Anekant Education Society's
Tuljaram Chaturchand College of Arts, Science and Commerce, Baramati
(Autonomous)

Course Structure for M.Sc.- I Semester- II (STATISTICS)

Semester	Paper Code	Title of Paper	No. of Credits
II	STAT-4201	Probability Theory	4
	STAT-4202	Parametric Inference	4
	STAT-4203	Multivariate Analysis	4
	STAT-4204	Regression Analysis	4
	STAT-4205	Practical-III	4
	STAT-4206	Practical-IV	4

SYLLABUS (CBCS) FOR M.Sc.-I Sem.-II STATISTICS

(With effect from Academic Year 2019-2020)

Paper Code : STAT-4201

Paper : I Title of Paper : Probability Theory

Credit : 4 credits No. of lectures : 60

A) COURSE OBJECTIVES:

1. To apply learned theoretical concepts in solving problems, modeling real-world scenarios, and understanding statistical and probabilistic phenomena.
2. To develop analytical skills to critically evaluate and solve problems related to probability theory and stochastic processes.
3. To recognize the relevance and application of probability theory and stochastic processes in various fields such as finance, engineering, and sciences.

B) 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/CONTENTS:

Unit-1

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. **(18L)**

Unit 2

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. **(12L)**

Unit 3

Convergence of a sequence of r.v.s, convergence in probability, convergence in distribution, convergence in r^{th} 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) **(15L)**

Unit 4

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. **(15L)**

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.

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	1	1	1	1	3
CO2		3	1	3	1	1	1	1	3
CO3		3	1	3	1	1	1	1	3
CO4		3	1	3	1	1	1	1	3
CO5		3	1	3	1	1	1	1	3
CO6		3	1	3	1	1	1	1	3
CO7		3	1	3	1	1	1	1	3

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

PO1. Disciplinary Knowledge

CO1. Understand the concepts of random variables, sigma-fields generated by random variables. (Weightage: 3 - Strongly Related)

Justification: Understanding the concepts of random variables is fundamental to building disciplinary knowledge in probability theory.

PO2. Critical Thinking and Problem Solving

All COs (Weightage: 3 - Strongly Related)

Justification: All outcomes involve critical thinking and problem-solving skills related to probability measures, distribution functions, and expectations.

PO3. Social Competence

All COs (Weightage: 1 - Partially Related)

Justification: The outcomes are more technical and focused on probability theory, with less direct relevance to social competence.

PO4. Research-related Skills and Scientific Temper

All COs (Weightage: 3 - Strongly Related)

Justification: The outcomes align closely with research-related skills and the development of a scientific temper in the context of probability theory.

PO5. Trans-disciplinary Knowledge

All COs (Weightage: 1 - Partially Related)

Justification: The outcomes are specific to probability theory and have limited trans-disciplinary connections.

PO6. Personal and Professional Competence

All COs (Weightage: 1 - Partially Related)

Justification: The outcomes contribute more to technical competence in probability theory, with limited direct connections to personal and professional aspects.

PO7. Effective Citizenship and Ethics

All COs (Weightage: 1 - Partially Related)

Justification: The content is more technical and less directly related to effective citizenship and ethics.

PO8. Environment and Sustainability

All COs (Weightage: 1 - Partially Related)

Justification: The outcomes are more focused on probability theory and less on environmental or sustainability aspects.

PO9. Self-directed and Life-long Learning

All COs (Weightage: 3 - Strongly Related)

Justification: Probability theory is dynamic, and mastering its principles requires ongoing self-directed learning and adaptation.

SYLLABUS (CBCS) FOR M.Sc.-I Sem.-II STATISTICS

(With effect from Academic Year 2019-2020)

Paper Code : STAT-4202

Paper : II Title of Paper : Parametric Inference

Credit : 4 credits No. of lectures : 60

A) Course Objectives:

To guide students towards a comprehensive understanding of advanced statistical concepts and their practical applications in estimation, hypothesis testing, confidence intervals, and Bayesian inference.

B) Course Outcomes:

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

CO1. estimation and testing procedures to deal with real life problems.

CO2. Fisher Information matrix, Lower bounds to variance of estimators, MVUE.

CO3. prior and posterior data based modeling and analysis.

CO4. data reduction and different family of distributions

CO5. most powerful test, Neyman-Pearson fundamental lemma, UMP test, UMPU test.

CO6. Apply the factorization theorem to determine sufficient statistics and construct minimal sufficient statistics for given probability distributions, especially within the exponential family and Pitman family.

CO7. Understand UMP tests for one-sided alternatives within the Exponential class of densities and extensions to distributions having Monotone Likelihood Ratio property.

TOPICS/CONTENTS:

Unit-1

Sufficiency, Fisher's concept of sufficiency, Sufficient statistic, Factorization theorem, Joint Sufficiency, Likelihood Equivalence, Minimal Sufficiency, construction of Minimal Sufficient Statistic, Exponential family and Pitman family admitting Minimal Sufficient Statistic.

(15L)

Unit 2

Fisher information for one parameter and several parameter models, Unbiasedness, Estimable function, Best Linear Unbiased Estimator, Gauss-Markov theorem, Cramer Rao inequality and its application, Rao-Blackwell theorem, Completeness, Lehman-Scheffee theorem and its application, necessary sufficient condition of MVUE, Ancillary statistic. **(15L)**

Unit 3

Critical region and test function, Neyman Pearson lemma and Most Powerful test, Uniformly Most Powerful (UMP) test for one sided alternative for one parameter Exponential class of density and extension to the distribution having Monotone Likelihood Ratio property, statement of UMPU test. **(15L)**

Unit 4

Confidence Interval (C.I.), Shortest Expected Length C.I. Uniformly Most Accurate C.I., introduction to Bayesian estimation: Prior and Posterior distribution, Loss function, Conjugate family of Prior distribution and its example, Principal of Minimum Expected Posterior Loss.

(15L)

REFERENCES:

1. Casella G. and Beregar R.L. (2002) Statistical Inference, 2nd Edition (Duxbury Advanced Series)
2. Dudewitz E.J. & Mishra S.N.(1988) Modern Mathematical Statistics (John Wiley)
3. Kale B.K. (1999) A First course on Parametric Inference (Narosa)
4. Lehman E.L (1988) Theory of point estimation (John Wiley)
5. Lehman E.L(1986) Testing of Statistical hypotheses (John Wiley)
6. Rohatagi V.K. (1976) Introduction to theory of probability & mathematical statistics (John Wiley & sons)
7. Dasgupta A. (2008), Asymptotic Theory of Statistics and Probability, Spinger-Verlag, New York.

Programme Outcomes and Course Outcomes Mapping:

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

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

PO1. Disciplinary Knowledge

CO1. Estimation and testing procedures to deal with real-life problems. (Weightage: 3 - Strongly Related)

Justification: The application of estimation and testing procedures directly contributes to building disciplinary knowledge in statistical theory.

PO2. Critical Thinking and Problem Solving

All COs (Weightage: 3 - Strongly Related)

Justification: All outcomes involve critical thinking and problem-solving skills, especially in the context of statistical inference and testing.

PO3. Social Competence

All COs (Weightage: 1 - Partially Related)

Justification: The outcomes are more technical and focused on statistical theory, with less direct relevance to social competence.

PO4. Research-related Skills and Scientific Temper

All COs (Weightage: 3 - Strongly Related)

Justification: The outcomes align closely with research-related skills and the development of a scientific temper in the context of statistical modeling and analysis.

PO5. Trans-disciplinary Knowledge

All COs (Weightage: 1 - Partially Related)

Justification: The outcomes are specific to statistical theory and have limited trans-disciplinary connections.

PO6. Personal and Professional Competence

All COs (Weightage: 1 - Partially Related)

Justification: The outcomes contribute more to technical competence in statistical theory, with limited direct connections to personal and professional aspects.

PO7. Effective Citizenship and Ethics

All COs (Weightage: 1 - Partially Related)

Justification: The content is more technical and less directly related to effective citizenship and ethics.

PO8. Environment and Sustainability

All COs (Weightage: 1 - Partially Related)

Justification: The outcomes are more focused on statistical theory and less on environmental or sustainability aspects.

PO9. Self-directed and Life-long Learning

All COs (Weightage: 3 - Strongly Related)

Justification: Statistical theory is dynamic, and mastering its principles requires ongoing self-directed learning and adaptation.

SYLLABUS (CBCS) FOR M.Sc.-I Sem.-II STATISTICS

(With effect from Academic Year 2019-2020)

Paper Code : STAT-4203

Paper : III Title of Paper : Multivariate Analysis

Credit : 4 credits No. of lectures: 60

A) Course Objectives:

1. To apply exploratory multivariate data analysis techniques and statistical tests to analyze complex multivariate datasets.
2. To understand and perform hypothesis testing and parameter estimation in multivariate settings, especially in the context of multivariate normal distribution.
3. To interpret results from various multivariate statistical techniques and methods, and effectively communicate findings from the analysis.

B) 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

Unit-1

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. **(20L)**

Unit 2

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. **(12L)**

Unit 3

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 T^2 statistic and its distribution, its applications. Likelihood ratio test, confidence region for mean vector of multivariate normal distribution.

(15L)

Unit 4

Test for equality of dispersion matrices, discriminant analysis, Mahalanobis D^2 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). **(13L)**

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

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	1	1	1	1	3
CO2		3	1	3	1	1	1	1	3
CO3		3	1	3	1	1	1	1	3
CO4		3	1	3	1	1	1	1	3
CO5		3	1	3	1	1	1	1	3
CO6		3	1	3	1	1	1	1	3
CO7		3	1	3	1	1	1	1	3

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

PO1. Disciplinary Knowledge

CO1. Carry out an extensive exploratory multivariate analysis for a given multivariate data. (Weightage: 3 - Strongly Related)

Justification: Performing extensive exploratory multivariate analysis contributes directly to building disciplinary knowledge in multivariate statistics.

PO2. Critical Thinking and Problem Solving

All COs (Weightage: 3 - Strongly Related)

Justification: All outcomes involve critical thinking and problem-solving skills, especially in the context of multivariate data analysis.

PO3. Social Competence

All COs (Weightage: 1 - Partially Related)

Justification: The outcomes are more technical and focused on statistical analysis, with less direct relevance to social competence.

PO4. Research-related Skills and Scientific Temper

All COs (Weightage: 3 - Strongly Related)

Justification: The outcomes align closely with research-related skills and the development of a scientific temper in the context of multivariate statistical analysis.

PO5. Trans-disciplinary Knowledge

All COs (Weightage: 1 - Partially Related)

Justification: The outcomes are specific to multivariate statistics and have limited trans-disciplinary connections.

PO6. Personal and Professional Competence

All COs (Weightage: 1 - Partially Related)

Justification: The outcomes contribute more to technical competence in multivariate statistics, with limited direct connections to personal and professional aspects.

PO7. Effective Citizenship and Ethics

All COs (Weightage: 1 - Partially Related)

Justification: The content is more technical and less directly related to effective citizenship and ethics.

PO8. Environment and Sustainability

All COs (Weightage: 1 - Partially Related)

Justification: The outcomes are more focused on statistical analysis and less on environmental or sustainability aspects.

PO9. Self-directed and Life-long Learning

All COs (Weightage: 3 - Strongly Related)

Justification: Multivariate statistics is dynamic, and mastering its principles requires ongoing self-directed learning and adaptation.

SYLLABUS (CBCS) FOR M.Sc.-I Sem.-II STATISTICS

(With effect from Academic Year 2019-2020)

Paper Code : STAT-4204

Paper : IV Title of Paper : Regression Analysis

Credit : 4 credits No. of lectures : 60

A) Course Objectives:

1. To develop proficiency in handling complex multivariate datasets and applying appropriate statistical techniques for analysis.
2. To enhance analytical skills to extract meaningful information and insights from multivariate data.
3. To apply critical thinking to solve problems related to multivariate data analysis, inference, and interpretation.

B) 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/CONTENTS:

Unit-1

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, homoscadasticity, lack of fit, transformation on of dependent or independent variables. **(15L)**

Unit 2

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 intervals and regions, generalized and weighted least squares, Mallows Cp, stepwise regression methods – forward, backward, stepwise. **(15L)**

Unit 3

a) Multicollinearity: consequences, detection and remedies, autocorrelation consequences, Durbin Watson test, estimation of parameters in autocorrelation.**(4L)**

b) Multiple correlation, adjusted multiple correlation coefficient, null distribution of simple correlation and multiple correlation coefficient, partial correlation coefficient and its relation with multiple correlation coefficient, test for significance of simple, multiple and partial correlation coefficients. Residual and residual diagnostics, transformation of variables: Box-Cox power Transformation. **(11L)**

Unit 4

a) Polynomial regression, inverse regression, Non-linear regression: Non-linear least squares transformation to a linear model, their uses and limitations, examination of non-linearity, initial estimates, iterative procedure, Newton-Raphson method. **(5L)**

b) Generalized linear model: Link function: normal, binomial, Poisson, exponential, gamma. **(3L)**

c) Logistic regression: Logit transform, ML estimation, tests of hypothesis, Wald test, LR test, score test, test for overall regression. **(7L)**

REFERENCES

1. Draper, N. R. and Smith H. (1998) Applied regression analysis 3rd edition (John Wiley)
2. Hosmer, D. W. and Lemeshow, S. (1989) Applied logistic regression (John Wiley)
3. McCullagh, P. and Nelder, J. A.(1989) Generalized linear models (Chapman and Hall)
4. Montogomery D.C.,Elizabeth a. Peck, G.Geoffrey.(2003) Introduction to linear regression analysis (Wiley Eastern)
5. Neter, J.; Wasserman, W. and Kutner, M.H.(1985) Applied linear statistical models
6. Ratkowsky, D. A.(1983) Nonlinear regression modeling (Marcel Dekker)

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	1	1	1	1	3
CO2		3	1	3	1	1	1	1	3
CO3		3	1	3	1	1	1	1	3
CO4		3	1	3	1	1	1	1	3
CO5		3	1	3	1	1	1	1	3
CO6		3	1	3	1	1	1	1	3
CO7		3	1	3	1	1	1	1	3

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

PO1. Disciplinary Knowledge

CO1. Excellent familiarity with both linear and nonlinear regression models. (Weightage: 3 - Strongly Related)

Justification: Demonstrating excellent familiarity with regression models contributes directly to building disciplinary knowledge in statistical modeling.

PO2. Critical Thinking and Problem Solving

All COs (Weightage: 3 - Strongly Related)

Justification: All outcomes involve critical thinking and problem-solving skills, especially in the context of regression modeling and analysis techniques.

PO3. Social Competence

All COs (Weightage: 1 - Partially Related)

Justification: The outcomes are more technical and focused on statistical analysis, with less direct relevance to social competence.

PO4. Research-related Skills and Scientific Temper

All COs (Weightage: 3 - Strongly Related)

Justification: The outcomes align closely with research-related skills and the development of a scientific temper in the context of regression analysis.

PO5. Trans-disciplinary Knowledge

All COs (Weightage: 1 - Partially Related)

Justification: The outcomes are specific to regression modeling and have limited trans-disciplinary connections.

PO6. Personal and Professional Competence

All COs (Weightage: 1 - Partially Related)

Justification: The outcomes contribute more to technical competence in regression analysis, with limited direct connections to personal and professional aspects.

PO7. Effective Citizenship and Ethics

All COs (Weightage: 1 - Partially Related)

Justification: The content is more technical and less directly related to effective citizenship and ethics.

PO8. Environment and Sustainability

All COs (Weightage: 1 - Partially Related)

Justification: The outcomes are more focused on statistical analysis and less on environmental or sustainability aspects.

PO9. Self-directed and Life-long Learning

All COs (Weightage: 3 - Strongly Related)

Justification: Regression modeling is dynamic, and mastering its principles requires ongoing self-directed learning and adaptation.

SYLLABUS (CBCS) FOR M.Sc.-I Sem.-II STATISTICS

(With effect from Academic Year 2019-2020)

Paper Code : STAT-4205
Paper : V Title of Paper : Practical-III
Credit : 4 credits No. of lectures : 60

A) Course Objectives:

1. To develop proficiency in handling complex multivariate datasets and applying appropriate statistical techniques for analysis.
2. To enhance analytical skills to extract meaningful information and insights from multivariate data.
3. To apply critical thinking to solve problems related to multivariate data analysis, inference, and interpretation.

B) 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. Solve problems involving multivariate normal distribution evaluate.

CO3. Carry out statistical inference procedures using the data from a multivariate normaldistribution.

CO4. Apply likelihood ratio tests to perform hypothesis testing in multivariate scenarios, demonstrating understanding through practical examples.

CO5. Apply multivariate statistical methods to real-world datasets, interpreting and communicating the results effectively.

CO6. Calculate the confidence coefficient associated with a given confidence interval and interpret its meaning in the context of statistical estimation.

CO7. Develop skills in using statistical software/tools to perform computations and analyses related to likelihood ratio tests, discriminant analysis, MANOVA, power calculations, and confidence intervals.

Sr. No.	Title of Experiments
1.	Exploratory multivariate data analysis
2.	Principal component analysis
3.	Factor Analysis
4.	Canonical correlation analysis
5.	Cluster Analysis
6.	Visualizations in multivariate data
7.	Model sampling from multivariate normal distribution and computation of M.L.E.'s of parameters
8.	Model sampling from Wishart distribution.
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.	Computation of power of the test and level of significance
15	Computation of confidence coefficient for given confidence interval

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		1	1	1	3
CO2		3	1	3		1	1	1	3
CO3		3	1	3	2	1	1	1	3
CO4		3	1	3		1	1	1	3
CO5		3	1	3		1	1	1	3
CO6		3	1	3		1	1	1	3
CO7		3	1	3		1	1	1	3

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

PO1. Disciplinary Knowledge

CO1. Understand the link between multivariate techniques and corresponding univariate techniques. (Weightage: 3 - Strongly Related)

Justification: Understanding the link between multivariate and univariate techniques is fundamental to disciplinary knowledge in statistics.

PO2. Critical Thinking and Problem Solving

All COs (Weightage: 3 - Strongly Related)

Justification: All outcomes involve critical thinking and problem-solving skills, especially in the context of analyzing and interpreting multivariate data.

PO3. Social Competence

All COs (Weightage: 1 - Partially Related)

Justification: The outcomes are more technical and focused on statistical analysis, with less direct relevance to social competence.

PO4. Research-related Skills and Scientific Temper

All COs (Weightage: 3 - Strongly Related)

Justification: The outcomes align closely with research-related skills and the development of a scientific temper in the context of multivariate statistical analysis.

PO5. Trans-disciplinary Knowledge

CO3. Apply suitable tools for exploratory data analysis, dimension reduction, and classification to formulate and solve real-life problems. (Weightage: 2 - Moderately Related)

Justification: The application of tools for real-life problem-solving introduces a moderate level of trans-disciplinary knowledge.

PO6. Personal and Professional Competence

All COs (Weightage: 1 - Partially Related)

Justification: The outcomes contribute more to technical competence in multivariate statistical analysis, with limited direct connections to personal and professional aspects.

PO7. Effective Citizenship and Ethics

All COs (Weightage: 1 - Partially Related)

Justification: The content is more technical and less directly related to effective citizenship and ethics.

PO8. Environment and Sustainability

All COs (Weightage: 1 - Partially Related)

Justification: The outcomes are more focused on statistical analysis and less on environmental or sustainability aspects.

PO9. Self-directed and Life-long Learning

All COs (Weightage: 3 - Strongly Related)

Justification: Multivariate statistical analysis is dynamic, and mastering its principles requires ongoing self-directed learning and adaptation.

SYLLABUS (CBCS) FOR M.Sc.-I Sem.-II STATISTICS

(With effect from Academic Year 2019-2020)

Paper Code : STAT-4206

Paper : VI Title of Paper : Practical-IV

Credit : 4 credits No. of lectures : 60

A) Course Objectives:

To provide hands-on experience and practical applications for understanding and applying statistical techniques, regression analysis, and principles of probability and inference.

B) Course Outcomes:

CO1. Apply regression analysis techniques to real-world data sets from various domains, such as economics, biology, and social sciences.

CO2. Extend regression analysis to include nonlinear relationships between variables.

CO3. Apply polynomial regression and other nonlinear regression techniques.

CO4. Utilize multinomial and ordinal regression models to analyze and interpret categorical response variables.

CO5. Apply the Central Limit Theorem to demonstrate how the distribution of sample means or sums approximates a normal distribution regardless of the underlying distribution.

CO6. Apply modes of convergence in analyzing and interpreting convergence properties of sequences of random variables or functions.

CO7. Develop analytical skills to understand and apply mathematical and statistical concepts related to convergence, laws of large numbers, hypothesis testing, etc.

Sr. No.	Title of Experiments
1.	Simple regression and regression diagnostic I
2.	Multiple regression
3.	Lack of fit of the regression model
4.	Multiple regression (selection of variable)

5.	Multicollinearity and diagnosis I
6.	Multicollinearity and diagnosis II
7.	Polynomial regression
8.	Nonlinear regression
9.	Generalized Linear Model
10.	Logistic regression
11.	Modes of convergence
12.	Application and verification of Weak Law of Large Number
13.	Application and verification of Central Limit Theorem
14.	Comparison of lengths of CI
15	MP test and UMP test

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		1	1	1	3
CO2		3	1	3		1	1	1	3
CO3		3	1	3		1	1	1	3
CO4		3	1	3		1	1	1	3
CO5		3	1	3		1	1	1	3
CO6		3	1	3		1	1	1	3
CO7		3	1	3	2	1	1	1	3

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

PO1. Disciplinary Knowledge

CO1. Excellent familiarity with both linear and nonlinear regression models. (Weightage: 3 - Strongly Related)

Justification: Demonstrating excellent familiarity with regression models directly contributes to disciplinary knowledge in statistics and data analysis.

PO2. Critical Thinking and Problem Solving

All COs (Weightage: 3 - Strongly Related)

Justification: All outcomes involve critical thinking and problem-solving skills, especially in the context of regression modeling and analysis.

PO3. Social Competence

All COs (Weightage: 1 - Partially Related)

Justification: The outcomes are more technical and focused on statistical analysis, with less direct relevance to social competence.

PO4. Research-related Skills and Scientific Temper

All COs (Weightage: 3 - Strongly Related)

Justification: The outcomes align closely with research-related skills and the development of a scientific temper in the context of regression analysis.

PO5. Trans-disciplinary Knowledge

CO7. Utilize multinomial and ordinal regression models to analyze and interpret categorical response variables. (Weightage: 2 - Moderately Related)

Justification: Utilizing regression models for categorical response variables introduces a moderate level of trans-disciplinary knowledge.

PO6. Personal and Professional Competence

All COs (Weightage: 1 - Partially Related)

Justification: The outcomes contribute more to technical competence in regression analysis, with limited direct connections to personal and professional aspects.

PO7. Effective Citizenship and Ethics

All COs (Weightage: 1 - Partially Related)

Justification: The content is more technical and less directly related to effective citizenship and ethics.

PO8. Environment and Sustainability

All COs (Weightage: 1 - Partially Related)

Justification: The outcomes are more focused on statistical analysis and less on environmental or sustainability aspects.

PO9. Self-directed and Life-long Learning

All COs (Weightage: 3 - Strongly Related)

Justification: Mastering regression analysis and modeling requires ongoing self-directed learning and adaptation, aligning well with the lifelong learning goal.