items that fail completely: Individual replacement and Group replacement policies. **Reliability:** 1. Concept of reliability, Hazard-rate. Bath tub curve. Failure time distributions: (i) Exponential, (ii) Gamma, (iii) Weibull, (iv) Gumbel, 2. Definitions of increasing (decreasing) failure rate. System Reliability. 3. Reliability of: (i) series (ii) parallel system of independent components having exponential life distributions. Mean Time to Failure of a system (MTTF).	

References:

1. Vora N. D.: Quantitative Techniques in Management, Third edition, McGraw Hill Companies.
2. Kantiswarup, P.K. Gupta, Manmohan: Operations Research, Twelfth edition, Sultan Chand & sons.
3. Sharma S. D.: Operations Research, Eighth edition, Kedarnath Ramnath & Co.
4. Taha Hamdy A.: Operations Research: Eighth edition, Prentice Hall of India Pvt. Ltd.

Course Code	ELECTIVE SEM - VI	Credits	Lectures /Week
25STAELP62	**Elective-2: Practical - II**	**2**	**4**

Course Outcomes:

After successful completion of this course, students would be able to:

CO1: Identify and recall basic models and assumptions used in inventory control, replacement strategies, and system reliability analysis.

CO2: Interpret the behavior and outcomes of inventory and replacement models under different cost and demand conditions, and describe the impact of reliability parameters on system performance.

CO3: Apply inventory, replacement, and reliability models to real-world scenarios and compute relevant measures.

CO4: Analyze and evaluate the effectiveness of various inventory models, replacement policies, and system reliability configurations by comparing outcomes across different scenarios.

Practical No.	Title	No. of lectures
1	Inventory – I	**60**
2	Inventory – II	
3	Inventory – III	
4	Replacement - I	
5	Replacement - II	
6	Replacement - III	
7	Reliability - I	
8	Reliability - II	
9	Reliability - III	
10	Data Analysis using Inventory	
11	Data Analysis using Replacement	
12	Data Analysis using Reliability	

References:

1. Vora N. D.: Quantitative Techniques in Management, Third edition, McGraw Hill Companies.
2. Kantiswarup, P.K. Gupta, Manmohan: Operations Research, Twelfth edition, Sultan Chand & sons.
3. Sharma S. D.: Operations Research, Eighth edition, Kedarnath Ramnath & Co.
4. Taha Hamdy A.: Operations Research: Eighth edition, Prentice Hall of India Pvt. Ltd.

Evaluation Scheme for Third Year (UG) under NEP

(2 credits)

I. Internal Evaluation for Theory Courses – 20 Marks

1) **Continuous Internal Assessment(CIA) Assignment** – 10 marks

2) **Continuous Internal Assessment(CIA)** ONLINE Unit Test – 10 marks

II. External Examination for Theory Courses – 30 Marks

Duration: 1 Hours

Theory question paper pattern: All questions are compulsory.

Question	Based on	Marks
Q.1	Unit I	15
Q.2	Unit II	15

- All questions shall be compulsory with internal choice within the questions.
- Each Question may be sub-divided into sub questions as a, b, c, d, etc. & the allocation of Marks depends on the weightage of the topic.

III. Practical Examination

- Each core subject carries 50 Marks.
- Duration: 2 Hours for each practical course.
- Minimum 80% practical from each core subjects are required to be completed.
- Certified Journal is compulsory for appearing at the time of Practical Exam

NOTE: To pass the examination, attendance is compulsory in both Internal & External (Theory + Practical) Examinations.