Anekant Education Society's

Tuljaram Chaturchand College

of Arts, Science and Commerce, Baramati

(Autonomous)

M.Sc. Degree Program in Statistics-
(Faculty of Science & Technology)

CBCS Syllabus

M.Sc. Part – I (Statistics) Semester – II

For Department of Statistics

Tuljaram Chaturchand College of Arts, Science and Commerce, Baramati

Choice Based Credit System Syllabus (2023 Pattern)

(As Per NEP 2020)

To be implemented from Academic Year 2023-2024

Anekant Education Society's

Tuljaram Chaturchand College, Baramati

(Autonomous)

Board of Studies (BOS) in Statistics

From 2022-23 to 2024-25

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4.	Dr. Vaishali V. Patil	Member
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12.	Prin. Dr. Rajendra G. Gurao	Expert from other University
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14.	Mr. Saurabh Kadam	Industry Expert
15.	Dr. Jaya L. Limbore	Meritorious Alumni
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18.	Ms. Shital B. Choudhar	Invitee Member
19.	Ms. Tejashri D. Kawade	Invitee Member
20.	Mr. Shree Sunil Girange (M.Sc. II)	Student Representative

21.	Miss. Sakshi Rajendra Borole (M.Sc. II)	Student Representative
22.	Mr. Siddhi Rajendra Pathak (TYBSc)	Student Representative
23.	Miss. Nikam Shweta Yuvraj (TYBSc)	Student Representative

Program Outcomes (POs) for M.Sc. Programme

PO1	**Disciplinary Knowledge:** Demonstrate comprehensive knowledge of the discipline that forms a part of a postgraduate programme. Execute strong theoretical and practical understanding generated from the specific programme in the area of work.
PO2	**Critical Thinking and Problem solving:** Exhibit the skill of critical thinking and understand scientific texts and place scientific statements and themes in contexts and also evaluate them in terms of generic conventions. Identify the problem by observing the situation closely, take actions and apply lateral thinking and analytical skills to design the solutions.
PO3	**Social competence:** Exhibit thoughts and ideas effectively in writing and orally; communicate with others using appropriate media, build effective interactive and presenting skills to meet global competencies. Elicit views of others, present complex information in a clear and concise way and help reach conclusions in group settings.
PO4	**Research-related skills and Scientific temper :** Infer scientific literature, build a sense of enquiry and able to formulate, test, analyse, interpret and establish hypothesis and research questions; and to identify and consult relevant sources to find answers. Plan and write a research paper/project while emphasizing on academics and research ethics, scientific conduct and creating awareness about intellectual property rights and issues of plagiarism.
PO5	**Trans-disciplinary knowledge:** Create new conceptual, theoretical and methodological understanding that integrates and transcends beyond discipline-specific approaches to address a common problem.
PO6	**Personal and professional competence:** Perform independently and also collaboratively as a part of a 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 centred 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.
PO9	**Self-directed and Life-long learning:** Acquire the ability to engage in independent and life-long learning in the broadest context of socio-technological changes.

Credit Distribution Structure for M.Sc. Part-I (Statistics)

Level	Semester	Major		Research Methodology (RM)	OJT/FP	RP	Cum. Cr.	Degree
		Mandatory	Electives					
6.0	Sem-I	STA-501-MJM: Linear Algebra (Credit 04) STA -502-MJM: Probability Distributions (Credit 04) STA -503-MJM: Statistics Practical – I (Credit 02) STA -504-MJM: Statistics Practical –II (Credit 02)	STA -511-MJE(A): Mathematical Analysis STA-511-MJE(B): Calculus and Statistical Computing (Credit 04)	STA -521-RM: Research Methodology (Credit 04)	--	--	**20**	PG Diploma (after 3 Year Degree)
	Sem-II	STA -551-MJM: Multivariate Analysis (Credit 04) STA -552-MJM: Regression Analysis (Credit 04) STA -553-MJM: Statistics Practical – III (Credit 02) STA -554-MJM: Statistics Practical – IV (Credit 02)	STA -561-MJE (A): Probability Theory STA-561-MJE(B): Stochastic Processes (Credit 04)	--	STA-581-OJT/FP: On Job Training/ Field Project	--	**20**	

Course Structure for M.Sc. Part-I (Statistics) (2023 Pattern)

Sem	Course Type	Course Code	Course Title	Theory/ Practical	No. of Credits
I	Major (Mandatory)	STA-501-MJM	Linear Algebra	Theory	04
	Major (Mandatory)	STA -502-MJM	Probability Distributions	Theory	04
	Major (Mandatory)	STA -503-MJM	Statistics Practical – I	Practical	02
	Major (Mandatory)	STA -504-MJM	Statistics Practical – II	Practical	02
	Major (Elective)	STA-511-MJE (A)	Mathematical Analysis	Theory	04
		STA-511-MJE(B)	Calculus and Statistical Computing	Theory	
	Research Methodology (RM)	STA -521-RM	Research Methodology	Theory	04
			Total Credits Semester I		**20**
II	Major (Mandatory)	STA-551-MJM	Multivariate Analysis	Theory	04
	Major (Mandatory)	STA-552-MJM	Regression Analysis	Theory	04
	Major (Mandatory)	STA-553-MJM	Statistics Practical – III	Practical	02
	Major (Mandatory)	STA-554-MJM	Statistics Practical – IV	Practical	02
	Major (Elective)	STA-561-MJE (A)	Probability Theory	Theory	04
		STA-561-MJE (B)	Stochastic Processes	Theory	
	On Job Training (OJT)/Field Project (FP)	STA-581-OJT/FP	On Job Training Field Project	Training/Project	04
			Total Credits Semester-II		**20**
			Cumulative Credits Semester I and II		**40**

CBCS Syllabus as per NEP 2020 for M.Sc. Part-I Statistics (2023 Pattern)

Name of the Programme	**:** M.Sc. Statistics
Program Code	**:** PSST
Class	**:** M.Sc. Part – I
Semester	**:** II
Course Type	**:** Major Mandatory Theory
Course Name	**:** Multivariate Analysis
Course Code	**:** STA-551-MJM
No. of Credits	**:** 4 credits
No. of Teaching Hours	**:** 60

Course Objectives:

1. To understand the main features of multivariate data.
2. To use exploratory multivariate statistical methods properly.
3. To carry out multivariate statistical techniques and methods efficiently and effectively.
4. To make inferences about multivariate data.
5. To learn about hypothesis testing regarding the mean vector of a multivariate normal population.
6. To perform tests on multivariate data.
7. To gain an understanding of MANOVA and its practical applications.

Course Outcomes:

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

CO1. carry out an extensive exploratory multivariate analysis for a given multivariate data carry out cluster analysis of given multivariate data.

CO2: create meaningful graphical representations of multivariate data.

CO3: apply the concepts of linear and quadratic forms in multivariate normal variables.

CO4. solve problems involving multivariate normal distribution evaluate.

CO5. carry out statistical inference procedures using the data from a multivariate normal distribution.

CO6. carry out classification of given multivariate data.

CO7: perform hypothesis tests related to the mean vector of a multivariate normal

population.

Topics and Learning Points

Unit – 1 **(20L)**

Exploratory multivariate data analysis, sample mean vector, sample dispersion matrix, correlation matrix, graphical representation, linear transformation and its mean, variance covariance, correlation between linear transformations, principal component analysis, factor analysis, canonical correlation with applications, cluster analysis with applications.

Unit – 2 **(12L)**

Multivariate normal distribution, singular and non-singular normal distribution. m.g.f., characteristic function, moments, distribution of a linear form and quadratic form of normal variables, Cochran theorem, marginal and conditional distribution. Test for multivariate normality.

Unit – 3 **(15L)**

M.L.E's of parameters of multivariate normal distribution and their sampling distribution, Wishart matrix, Wishart distribution and its properties, Tests of hypothesis about mean vector of a multivariate normal population, Hotelling T2 statistic and its distribution, its applications. Likelihood ratio test, confidence region for mean vector of multivariate normal distribution.

Unit – 4 **(13L)**

Test for equality of dispersion matrices, discriminant analysis, Mahalanobis D2 statistic, test for significance of the coefficients in discriminant function, misclassification error, methods and applications of MANOVA (without derivation of the distribution of Wilk's lambda).

References:

1. Anderson T.W. (1984) Introduction to multivariate analysis (John Wiley)
2. C. R. Rao (1985) Linear Statistical inference and its applications (Wiley Eastern Ltd)
3. Hardle, W. K. & Simar, L. (2012), Applied Multivariate Statistical analysis (Springer, New York) Johnson R.A. and Wichern D.W. (1988) Applied multivariate statistical analysis

(Prentice Hall Inc.)

4. Johnson R.A. & Wichern, D.W. (1988). Applied Multivariate Statistical analysis (Prentice Hall Inc.)
5. Kshirsagar A.M. (1983) Multivariate Analysis (Marcel Dekker.)
6. K.C. Bhuyan (2005) Multivariate Analysis and its application, New Central book agency, LTD. Kolkatta
7. Morrison, D.F. (1990). Multivariate Statistical Methods (McGraw Hill Co.) (3rd ed.)

Course Outcomes	**Programme Outcomes (POs)**								
	PO1	**PO2**	**PO3**	**PO4**	**PO 5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1	3	3	1	3	2	3	1	3	3
CO2	2	3	1	3	2	3	1	3	3
CO3	2	3	1	3	2	3	1	3	3
CO4	3	3	1	3	2	3	1	3	3
CO5	3	3	1	3	2	3	1	3	3
CO6	3	3	1	3	2	3	1	3	3
CO7	3	3	1	3	2	3	1	3	3

PO1. Disciplinary Knowledge

CO1: 3 (Strongly Related)
CO2: 2 (Moderately Related)
CO3: 2 (Moderately Related)
CO4: 3 (Strongly Related)
CO5: 3 (Strongly Related)
CO6: 3 (Strongly Related)
CO7: 3 (Strongly Related)

Justification: Multivariate analysis is a core aspect of statistical theory and practice, directly contributing to disciplinary knowledge in statistics. CO1, CO4, CO5, CO6, and CO7 involve various aspects of multivariate analysis, such as exploring data, performing inference procedures,

hypothesis testing, and classification, thus strongly relating to the development of disciplinary knowledge.

PO2. Critical Thinking and Problem solving

CO1: 3 (Strongly Related)
CO2: 3 (Strongly Related)
CO3: 3 (Strongly Related)
CO4: 3 (Strongly Related)
CO5: 3 (Strongly Related)
CO6: 3 (Strongly Related)
CO7: 3 (Strongly Related)

Justification: Multivariate analysis requires critical thinking and problem-solving skills to interpret results and make decisions based on complex data sets. CO1 to CO7 involve various problem-solving tasks related to multivariate analysis, including exploratory analysis, graphical representation, hypothesis testing, and classification, directly contributing to critical thinking and problem-solving abilities.

PO3. Social competence

CO1: 1 (Partially Related)
CO2: 1 (Partially Related)
CO3: 1 (Partially Related)
CO4: 1 (Partially Related)
CO5: 1 (Partially Related)
CO6: 1 (Partially Related)
CO7: 1 (Partially Related)

Justification: Multivariate analysis objectives primarily focus on technical skills and statistical methodologies, with limited direct relevance to social competence, which involves interpersonal skills and collaboration.

PO4. Research-related skills and Scientific temper

CO1: 3 (Strongly Related)
CO2: 3 (Strongly Related)
CO3: 3 (Strongly Related)
CO4: 3 (Strongly Related)
CO5: 3 (Strongly Related)
CO6: 3 (Strongly Related)
CO7: 3 (Strongly Related)

Justification: Multivariate analysis is an integral part of research in various fields, and the objectives of CO1 to CO7 directly contribute to research-related skills and scientific temper by providing tools and methodologies for analyzing complex data sets and drawing valid conclusions.

PO5. Trans-disciplinary knowledge

CO1: 2 (Moderately Related)
CO2: 2 (Moderately Related)
CO3: 2 (Moderately Related)
CO4: 2 (Moderately Related)
CO5: 2 (Moderately Related)
CO6: 2 (Moderately Related)
CO7: 2 (Moderately Related)

Justification: While multivariate analysis techniques can be applied across various disciplines, the specific focus of the objectives on statistical methodologies and data analysis limits their direct trans-disciplinary relevance.

PO6. Personal and professional competence

CO1: 3 (Strongly Related)
CO2: 3 (Strongly Related)

CO3: 3 (Strongly Related)

CO4: 3 (Strongly Related)

CO5: 3 (Strongly Related)

CO6: 3 (Strongly Related)

CO7: 3 (Strongly Related)

Justification: Mastery of multivariate analysis techniques enhances personal and professional competence by providing valuable skills for data analysis and decision-making. CO1 to CO7 contribute to this by developing expertise in various aspects of multivariate analysis.

PO7. Effective Citizenship and Ethics

CO1: 1 (Partially Related)

CO2: 1 (Partially Related)

CO3: 1 (Partially Related)

CO4: 1 (Partially Related)

CO5: 1 (Partially Related)

CO6: 1 (Partially Related)

CO7: 1 (Partially Related)

Justification: While ethical considerations may arise in the handling and interpretation of data in multivariate analysis, the technical objectives of CO1 to CO7 primarily focus on statistical methodologies and do not directly address effective citizenship and ethics.

PO8. Environment and Sustainability

CO1: 1 (Partially Related)

CO2: 1 (Partially Related)

CO3: 1 (Partially Related)

CO4: 1 (Partially Related)

CO5: 1 (Partially Related)

CO6: 1 (Partially Related)

CO7: 1 (Partially Related)

Justification: The objectives of multivariate analysis do not directly address environmental or sustainability concerns.

PO9. Self-directed and Life-long learning

CO1: 3 (Strongly Related)
CO2: 3 (Strongly Related)
CO3: 3 (Strongly Related)
CO4: 3 (Strongly Related)
CO5: 3 (Strongly Related)
CO6: 3 (Strongly Related)
CO7: 3 (Strongly Related)

Justification: Mastery of multivariate analysis requires continuous learning and adaptation to new methodologies and data sets. CO1 to CO7 provide a solid foundation for self-directed and life-long learning in the field of multivariate analysis by covering various techniques and applications.

CBCS Syllabus as per NEP 2020 for F.Y.B.Sc. Statistics (2023 Pattern)

Name of the Programme : M.Sc. Statistics

Program Code : PSST

Class : M.Sc. Part – I

Semester : II

Course Type : Major Mandatory Theory

Course Name : Regression Analysis

Course Code : STA-552-MJM

No. of Credits : 04

No. of Teaching Hours : 60

Course Objectives:

1. To provide a comprehensive understanding of the fundamental concepts of regression analysis.
2. To explain the importance of regression in statistical modeling and its applications in various fields.
3. To interpret and communicate the results of simple linear regression models.
4. Enable students to use multiple linear regression for practical problem-solving.
5. Explain the importance of residual analysis in assessing model adequacy.
6. Discuss when and how to apply these models to capture more complex relationships in data.
7. To provide an overview of Generalized Linear Models (GLM) and their significance in statistical analysis. Also explain the components of a GLM: link function, linear predictor.

Course Outcomes:

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

CO1. Gain proficiency in building regression models to analyze relationships between variables.

CO2. Apply regression analysis techniques to real-world data sets from various domains, such as economics, biology, and social sciences.

CO3. Learn techniques for evaluating the goodness-of-fit of regression models, including the use of residual analysis, R-squared, and adjusted R-squared.

CO4. Extend regression analysis to include nonlinear relationships between variables.

CO5. Apply polynomial regression and other nonlinear regression techniques.

CO6. Utilize multinomial and ordinal regression models to analyze and interpret categorical response variables.

CO7. Apply Poisson regression to model count data.

Topics and Learning Points

Unit – 1 **(15L)**

Simple linear regression, assumptions, least square (LS) estimators of parameters, standard error of estimators, testing of hypothesis for coefficient of regression, S.E. of prediction, testing of hypothesis about parallelism (slopes), equality of intercepts, generalized and weighted least squares, congruence, extrapolation, optimal choice of independent variables diagnostics checks and correction: graphical technique, tests for normality, uncorrelatedness, homoscedasticity, lack of fit, transformation on of dependent or independent variables

Unit – 2 **(15L)**

Multiple regression: Standard Gauss-Markov setup, least square estimation, error and estimation spaces, variance and covariance of LS estimators, properties of LS estimators, estimation of error variance, case with correlated observation, LS estimation with restriction on parameters, simultaneous estimation of linear parametric functions ,testing of hypothesis for one and more than one linear parametric functions, confidence interval sand regions, generalized and weighted least squares, Mallows Cp, step wise regression methods – forward, backward, stepwise.

Unit – 3 **(15L)**

Multi collinearity: consequences, detection and remedies: (Principal component regression, ridge regression), auto correlation consequences, Durbin Watson test, estimation of parameter sin auto correlation. Test for significance of simple, multiple and partial correlation coefficients. Residual and residual diagnostics, transformation of variables: Box-Cox power Transformation.

Unit – 4 **(15L)**

Polynomial regression, inverse regression, Non-linear regression: Non-linear least square stransformation to a linear model, their uses and limitations, examination of non-linearity, initial estimates, iterative procedure, and Newton- Raphson method. Generalized linear model: Link function: normal, binomial, Poisson, exponential, gamma. Logit transform, ML estimation of

Logistic regression, tests of hypothesis, Wald test, LR test, score test, test for over all regression.

References:

1. Draper, N.R .and Smith H.(1998)Applied regression analysis3rd edition(John Wiley)
2. Hosmer, D. W and Leme show, S. (1989) Applied logistic regression(John Wiley)
3. McCullagh,P.andNelder,J.A.(1989)Generalizedlinearmodels(ChapmanandHall)
4. Montogomery D. C., Elizabetha, Peck, G. Geoffrey.(2003) Introduction to linear regression analysis (Wiley Eastern)
5. Neter, J.;Wasserman,W.andKutner,M.H.(1985)Appliedlinearstatisticalmodels
6. Ratkowsky, D. A.(1983) Nonlinear regression modelling (MarcelDekker)

Programme Outcomes and Course Outcomes Mapping:

Course Outcomes	Programme Outcomes (POs)								
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	3	1	3	3	3	1	1	3
CO2	3	3	1	3	3	3	1	1	3
CO3	3	3	1	3	3	3	1	1	3
CO4	3	3	1	3	3	3	1	1	3
CO5	3	3	1	3	3	3	1	1	3
CO6	3	3	1	3	3	3	1	1	3
CO7	3	3	1	3	3	3	1	1	3

Weight: 1 - Partially related 2 - Moderately Related 3 - Strongly related

PO1. Disciplinary Knowledge

CO1: 3 (Strongly Related)

CO2: 3 (Strongly Related)

CO3: 3 (Strongly Related)

CO4: 3 (Strongly Related)

CO5: 3 (Strongly Related)

CO6: 3 (Strongly Related)

CO7: 3 (Strongly Related)

Justification: All objectives directly contribute to disciplinary knowledge in regression analysis. They cover a range of regression techniques and their applications in various domains, providing a comprehensive understanding of the subject matter.

PO2. Critical Thinking and Problem solving

CO1: 3 (Strongly Related)

CO2: 3 (Strongly Related)

CO3: 3 (Strongly Related)

CO4: 3 (Strongly Related)

CO5: 3 (Strongly Related)

CO6: 3 (Strongly Related)

CO7: 3 (Strongly Related)

Justification: Critical thinking and problem-solving skills are essential for applying regression analysis techniques effectively. Each objective involves analyzing data, interpreting results, and making decisions based on regression models, thus fostering critical thinking and problem-solving abilities.

PO3. Social competence

CO1: 1 (Partially Related)

CO2: 1 (Partially Related)

CO3: 1 (Partially Related)

CO4: 1 (Partially Related)

CO5: 1 (Partially Related)

CO6: 1 (Partially Related)

CO7: 1 (Partially Related)

Justification: While regression analysis may have social implications, such as in social sciences research, the technical skills involved in CO1 to CO7 do not directly address social competence, which involves interpersonal skills and collaboration.

PO4. Research-related skills and Scientific temper

CO1: 3 (Strongly Related)

CO2: 3 (Strongly Related)

CO3: 3 (Strongly Related)

CO4: 3 (Strongly Related)

CO5: 3 (Strongly Related)

CO6: 3 (Strongly Related)

CO7: 3 (Strongly Related)

Justification: Research-related skills and a scientific temper are integral to regression analysis, as it involves analyzing data, testing hypotheses, and drawing conclusions. CO1 to CO7 directly contribute to developing these skills by providing techniques for analyzing real-world data sets and evaluating model performance.

PO5. Trans-disciplinary knowledge

CO1: 3 (Strongly Related)

CO2: 3 (Strongly Related)

CO3: 3 (Strongly Related)

CO4: 3 (Strongly Related)

CO5: 3 (Strongly Related)

CO6: 3 (Strongly Related)

CO7: 3 (Strongly Related)

Justification: Regression analysis techniques are applicable across various disciplines, and CO1 to CO7 cover a wide range of regression methods and their applications in different domains, making them highly trans-disciplinary.

PO6. Personal and professional competence

CO1: 3 (Strongly Related)

CO2: 3 (Strongly Related)

CO3: 3 (Strongly Related)

CO4: 3 (Strongly Related)

CO5: 3 (Strongly Related)

CO6: 3 (Strongly Related)

CO7: 3 (Strongly Related)

Justification: Proficiency in regression analysis enhances personal and professional competence, particularly in fields requiring data analysis and decision-making. CO1 to CO7 provide essential skills for analyzing and interpreting data, which are valuable in various professional settings.

PO7. Effective Citizenship and Ethics

CO1: 1 (Partially Related)

CO2: 1 (Partially Related)

CO3: 1 (Partially Related)

CO4: 1 (Partially Related)

CO5: 1 (Partially Related)

CO6: 1 (Partially Related)

CO7: 1 (Partially Related)

Justification: While ethical considerations may arise in the collection and analysis of data for regression analysis, the technical skills involved in CO1 to CO7 are not inherently linked to effective citizenship and ethics.

PO8. Environment and Sustainability

CO1: 1 (Partially Related)

CO2: 1 (Partially Related)

CO3: 1 (Partially Related)

CO4: 1 (Partially Related)

CO5: 1 (Partially Related)

CO6: 1 (Partially Related)

CO7: 1 (Partially Related)

Justification: The objectives of regression analysis do not directly address environmental or

sustainability concerns.

PO9. Self-directed and Life-long learning

CO1: 3 (Strongly Related)

CO2: 3 (Strongly Related)

CO3: 3 (Strongly Related)

CO4: 3 (Strongly Related)

CO5: 3 (Strongly Related)

CO6: 3 (Strongly Related)

CO7: 3 (Strongly Related)

Justification: CO1 to CO7 equip students with skills that are essential for self-directed and life-long learning in data analysis and statistical modeling. They provide a solid foundation for continued learning and professional development in related fields.

CBCS Syllabus as per NEP 2020 for M.Sc. Part-I Statistics (2023 Pattern)

Name of the Programme	**:** M.Sc. Statistics
Program Code	**:** PSST
Class	**:** M.Sc. Part – I
Semester	**:** II
Course Type	**:** Major Mandatory Practical
Course Name	**:** Statistics Practical – III
Course Code	**:** STA-553-MJM
Credit	**:** 2 credits
No. of lectures	**:** 60

Course Objectives:

1. Students will develop a deep understanding of what multivariate data is, including the characteristics and challenges associated with analyzing data with multiple variables.
2. Students will learn techniques for exploring multivariate data, including data visualization, summary statistics, and data transformation.
3. Students will learn how to perform and interpret MANOVA, which extends the analysis of variance to multiple dependent variables.
4. Students will learn how to effectively explore and visualize multivariate data to get a sense of its complexity and characteristics.
5. Students will learn techniques for data cleaning, handling missing values, and transforming variables to make them suitable for multivariate analysis.
6. Students will learn how to apply Exploratory Multivariate Data Analysis (EMDA) techniques to real-world datasets through practical exercises and projects.
7. Students will learn knowledge about multivariate probability distributions, covariance, and correlation, and their significance in analyzing multivariate data.

Course Outcomes:

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

CO1. Understand the link between multivariate techniques and corresponding univariate

techniques.

CO2. Analyze multivariate data and the dependence structure of variates to extract the useful information from a massive dataset.

CO3. Apply suitable tools for exploratory data analysis, dimension reduction, and classification to formulate and solve real-life problems.

CO4. Analyze multivariate data using data reduction techniques like principal component analysis, factor analysis.

CO5. Explore methods for reducing the dimensionality of multivariate data while preserving important information. Techniques like Principal Component Analysis (PCA) or Factor analysis are often covered.

CO6. Gain knowledge of discriminant analysis techniques, including Linear Discriminant Analysis (LDA) and Quadratic Discriminant Analysis (QDA), for classification and dimensionality reduction.

CO7. Learning how to use discriminant analysis to classify observations into different groups based on their multivariate characteristics.

Topics and Learning Points

Sr. No.	Title of Experiments
1.	Exploratory multivariate data analysis
2.	Testing multivariate normality
3.	Model sampling from multivariate normal distribution and computation of M.L.E.'s of parameters.
4.	Principal component analysis (PCA)
5.	Factor analysis
6.	Hierarchical clustering analysis
7.	Non-Hierarchical clustering analysis
8.	Canonical correlation techniques
9.	Application of Hotelling T^2 statistics- I
10.	Application of Hotelling T^2 statistics- II
11.	Likelihood ratio tests (Multivariate Test)
12.	Discriminant analysis
13.	Multivariate analysis of variance
14.	Mini project on Multivariate data analysis (2 practicals)

Course Outcomes	Programme Outcomes(POs)								
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	-	-	-	-	-	-	-	-	2
CO2	3	-	-	-	-	-	-	2	
CO3		3	-		-	-	-	-	-
CO4	-	-	-	3	-	-	-	-	-
CO5	-	-	-	-	3	-	-	-	-
CO6	-	-	-	-	-	2	-	-	-
CO7	-	-	2	-	-	-	2	-	-

1-Weight: 1 - Partially related 2 - Moderately Related 3 - Strongly related

PO1. Disciplinary Knowledge:

CO2. 3 (Strongly related)

Justification: Strongly related as analyzing multivariate data requires a deep understanding of the discipline and its theoretical foundations.

PO2. Critical Thinking and Problem Solving:

CO3. 3 (Strongly related)

Justification: Strongly related as applying tools for data analysis requires critical thinking and problem-solving skills to address real-life problems.

PO3. Social Competence:

CO7. : 2 (Moderately Related)

Justification: Moderately related as understanding discriminant analysis enhances communication and collaboration in group settings, albeit indirectly.

PO4. Research-related Skills and Scientific Temper:

CO4. 3(Strongly related)

Justification: Strongly related as conducting research often involves analyzing multivariate data using data reduction techniques.

PO5. Trans-disciplinary Knowledge:

CO5.3 (Strongly related)

Justification: Strongly related as exploring methods for dimensionality reduction involves integrating knowledge from various disciplines to address common problems.

PO6. Personal and Professional Competence:

CO6. 2 (Moderately Related)

Justification: Moderately related as understanding discriminant analysis contributes to both independent and collaborative work, enhancing personal and professional competence.

PO7. Effective Citizenship and Ethics:

CO7. 2 (Moderately Related)

Justification: Moderately related as understanding discriminant analysis involves considerations of ethics and responsibility in data analysis and decision-making.

PO8. Environment and Sustainability:

CO2. 2 (Moderately Related)

Justification: Moderately related as understanding multivariate data analysis contributes to addressing societal and environmental issues through data-driven solutions.

PO9. Self-directed and Lifelong Learning:

CO1. 2 (Moderately Related)

Justification: Moderately related as understanding the link between different data analysis techniques enhances the ability to engage in lifelong learning in the field of data analysis.

CBCS Syllabus as per NEP 2020 for M.Sc. Part-I Statistics (2023 Pattern)

Name of the Programme : M.Sc. Statistics
Program Code : PSST
Class : M.Sc. Part – I
Semester : II
Course Type : Major Mandatory Practical
Course Name : Statistics Practical – IV
Course Code : STA-554-MJM
No. of Credits : 02
No. of Teaching Hours : 60

Course Objectives:

1. Students will learn to use numerical computing tools and programming languages, such as MATLAB, Python, or R or Minitab, to implement and solve problems.
2. Students will learn how to apply linear regression models in practice, identify situation where linear regression is appropriate, build and fit linear regression models with software also interpret estimates and diagnostic statistics, produce exploratory graphs.
3. Students will learn to predict an ordinal dependent variable given one or more independent variables.
4. Students will learn to diagnose the presence of multicollinearity in a model.
5. Students will learn Multicollinearity refers to a state wherein there exists inter-association or inter-relation between two or more independent variables.
6. Student should be able to understand when it is relevant to choose logistic regression.
7. Students should able to predict the value of the dependent variable for individuals for whom some information concerning the explanatory variables is available, or in order to estimate the effect of some explanatory variable on the dependent variable.

Course Outcomes:

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

CO1. Handle statistical software, packages such as R, Python, MATLAB, SPSS or Minitab to implement and analyze real life situations.

CO2. Understand of model selection and regression modelling techniques should be demonstrated.

CO3. Understand **e**xcellent familiarity with both linear and nonlinear regression models.
CO4. Estimate the parameters and fit a model.

CO5. Investigate possible diagnostics in regression modeling and analysis concepts.

CO6. Predict categorical placement in or the probability of category membership on a dependent variable based on multiple independent variables.

CO7. Diagnose the presence of multicollinearity in a model.

Topics and Learning Points

Sr. No.	Title of Experiments
1.	Simple regression and regression diagnostic
2.	Multiple regression and regression diagnostic
3.	Lack of fit of the regression model
4.	Multiple regression (selection of variable)
5.	Detection of multicollinearity
6.	Dealing with multicollinearity by using Principle Component Regression
7.	Dealing with multicollinearity by using Ridge Regression
8.	Polynomial regression
9.	Non-linear regression
10.	Poisson regression
11.	Logistic regression
12.	Ordinary logistic regression
13.	Multinomial logistic regression.
14.	Case Study (Two Practical's).

Course Outcomes	Programme Outcomes (POs)								
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	3	1	3	2	3	1	1	3
CO2	2	3	1	3	3	3	1	1	3
CO3	2	3	1	3	3	3	1	1	3
CO4	3	3	1	3	3	3	1	1	3
CO5	3	3	1	3	3	3	1	1	3
CO6	3	3	1	3	3	3	1	1	3
CO7	3	3	1	3	3	3	1	1	3

Weight: 1 - Partially related 2 - Moderately Related 3 - Strongly related

PO1. Disciplinary Knowledge

CO1: 3 (Strongly Related)
CO2: 2 (Moderately Related)
CO3: 2 (Moderately Related)
CO4: 3 (Strongly Related)
CO5: 3 (Strongly Related)
CO6: 3 (Strongly Related)
CO7: 3 (Strongly Related)
Justification: CO1 is strongly related to disciplinary knowledge as it directly involves the practical implementation of statistical software for real-life situations. CO2 to CO7 contribute moderately to disciplinary knowledge by covering various regression modeling techniques and diagnostics in statistical analysis.

PO2. Critical Thinking and Problem solving

All COs: 3 (Strongly Related)
Justification: CO1 to CO7 all involve critical thinking and problem-solving skills. These objectives require students to analyze data, choose appropriate models, interpret results, and diagnose issues in regression modeling, fostering critical thinking abilities.

PO3. Social competence

All COs: 1 (Partially Related)
Justification: While statistical analysis may have implications in various social contexts, the technical nature of the objectives does not directly address social competence.

PO4. Research-related skills and Scientific temper

All COs: 3 (Strongly Related)
Justification: All objectives contribute significantly to research-related skills and scientific temper by providing students with the tools and techniques necessary for conducting regression analysis and interpreting results in research settings.

PO5. Trans-disciplinary knowledge

CO1: 2 (Moderately Related)
CO2: 3 (Strongly Related)
CO3: 3 (Strongly Related)
CO4: 3 (Strongly Related)
CO5: 3 (Strongly Related)
CO6: 3 (Strongly Related)
CO7: 3 (Strongly Related)
Justification: While CO1 is moderately related to trans-disciplinary knowledge as it involves the use of statistical software, CO2 to CO7 contribute strongly to trans-disciplinary knowledge by covering various regression modeling techniques applicable across different fields.

PO6. Personal and professional competence

All COs: 3 (Strongly Related)
Justification: All objectives enhance personal and professional competence by equipping students with

practical skills and knowledge in regression modeling and analysis, which are valuable in various professional settings.

PO7. Effective Citizenship and Ethics

All COs: 1 (Partially Related)
Justification: While ethical considerations may arise in statistical analysis, the objectives do not explicitly address effective citizenship and ethics.

PO8. Environment and Sustainability

All COs:1 (Partially Related)
Justification: The objectives of the course do not directly address environmental or sustainability concerns.

PO9. Self-directed and Life-long learning

All COs: 3 (Strongly Related)
Justification: All objectives promote self-directed and life-long learning by providing students with foundational knowledge and practical skills in regression modeling and analysis, essential for continuous professional development.

CBCS Syllabus as per NEP 2020 for M.Sc. Part-I Statistics (2023 Pattern)

Name of the Programme	**:** M.Sc. Statistics
Program Code	**:** PSST
Class	**:** M.Sc. Part – I
Semester	**:** II
Course Type	**:** Major Mandatory Elective
Course Name	**:** Probability Theory
Course Code	**:** STA-561-MJE(A)
No. of Credits	**:** 04
No. of Teaching Hours	**:** 60

Course Objectives:

1. To understand the concept of random variables, sigma-fields generated by random variables
2. To acquire the knowledge of probability measure, distribution function and Expectation.
3. To become familiar with the notion of a measurable function particularly a probability measure.
4. To gain the independence of random variables related to measurable functions.
5. To understand the concept and application of laws of large numbers.
6. To forms the foundation for statistical inference.
7. To provide a framework for dealing with uncertainty and randomness

Course Outcomes:

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

CO1. understand the concepts of random variables, sigma-fields generated by random variables.

CO2. solve the problems based on probability measure, distribution function and expectation.

CO3. understand the concepts of independence of events, random variables.

CO4. understand different modes of convergences

CO5. understand interrelationships between different modes of convergences.

CO6. apply WLLN related to sequence of random variables.

CO7. apply CLT related to sequence of random variables.

Topics and Learning Points

Unit – 1 **(18L)**

Review of algebra of sets, sequence of sets, limsup, liminf and limit of a sequence of sets, Classes of sets, field, sigma field, minimal sigma field, Borel fields, measurable space, monotone classes, Measurable function, Real and Vector valued random variables, simple r.v., r.v. as a limit of sequence of simple r.v.s, Probability measure on a measurable space, probability space, properties of probability measure: continuity, mixture of probability measures, Lebesgue and Lebesgue-Steltjes measures.

Unit – 2 **(12L)**

Distribution function, decomposition of a distribution function, discrete and continuous type r.v., Correspondence theorem (without proof), Expectation of simple r.v, non-negative r.v. and arbitrary r.v., properties of expectation, moments, moment inequalities.

Unit – 3 **(15L)**

Convergence of a sequence of r.v.s, convergence in probability, convergence in distribution, convergence in rth mean, almost sure convergence, their inter-relations, Slutkey's theorem, convergence theorem for expectations, characteristic function and properties, conjugate pairs of distributions, uniqueness theorem (without proof).

Unit – 4 **(15L)**

Independence of events, class of independent events, independence of classes, independence of r.v's, expectation of the product of independent r.v.'s, equivalent definitions of independence, Kolmogorov 0-1 Law, Borel 0-1 criterion, Borel Cantelli Lemma, Khintchin's WLLN, Strong Law of Large Numbers (SLLN) (Statement only), Central Limit Theorem (CLT), Levy continuity theorem, CLT for i.i.d. r.v.s, Liaponove's form, Lindeberg Feller form and their applications.

References:

1. Bhat, B.R. (2007) Modern Probability Theory, Third Edition. New Age Inter-national

2. Billingsley, P. (1995) Probability and Measure, Wiley Publication.

3. Chung, K. L. (2001) A Course in Probability Theory, Third Edition, Academic Press, London

4. Basu, A. K. (1999) Measure Theory and Probability (Prentice Hall of India)

5. Ash, Robert. (1972) Real Analysis and Probability, (Academic Press)

6. Feller, W. (1969) Introduction to Probability and its applications Vol.II, (Wiley Easter Ltd.)

7. Gut A. (2005), Probability: A Graduate Course, Spinger-Verlag, New York.

8. Dasgupta A. (2008), Asymptotic Theory of Statistics and Probability, Spinger-Verlag, New York.

Course Outcomes	**Programme Outcomes (POs)**								
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	3	1	3	2	3	1	1	3
CO2	3	3	1	3	2	3	1	1	3
CO3	3	3	1	3	2	3	1	1	3
CO4	2	3	1	3	2	3	1	1	3
CO5	3	3	1	3	2	3	1	1	3
CO6	3	3	1	3	2	3	1	1	3
CO7	3	3	1	3	2	3	1	1	3

Weight: 1 - Partially related 2 - Moderately Related 3 - Strongly related

PO1. Disciplinary Knowledge

CO1: 3 (Strongly Related)

CO2: 3 (Strongly Related)

CO3: 3 (Strongly Related)

CO4: 2 (Moderately Related)

CO5: 3 (Strongly Related)

CO6: 3 (Strongly Related)

CO7: 3 (Strongly Related)

Justification: CO1 to CO7 directly contribute to disciplinary knowledge in probability theory and stochastic processes. They cover fundamental concepts such as random variables, probability measures, convergence modes, and important theorems like the Law of Large Numbers (WLLN) and Central Limit Theorem (CLT), which are essential for understanding probability theory.

PO2. Critical Thinking and Problem solving

All COs: 3 (Strongly Related)

Justification: Critical thinking and problem-solving skills are inherent in the study of probability theory and its applications. CO1 to CO7 require students to analyze concepts, solve problems, and apply theorems in various scenarios, fostering critical thinking and problem-solving abilities.

PO3. Social competence

All COs: 1 (Partially Related)

Justification: The objectives mainly focus on technical skills and theoretical knowledge in probability theory, with limited direct relevance to social competence.

PO4. Research-related skills and Scientific temper

All COs: 3 (Strongly Related)

Justification: The objectives directly contribute to research-related skills and scientific temper by providing students with the theoretical foundation and problem-solving skills necessary for conducting research in probability theory and stochastic processes.

PO5. Trans-disciplinary knowledge

All COs: 2 (Moderately Related)

Justification: While probability theory has applications across various disciplines, the specific focus of CO1 to CO7 on probability concepts and stochastic processes limits their direct trans-disciplinary relevance.

PO6. Personal and professional competence

All COs: 3 (Strongly Related)

Justification: The objectives enhance personal and professional competence by equipping students with essential skills and knowledge in probability theory and stochastic processes, which are valuable in various professional settings.

PO7. Effective Citizenship and Ethics

All COs: 1 (Partially Related)

Justification: The technical objectives of the course primarily focus on probability theory concepts and their applications, with limited direct relevance to effective citizenship and ethics.

PO8. Environment and Sustainability

All COs: 1 (Partially Related)

Justification: The objectives of the course do not directly address environmental or sustainability concerns.

PO9. Self-directed and Life-long learning

All COs: 3 (Strongly Related)

Justification: The objectives promote self-directed and life-long learning by equipping students with foundational knowledge and problem-solving skills in probability theory and stochastic processes, essential for continuous professional development.

CBCS Syllabus as per NEP 2020 for M.Sc. Part-I Statistics (2023 Pattern)

Name of the Programme : M.Sc. Statistics
Program Code : PSST
Class : M.Sc. Part – I
Semester : I
Course Type : Major Elective Theory
Course Name : Stochastic Processes
Course Code : STA-561-MJE(B)
No. of Credits : 4 credits
No. of Teaching Hours : 60

Course Objectives:

1. To define and describe stochastic processes, including their characteristics and key differences from deterministic processes.
2. To understand the difference between various types of stochastic processes.
3. To analyze and model discrete-time Markov chains, including calculating transition probabilities, classifying states, and predicting long-term behavior.
4. becomes proficient in using specialized statistical packages for modeling and analyzing stochastic processes.
5. gain proficiency in continuous-time processes like Poisson processes and Brownian motion, understanding their characteristics and applications.
6. apply stochastic processes to practical problems in fields such as finance, engineering, and biology, and develop the ability to select appropriate models for specific applications

Course Outcomes:

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

CO1. develop a deep understanding of what stochastic processes are, including their definitions, characteristics, and mathematical representations.

CO2. understanding stationary processes and its properties.

CO3. apply stochastic processes to various real-world problems.

CO4. develop problem-solving skills of stochastic processes problems.

CO5. explore the ethical implications of using stochastic processes in various fields.

CO6. learn statistical packages for modeling and analyzing stochastic processes.

CO7. learn about continuous-time stochastic processes, including the Poisson process,

Brownian motion, Wiener process and Renewal process.

Topics and Learning Points

Unit – 1 **(15L)**

Introduction to stochastic processes, classification of stochastic processes according to states space and time, Markov property, Markov Chains (MC), finite MC, transition probabilities, initial distribution, Chapman Kolmogorov equation, n-step transition probabilities, Transition Probability Matrix (T.P.M.), Classification of states: Communicating states, first return probability, probability of ever return Classification of states, as persistent and transient states. Decomposition of state space, closed set of states, irreducible set of states, irreducible MC, periodicity of M.C. aperiodic M.C. ergodic M. C, absorption probabilities, random walk, gambler's ruin chain with absorbing , reflecting and elastic barrier, etc. probability of ruin cases (i) adversary is infinitely rich (ii) stakes are doubled or halved ,expected gain, expected duration of the game.

Unit – 2 **(10L)**

Long-Run proportions and limiting probabilities, relation with mean recurrence time, stationary distribution.

The markovchain Package in R: Creating markovchain objects, Handling markovchain objects, Classification of states, Statistical analysis.

Unit – 3 **(15L)**

Poisson process: Postulates and properties of Poisson process, probability distribution of N(t) the number of occurrences of the event in (0,t], Poisson process and probability distribution of inter arrival time, generalizations of Poisson process: pure birth process: Yule Furry process, Birth immigration process. Birth and death process: (i) immigration-emigration process, (ii) linear growth process, (iii) linear growth with immigration, (iv) immigration death process. (v) Pure death process.

Unit - 4 **(8L)**

Branching Chain: BGW branching process, offspring distribution, mean and variance, generating

function for probability of ultimate extinction, n^{th} generation size and related recurrence relations.

Unit – 5 **(12L)**

Continuous Time Markov Chains (CTMC), Markov processes with continuous state space: Introduction to Brownian motion and its properties, Wiener process. Renewal process: renewal process in continuous time, renewal function and renewal density, renewal equation, stopping time: Wald's equation, elementary renewal theorem and its applications**.**

References:

1. Medhi J. (1982), Stochastic processes (Wiley Eastern).
2. Ross, S. (1996). Stochastic processes (John Wiley).
3. Ross, S. (2000). Introduction to probability models, 7th edition (Academic Press).
4. Hoel , P.G.,Port, S.C. ,Stone, C.J. (1972) : Introduction to stochastic processes.
5. Bhat, B.R. (2000). stochastic models: Analysis and applications (New Age International).
6. Adke, S.R., Manjunath, S.M. (1984). An introduction to finite Markov processes (WileyEastern).
7. Taylor, H N and Karlin, S. (1984). An introduction to stochastic modeling(AcademicPress).
8. Giorgio Alfredo Spedicato, Tae Seung Kang, Sai Bhargav Yalamanchi, Deepak Yadav, Ignacio Cordón, The Markov chain Package: A Package for Easily Handling Discrete Markov Chains in R.

Course Outcomes	**Programme Outcomes (POs)**								
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	3	1	3	2	3	1	1	3
CO2	3	3	1	3	2	3	1	1	3
CO3	3	3	2	3	3	3	2	1	3
CO4	3	3	1	3	2	3	1	1	3
CO5	2	3	3	3	3	3	3	1	3
CO6	2	3	2	3	2	3	2	1	3
CO7	3	3	1	3	3	3	1	1	3

Weight: 1 - Partially related 2 - Moderately Related 3 - Strongly related

PO1. Disciplinary Knowledge

CO1: 3 (Strongly Related)
CO2: 3 (Strongly Related)

CO3: 3 (Strongly Related)
CO4: 3 (Strongly Related)
CO5: 2 (Moderately Related)
CO6: 2 (Moderately Related)
CO7: 3 (Strongly Related)
Justification: CO1 to CO7 directly contribute to disciplinary knowledge in stochastic processes. They cover foundational concepts, mathematical representations, problem-solving skills, and real-world applications of stochastic processes, providing a comprehensive understanding of the discipline.

PO2. Critical Thinking and Problem solving

All COs: 3 (Strongly Related)
Justification: Critical thinking and problem-solving skills are essential in dealing with stochastic processes. CO1 to CO7 require students to analyze concepts, apply them to real-world problems, and consider ethical implications, fostering critical thinking and problem-solving abilities throughout.

PO3. Social competence

CO1: 1 (Partially Related)
CO2: 1 (Partially Related)
CO3: 2 (Moderately Related)
CO4: 1 (Partially Related)
CO5: 3 (Strongly Related)
CO6: 2 (Moderately Related)
CO7: 1 (Partially Related)
Justification: While some aspects of social competence, such as considering ethical implications (CO5), are addressed, the technical nature of stochastic processes limits direct relevance to social competence.

PO4. Research-related skills and Scientific temper

All COs: 3 (Strongly Related)
Justification: CO1 to CO7 contribute significantly to research-related skills and scientific temper by providing students with the knowledge and tools necessary for conducting research in stochastic processes, including problem-solving skills, ethical considerations, and proficiency in statistical packages.

PO5. Trans-disciplinary knowledge

CO1: 2 (Moderately Related)
CO2: 2 (Moderately Related)
CO3: 3 (Strongly Related)
CO4: 2 (Moderately Related)
CO5: 3 (Strongly Related)
CO6: 2 (Moderately Related)
CO7: 3 (Strongly Related)
Justification: While stochastic processes have applications across various fields, the focus of CO1 to CO7 is primarily on stochastic processes themselves, limiting direct trans-disciplinary relevance.

PO6. Personal and professional competence
All COs: 3 (Strongly Related)
Justification: The objectives enhance personal and professional competence by equipping students with

essential skills and knowledge in stochastic processes, which are valuable in various professional settings.

PO7. Effective Citizenship and Ethics
CO1: 1 (Partially Related)
CO2: 1 (Partially Related)
CO3: 2 (Moderately Related)
CO4: 1 (Partially Related)
CO5: 3 (Strongly Related)
CO6: 2 (Moderately Related)
CO7: 1 (Partially Related)
Justification: While ethical implications are explicitly addressed in CO5, the technical nature of stochastic processes limits direct relevance to effective citizenship and ethics.

PO8. Environment and Sustainability
All COs: 1 (Partially Related)
Justification: The objectives of the course do not directly address environmental or sustainability concerns.

PO9. Self-directed and Life-long learning
All COs: 3 (Strongly Related)
Justification: The objectives promote self-directed and life-long learning by equipping students with foundational knowledge, problem-solving skills, and ethical considerations in stochastic processes, essential for continuous professional development.