Progressive Education Society's

Modern College of Arts, Science and Commerce,

Shivajinagar, Pune 5

(An Autonomous College Affiliated to Savitribai Phule Pune University)

Framework of Syllabus

For M. Sc. Statistics

(2019-20 Course)

(with effect from 2019-20)

CIA: Continuous Internal Evaluation

Semester 1 (Part 1)

Course Type	Course Code	Course / Paper Title	Hours / Week	Credit	CIA	End Sem Exam	Total
CCT-1	19ScStaP101	Basics of Real Analysis and Calculus	4	4	50	50	100
CCT-2	19ScStaP102	Linear algebra and Numerical methods	4	4	50	50	100
CCT-3	19ScStaP103	Probability Distributions	4	4	50	50	100
CCT-4	19ScStaP104	Sampling Theory	4	4	50	50	100
CCT-5	19ScStaP105	Practical I	4	4	50	50	100
AECCT-1	19CpCysP101	Cyber Security-I	1	1	-	-	25
AECCT-2	19CpHrtP102	Human Rights-I	1	1	-	-	25
	Total			**22**			

Semester II (Part 1)

Course Type	Course Code	Course / Paper Title	Hours / Week	Credit	CIA	End Sem Exam	Total
CCT-6	19ScStaP201	Probability Theory	4	4	50	50	100
CCT-7	19ScStaP202	Regression Analysis	4	4	50	50	100
CCT-8	19ScStaP203	Statistical Inference I	4	4	50	50	100
CCT-9	19ScStaP204	Multivariate Analysis	4	4	50	50	100
CCT-10	19ScStaP205	Practical II	4	4	50	50	100
AECCT-3	19CpCysP201	Cyber Security-II	1	1	-	-	25
AECCT-4	19CpHrtP202	Human Rights-II	1	1	-	-	25
	Total			**22**			

Progressive Education Society's

Modern College of Arts, Science and Commerce (Autonomous), Shivajinagar, Pune – 5

First Year of B. Sc. Physics (2019 Course)

Course Code: 19ScStaP101

Course Name: Basics of Real Analysis and Calculus

Teaching Scheme: TH: 3 Lectures /Week **Credit: 02**

Examination Scheme: CIA: 50 Marks **End-Sem: 50 Marks**

Prerequisite Courses:

- Basics of Mathematical analysis.
- Basics of Calculus

Course Objectives:

- To understand the basic concepts of Real analysis and Calculus
- To solve the mathematical problems

Course Outcomes:

- Students are enabled to solve problems of real analysis and calculus.

Course Contents:

Chapter 1		10 lectures
	1.1 Review of Set theory, Set of real numbers , Supremum and infimum of sets of real numbers, real field, odered set and field, Archimedean principal, countable and uncountable sets, countability of rational numbers, uncountability of real numbers. 1.2 Metric space, Properties of metric space Neighborhood points, Exterior and interior points , boundary points , limit points, open , closed and compact sets. Bolzano – Weierstrass and heine- Borel theorem.	
Chapter 2		15 lectures
	2.1 Sequence of real numbers, limit of sequence and its properties, Convergence and divergence of sequence Cauchy sequence and related theorems (Cauchy criteria of convergence), subsequence and their convergence and divergence, convergence of bounded monotone sequence. 2.2 Series of real numbers, convergence and divergence of series of real numbers, test for convergence (root test, ratio test) , absolute convergence (without proof), uniform convergence, power series , radius of convergence of power series (Binomial , Exponential, geometric and log series), term by term differentiation (integration) of absolute convergent series, change of order of summation of series.	

Chapter 3		15lectures
	3.1 Revision: derivative of function of single variable, Mean value theorem, Taylor's series expansion 3.2 Multivariate calculus: explicit and implicit functions, continuity, partial derivatives, differentiability, partial derivatives of higher order, Hessian matrix, Taylor's theorem, extreme values, differentiation with respect to vector and matrix, jacobian of transformation.	
Chapter 4		19 lectures
	4.1 Riemann and Riemann – Stieltjes integral**:** Partition of interval, norm of partition, finer partion, tagged partion, Upper and Lower Riemann and R-S sums, order relation between Upper and Lower Riemann sums. Effect of finer partition on the difference between Upper and Lower Riemann sums. Necessary and sufficient condition for a function to be R and R-S integrable Properties with proof (i) Continuous bounded function is R and R-S integrable (ii) Monotonic bounded function is R and R-S integrable (iii) Fundamental theorem of integral calculus. 4.2 Improper integrals: Definition, convergence of an integral, P-integral , exponential integral test for convergence (comparison test), convergence of beta and gamma integrals, relationship between beta and gamma functions 4.3 Double integrals: Definition, properties, change of order, iterated integrals, Fubini's theorem, differentiation under integral sign (Leibnitz rule) and transformation of variables. (20L)	
Chapter 5	Experiential Learning	1 lecture

Reference Books

1. Ajitkumar and S. Kumaresan (2014), A Basic Course in Real Analysis (Chapman and Hall)

2. Rudin W. (1985), Principles of Mathematical Analysis (McGraw–Hill)

3. Apostol T. M. (1975) Mathematical Analysis: A Modern Approach to Advanced Calculus (Addison - Wesley)

4. Bartle R. G. (1976), Elements of Real Analysis (Wiley)

5. Malik S. C. &Arora S. (1991), Mathematical Analysis (Wiley Eastern Limited 2nd edition)

6. Goldberg R. R. (1964), Methods of Real Analysis- Blasdell Publishing company, New York, U.S.A.

7. Bartle G.R. &Sherbert D. R. (2000), Introduction to Real Analysis- John Wiley & Son Inc.

8. Royden (1988), Principles of Real Analysis (Macmillian)

9. S R Ghorpade and B V Limaye(2000), A Course in Calculus and Real Analysis, Springer

10. S R Ghorpade and B V Limaye(2009), A Course in Multivariate Calculus and Analysis, Springer

Progressive Education Society's

Modern College of Arts, Science and Commerce (Autonomous), Shivajinagar, Pune – 5

First Year of B. Sc. Physics (2019 Course)

Course Code: 19ScStaP102

Course Name: Linear Algebra and Numerical Methods

Teaching Scheme: TH: 3 Lectures /Week **Credit: 02**

Examination Scheme: CIA: 50 Marks **End-Sem: 50 Marks**

Prerequisite Courses:

- Basics of Matrix Algebra
- Basics of vector analysis**.**

Course Objectives:

- To understand the concepts and applications of matrix algebra and Numerical methods.

Course Outcomes:

- Student is able to solve the problems on matrices.
- Student is able to use iterative methods.

Course Contents

Chapter 1		15 lectures
	1.1 Vector Space, Subspace, Linear dependence and independence, Basis of a vector space, dimension of vector space, orthogonal and orthonormal basis, Gram –Schmidt orthogonalization, 1.2 Matrix algebra, special types of matrices, rank, inverse and determinant of a matrix and their properties, Orthogonal and idempotent matrix and their properties, Projection theorem, linear transformation, linear equations Solution space and null Space.	
Chapter 2		12 lectures
	2.1 Generalized (g) inverse and Moore-Penrose g- inverse (MP g-inverse), its properties and examples. 2.2 System of homogeneous and non- homogeneous linear equations, solution space and null Space.	
Chapter 3		15 lectures
	3.1 Characteristic roots (eigen values) of real matrices, right and left characteristics vectors (eigen vectors), Independence of characteristics vectors corresponding to distinct Characteristic roots, Algebraic and geometric multiplicity 3.2 Spectral decomposition, power of a matrix, Cayley-Hamilton theorem, singular value decomposition	

Chapter 4		12 lectures
	4.1 Introduction of quadratic forms, reduction and classification of a quadratic form, simultaneous reduction of two quadratic forms, Maxima and minima of a quadratic form 4.2 Properties of a quadratic form for orthogonal and idempotent matrices.	
Chapter 5		5 lectures
	5.1 Newton Raphson iterative method for two or more simultaneous transcendental equations, Newton's bivariate interpolation formula 5.2 Simson's, Trapezoidal rule for bivariate integrals	
Chapter 6	Experiential Learning	1 lecture

Reference Books

1. Bapat, R.B. (2011). Linear Algebra and Linear Models.Springer and Hindustan Book Agency.

2. Beezer, R. A. (2004). A First Course in Linear Algebra, Congruent Press, Washigton

3. Hohn, F. E. (1973). Elements of Matrix Algebra, Macmillan

4. Kollo, T. and Rosen, D. von (2005). Advanced Multivariate Statistics withMatrices, Springer, New York.

5. Kumaresan, S. (2000). Linear Algebra: A Geometric Approach, Prentice Hall

6. Lay, D. C. Lay, S. R. and Mc Donald, J. J. (2016) .Linear Algebra and Its Applications, Fifth Edition, Pearson, Boston.

7. RamachandraRao, A. and Bhimasankaram, P. (2000). Linear Algebra.Hindustan Book Agency

8. Rao, C. R. (1995). Linear Statistical Inference and Its Applications, Wiley

9. Searle, S. R. (1982). Matrix Algebra Useful for Statistics, John Wiley, New York

10. Sastri (2009 , fourth edition) Prentice Hall : Introductory methods of Numerical Analysis.

11. Rajaraman (1993): Prentice Hall , Computer oriented Numerical Methods.

Progressive Education Society's

Modern College of Arts, Science and Commerce (Autonomous), Shivajinagar, Pune – 5

First Year of B. Sc. Physics (2019 Course)

Course Code: 19ScStaP103

Course Name: Probability Distrubutions

Teaching Scheme: TH: 3 Lectures /Week **Credit: 02**

Examination Scheme: CIA: 50 Marks **End-Sem: 50 Marks**

Prerequisite Courses:

- Basic probability distributions and related theory

Course Objectives:

- To introduce students to various univariate, bivariate and multivariate distributions and related theoretical results.

Course Outcomes:

- Students can derive theoretical results of various probability distributions which is a prerequisite for inference course.

Course Contents

Chapter 1		15 lectures
	1.1 Random Variables: Axiomatic definition of probability, elementary properties of probability measures, Continuity of probability measure (without proof), Borel field and random variables, probability distributions and probability distribution functions (p.d.f.) of random variables. (4L) **1.2 Distribution function:** Properties of p.d.f. Discrete, continuous and mixture type p.d.f. Standard distribution functions. Decomposition theorem. Construction of new distributions from the given p.d.f. - products and powers of distribution functions, truncated distributions. Symmetric p.d.f. and its properties. Probability mass function (p.m.f.) and density function and relation to distribution functions. **1.3 Expectations and Moments of Random Variables:** Expectation of a random variable. Moments and moment inequalities. Moment Problem. **1.4 Generating functions**-Probability generating function (p.g.f.) and its properties, PGF of compound distribution. Moment generating function (M.G.F.)Characteristic function and properties, conjugate pairs of distributions, Parseval relation, uniqueness theorem	
Chapter 2		15 lectures

	2.1 Random vectors: Bivariate and multivariate probability distributions and their characteristic properties. Joint, marginal and conditional distributions. Independent random variables.(4L) **2.2 Regression:** Mixed moments, covariance matrix, conditional mean and variance. Conditional expectation as a regression function. Best linear regression. Multiple and partial correlations. M.G.F. of a random vector. **2.3 Standard multivariate distributions:** Compound distributions and Wald's Identity. Multivariate normal and its properties. Multinomial Distribution. Bivariate Poisson distribution .Dirichlet distribution and its properties.	
Chapter 3		15 lectures
	3.1 Bivariate exponential distributions: Decomposition theorem of Bivariate distributions. Marshal-Olkin, Freund, Moran, and Gumbel Bivariate exponential distributions and their properties. **3.2 Transformations of random variables:** Functions of univariate random variables and their distributions. Quantile functions (probability integral transformation) and their properties, relationship with uniform distribution. **3.3 Transformations of random vectors:** Distribution of sums of random variables and convolutions, Order statistics and related distributions. Distribution of spacings.	
Chapter 4		15 lectures
	4.1 Quadratic forms: Quadratic forms and their classification and related distributions. Fisher-Cochran theorem. **4.2 Non-central distributions:** Chi-square, t and F distributions and their properties. **4.3 Distribution free statistics:** Some distribution free statistics and their distributions.	
Chapter 5	Experiential Learning	1 lecture

Reference Books

1. Berger, R. and Casella G. (2002). Statistical Inference, Duxbury Resource Center, Second Edition.

2. Dasgupta, A. (2010) Fundamentals of Probability: A First Course, Springer, NewYork.

3. Hogg, R. V. , McKean, J. W. and Craig, T. T. (2005). Introduction to Mathematical Statistics, Sixth Edition, Pearson Prentice Hall, New Jersey.

4. Rao, C. R. (2002). Linear Statistical Inference and Its Applications, Wiley

5. Rohatgi, V. K. & A. K. M. E Saleh (2001). Introduction to Probability and Statistics, Wiley,New York.

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Modern College of Arts, Science and Commerce (Autonomous), Shivajinagar, Pune – 5

First Year of B. Sc. Physics (2019 Course)

Course Code: 19ScStaP104

Course Name: Sampling Theory

Teaching Scheme: TH: 3 Lectures /Week **Credit: 02**

Examination Scheme: CIA: 50 Marks **End-Sem: 50 Marks**

Prerequisite Courses:

- Basic statistical methods.

Course Objectives:

- To acquaint students with various sampling techniques.

Course Outcomes:

- Student can apply various sampling techniques.

Course Contents

Chapter 1		15 lectures
	1.1 Review of finite population sampling techniques (random and non-random), SRSWR and SRSWOR: Inclusion probabilities, related results on estimation of population total 1.2 Determination of sample size for pre-specified variance, pre-specified error in the estimation, pre-specified width of the confidence interval, pre-specified relative error in the estimation, Simple random sampling for the proportion**,** Estimation of proportion for the more than two classes**,** Inverse Sampling (Sampling for the rare attribute) and estimator of the population mean and its variance**.** 1.3 Probability Proportional to Size with Replacement (PPSWR) methods, cumulative total method and Lahiri's method for estimation problem, estimation of finite population mean and total. Sampling with varying probability without replacement, Ordered and Unordered estimates**,** Horwitz–Thompson estimator, its variance and properties, midzuno scheme of sampling, Yates-Grundy sampling estimate, Murthy's estimate.	
Chapter 2		15 lectures

	2.1 Stratified sampling, comparison of allocation problem of allocation in stratified sampling, construction of strata, deep stratification, The method of Collapsed strata, post stratification, estimator of population mean and variance of estimator of population mean under post stratification, Stratified random sampling for the proportion, comparison of stratified random sampling with simple random sampling. 2.2 Use of supplementary information for estimation, ratio estimator of population mean, its bias and mean square error, unbiased ratio type estimators of population mean, variance of estimator of population mean under it, , ratio estimator for the stratified random Sampling**,** regression method of estimation, estimator of population mean, its bias and mean square error of the Estimator, comparison of estimator of population mean under ratio, regression and simple random sampling, 2.3 Jack-Knife and bootstrap method of estimation, estimate of bias and standard error	1
Chapter 3		15 lectures
	3.1 Systematic sampling, sample mean and its variance, Comparison of systematic sampling under linear trend, Yates corrected estimator, Centered systematic sampling, Balanced systematic sampling and Modified systematic sampling, circular systematic sampling, two dimensional systematic sampling (Aligned and Unaligned Systematic sampling), comparison of systematic sampling with random sampling and stratified sampling, PPS systematic sampling. 3.2 Cluster sampling with clusters of equal sizes, estimation of populationmean and itsstandarderror, Relative efficiency of cluster sampling w.r.t. SRSWOR, Effect of cluster size on relative efficiency, unbiased estimator of relative efficiency, cluster sampling as a one way ANOVA, Optimum value of the cluster size, cluster sampling for the proportion, Cluster sampling with cluster of unequal sizes ,bias in estimator of population mean , bias in the estimator and its MSE, unbiased estimator and relative efficiency of unequal cluster sampling, PPS cluster sampling, estimation of population mean.	
Chapter 4		14 lectures
	4.1 Two stage sampling with equal and unequal second stage units, estimation of population mean and its standard error, optimum value of the number of clusters and second stage units in the two stage sampling having equal second stage units. 4.2 Two phase sampling, ratio and regression estimator of population mean under two phase sampling, bias in the	

	estimator and its MSE, 4.3 Sampling and non– sampling errors, response errors, mathematical model for Response errors, Hansen Hurwitz technique, Randomized Response Technique (RRT), Warner's randomized response technique.	
Chapter 5	Experiential Learning	1 lecture

Reference Books

1. Arnab, R. (2017). Survey Sampling: Theory & Applications, Academic Press

2. Chaudhuri, A. (2014). Modern Survey Sampling, CRC Press
3. Cochran, W.G. (1984). Sampling Techniques,Wiley.
4. Des Raj and Chandhok, P. (1998). Sample Survey Theory, Narosa.
5. Murthy M.N.(1977) Sampling theory and methods (Statistical PublishingSociety)
6. S. Sampath (2005) Sampling theory and methods (Narosa)
7. Singh, D. and Chaudhary F.S (1986).Theory and Analysis of Sample Survey Designs, Wiley Eastern Limited.
8. Singh, S. (2003). Advance Sampling Theory and Applications (Volume I and II), Kluwer Academic Publishers.
9. Sukhatme, P.V, Suktatme, B.V., Sukhatme, S. and Asok, C. (1984).Sampling Theory of Surveys with Applications, Indian Society for Agricultural Statistics, New Delhi.
10. Thompson, S. K. (2012). Samplig, 3rdEdn., Wiley
11. Parimal Mukhopadhyay: New Central Book Agency: Sampling Theory

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Modern College of Arts, Science and Commerce (Autonomous), Shivajinagar, Pune – 5

First Year of B. Sc. Physics (2019 Course)

Course Code: 19ScStaP105

Course Name: Practical - I

Teaching Scheme: TH: 3 Lectures /Week **Credit: 02**

Examination Scheme: CIA: 50 Marks **End-Sem: 50 Marks**

Prerequisite Courses

- Knowledge of MS-Office, C language, R software
- Basic concepts of linear algebra, sampling theory, probability distributions and numerical analysis

Course Objectives

- To acquaint students with data analysis techniques with the help of software

Course Outcomes

- Students can solve problems from sampling theory, probability distributions, linear algebra etc. using statistical software.

Course Contents

Title and Content	Number of Practicals
1. Introduction to Statistical Software: Classification, tabulation and frequency tables (univariate and bivariate data). • Graphical representation of data. • Summary statistics. • Scatter diagram, correlation, Regression.	1
2. Matrices: Properties of Matrices (rank, inverse, transpose, determinant etc), Getting vectors in row/column space and null space of the given matrix.	1
3. Definiteness of Matrix, eigen values and eigen vectors of a matrix, algebraic and geometric multiplicity of an eigen value, etc. Computing power of a given matrix using spectral decomposition.	1
4. Inverse of a square matrix (by direct method and partitioning method), g-	1

inverse, MP g-inverse. 5. Gram-Schmidt orthonormalization: Forming an orthogonal matrix of specified order using Gram-Schmidt orthogonalization.	1
6. Solution of System of Linear Equations using Gauss elimination, Gauss Jorden, Gauss Seidal and Gauss Jacobbi methods.	2
7. Classification and Reduction of Quadratic forms, Verification of Cayley-Hamilton theorem	1
8. Model sampling from discrete, continuous and mixture distribution (Use inversion method if necessary).	1
9. Model sampling from bivariate probability distribution. Computation of probability of events related to bivariate probability distribution	1
10. Computation of probability of non-central χ^2, t, F-distributions.	1
11. H-T estimator and PPS, π PS (Midzuno) designs. Confidences Interval of estimator	2
12. Stratified Random Sampling • Various kinds of allocation and estimation of population total and mean with S.E. • Post stratification.	1
13. Stratified Random Sampling: • Ratio method of estimation • Regression method of estimation	1
14. Circular Systematic Sampling	1
15. Cluster Sampling with equal and unequal cluster size	1
16. Jackknife and bootstrap methods of estimation (for Ratio, Regression coefficient, Coefficient of variation, Correlation coefficient)	1
17. Two stage sampling	1
18. Numerical methods: (i) Solution to Simultaneous Bivariate equations by Newton Raphson method (ii) Newton's Interrpolation for bivariate functions (iii) Evalution of double integral by Trapezoidal rule and Simpson"s rule	1

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Modern College of Arts, Science and Commerce (Autonomous), Shivajinagar, Pune – 5

First Year of B. Sc. Physics (2019 Course)

Course Code: 19ScStaP201

Course Name: Probability Theory

Teaching Scheme: TH: 3 Lectures /Week **Credit: 02**

Examination Scheme: CIA: 50 Marks **End-Sem: 50 Marks**

Prerequisite Courses:

- Basic concepts of probability
- Basics of Real analysis and Calculus.

Course Objectives:

- To understand the Basics of Probability theory.

Course Outcomes:

- Student is able to solve the problems of probability theory and Convergence of random variables.

Course Contents

Chapter 1		15 lectures
	1.1 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 **1.2** Real and Vector valued random variables, simple random variable, random variable as a limit of sequence of simple random variables. **1.3** Probability measure on a measurable space, probability space, properties of probability measure: continuity, mixture of probability measures, Lebesgue and Lebesgue-Steltjes measures.	
Chapter 2		15 lectures
	2.1 Distribution function, decomposition of a distribution function, discrete and continuous type random variable, Correspondence theorem, 2.2 Expectation of simple random variable, non-negative random variable, arbitrary random variable, properties of expectation, moments, moment inequalities.	
Chapter 3		15 lectures
	3.1 Convergence of a sequence of random variables, convergence	

	in probability, convergence in distribution, convergence in rth mean, almost sure convergence, their inter-relations, Slutkey's Theorem, convergence theorem for expectations**.**	
Chapter 4		14 lectures
	4.1 Independence of events, class of independent events, independence of classes, independence of random variables, expectation of the product of independent random variables, equivalent definitions of independence, 4.2 Kolmogorov 0-1 Law, Borel 0-1 criterion, Khintchin's WLLN, Strong Law of Large Numbers (SLLN) (Statement only), Central Limit Theorem (CLT), Levy continuity theorem, CLT for i.i.d. random variables, Liaponove's form, Lindeberg Feller form and their applications.	
Chapter 5	Experiential Learning	1 lecture

Reference Books

1. Athreya, K. B. and Lahiri S. (2006). Probability Theory, Hindustan Book Agency,

2. Bhat, B. R. (2007). Modern Probability Theory: An Introductory Text Book, New Age International

3. Billingsley, P. (1995). Probability and Measure, 3rdEdition, John Wiley, New York

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

5. Gut, Allan (2005), Probability: A Graduate Course. Springer, New

Progressive Education Society's

Modern College of Arts, Science and Commerce (Autonomous), Shivajinagar, Pune – 5

First Year of B. Sc. Physics (2019 Course)

Course Code: 19ScStaP202

Course Name: Regression Analysis

Teaching Scheme: TH: 3 Lectures /Week **Credit: 02**

Examination Scheme: CIA: 50 Marks **End-Sem: 50 Marks**

Prerequisite Courses

- Matrix algebra
- Multivariate normal distribution results

Course Objectives

- A student should be able to handle multivariate data
- A student should be able to predict response variable based on regressors**.**

Course Outcomes

- A student is enabled to do multivariate data analysis.

Course Contents

Chapter 1		15 lectures
	1.1 Brief review of simple linear regression assumptions, least square (LS) estimators of parameters, standard error of estimators, testing of hypothesis for coefficient of regression 1.2Multiple regression Standard Gauss-Markov (GM) setup, least square (LS) estimation with and without restrictions on parameters, variance and covariance of LS estimators, GM theorem (statement and proof for $Var(\varepsilon) = \sigma^2 I$ and $Var(\varepsilon) = \sigma^2 V$), estimation of error variance (with and without correlated observations)	
Chapter 2		15 lectures
	2.1 Confidence intervals and regions, testing of hypothesis for one and more than one linear parametric functions, testing of hypotheses about parallelism (slopes), equality of intercepts, congruence of two simple regression models, lack of fit test 2.2 Polynomial regression model (one and two repressors), orthogonal polynomial regression, cubic spline regression model	
Chapter 3		15 lectures

	3.1 Diagnostic checks and correction graphical techniques, tests for normality (Shapiro test, Anderson-Darling test), uncorrelatedness, homoscadasticity; Criteria for model adequacy R^2, adjusted R^2, Mallow's Cp etc. 3.2 Durbin Watson test, estimation of parameters in autocorrelation 3.3 Outlier, leverage points, influential points, PRESS statistic, Cook's D statistic 3.4 Multicollinearity consequences, tools for detection and remedies, Ridge Regression.	
Chapter 4		14lectures
	3.1 Non-linear regression linearization transforms, their uses and limitations. Box and Cox transformations . 3.2 Generalized linear model introduction to link functions suchas binomial, inverse binomial, inverse Gaussian and Gamma. 3.3 Logistic regression logit transform, ML estimation, tests of hypothesis, Wald test, LR test, score test, test for overall regression 3.4 Poisson regression log link transform, ML estimation, tests of hypothesis, Wald test, LR test, score test, test for overall regression.	
Chapter 5	Experiential Learning	1 lecture

Reference Books

1. Cameron, A. C. and P. K. Trivedi (1998). Regression Analysis of Count Data, Cambridge
2. Draper, N. R. and Smith, H. (1998). Applied Regression Analysis, John Wiley, Third Edition.
3. Hosmer, D. W. and Lemeshow, S. (1989). Applied Logistic Regression, Wiley.
4. Kleinbaum, D. G. & Klein, M. (2002). Logistic Regression A Self-Learning Text, Springer
5. McCullagh, P. and Nelder, J. A. (1989). Generalized Linear Models, Chapman& Hall.
6. Montgomery, D. C., Peck, E. A. and Vining, G. G. (2003). Introduction to Linear Regression Analysis, Wiley.
7. Neter, J., W., and Kutner, M. H. (1985). Applied Linear Statistical Models, Wiley.
8. Ratkowsky, D. A. (1983). Nonlinear Regression Modelling, Marcel Dekker, London.
9. Ruppert, D., Wand, M. P. and Carroll, R. J. (2003) Semiparametric Regression, Cambridge University Press.
10. Seber, G. E. F. and Wild, C. J. (1989). Nonlinear Regression, Wiley.
11. Weisberg, S. (2005). Applied Liner Regression, Wiley.

Progressive Education Society's

Modern College of Arts, Science and Commerce (Autonomous), Shivajinagar, Pune – 5

First Year of B. Sc. Physics (2019 Course)

Course Code: 19ScStaP203

Course Name: Statistical Inference - I

Teaching Scheme: TH: 3 Lectures /Week **Credit: 02**

Examination Scheme: CIA: 50 Marks **End-Sem: 50 Marks**

Prerequisite Courses

- Probability distribution theory

Course Objectives

- To teach finite sample inference tools.
- Introduction to Bayesian inference

Course Outcomes

- At the end of the course, a student learns estimation theory and testing of hypothesis theory.

Course Contents

Chapter 1		15 lectures
	1.1 Fisher information and information matrix 1.2 Concept of Sufficiency, Neyman factorization theorem, likelihood equivalence, minimal sufficiency, construction of minimal sufficient statistics 1.3 Special classes of distributions one parameter exponential family, multi parameter exponential family, Pitman family, minimal sufficient statistic for special classes of distributions.	
Chapter 2		15 lectures
	2.1 Completeness, bounded completeness, complete sufficient statistics, special classes of distributions admitting complete sufficient statistics 2.2 Ancillary statistic, Basu's theorem and its application 2.3 Estimability of parametric function, Cramer-Rao inequality, minimum variance unbiased estimators (MVUE), necessary and sufficient conditions for existence of MVUE, Minimum variance bound unbiased estimators (MVBUE), Chapman-	

	Robin Bounds (without proof), Bhattacharya Bounds (without proof), Rao- Blackwell theorem, Lehman- Scheffe theorem.	
Chapter 3		15 lectures
	3.1 Problem of testing of hypothesis, simple and composite hypotheses. randomized and non-randomized tests, most powerful test, Neyman-Pearson Lemma (with proof), power function of a test, existence of UMP tests for one-sided alternatives in one parameter exponential family and Pitman family 3.2 UMP tests for two sided alternatives, their existence and non-existence, unbiased test, UMP unbiased test, Monotone likelihood ratio property and its applications.	
Chapter 4		14 lectures
	4.1 Concept of confidence intervals, relation with testing of hypothesis, shortest expected length confidence intervals, uniformly most accurate confidence bounds. 4.2 Introduction to Bayesian estimation, prior and posterior distributions, loss functions, principle of minimum expected posterior loss, quadratic and other common loss functions, conjugate family of prior distributions and its examples.	
Chapter 5	Experiential Learning	1 lecture

Reference Books

1. Casella, G. and Berger, R. L. (2002). Statistical Inference. Duxbury Advanced Series, Second Edition.

2. Efron, B. and Hastie, T. (2016). Computer Age Statistical Inference Algorithms, Evidence and Data Science. Cambridge University Press

3. Kale, B.K. &Muralidharan, K. (2015) Parametric Inference An Introduction, Alpha Science International Ltd.

4. Lehmann, E.L. and Casella, G. (1998). Theory of Point Estimation. Springer, New York

5. Lehmann, E. L. and Romano, J. (2005). Testing Statistical Hypotheses, Springer

6. Rao, C. R. (1995). Linear Statistical Inference and its Applications, Wiley

7. Rohatgi, V. K. and Saleh, A.K. Md. E. (2001). Introduction to Probability and Statistics, John Wiley & Sons, New York.

8. Shao, J. (2003). Mathematical Statistics, Springer-Verlag, New, New York,

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Modern College of Arts, Science and Commerce (Autonomous), Shivajinagar, Pune – 5

First Year of B. Sc. Physics (2019 Course)

Course Code: 19ScStaP204

Course Name: Multivariate Analysis

Teaching Scheme: TH: 3 Lectures /Week **Credit: 02**

Examination Scheme: CIA: 50 Marks **End-Sem: 50 Marks**

Prerequisite Courses

- Matrix algebra
- Univariate statistical inference

Course Objectives

- To develop understanding of appropriate and relevant methods of multivariate data analysis.

Course Outcomes

- A student is able to perform analysis of multivariate data

Course Contents

Chapter 1		15 lectures
	1.1 Exploratory multivariate Data Analysis Sample mean vector, Dispersion Matrix, Correlation Matrix, Linear transformation and its mean and variance, graphical interpretation. 1.2 Principal component Analysis (by using covariance and correlation method, standardized method), Factor analysis (models, rotation types), Canonical correlation with real life examples.	
Chapter 2		15 lectures
	2.1 Cluster analysis (Hierarchical and Non hierarchical, Agglomerative, Single, complete, average , Wald's linkage , K-mean clustering method , qualitative method clustering) 2.2 Multivariate normal distribution, Singular and nonsingular normal distribution, mean, variance of multivariate normal distribution, independence of variables, M.G.F, Characteristic function, moments, Distribution of linear and quadratic form of normal variables, marginal and conditional distribution, multiple and partial correlation coefficient (3 random variable case) with examples on each of the topic.	
Chapter 3		15 lectures

	3.1 MLES of parameters of multivariate normal distribution and their sampling distribution, Tests and confidence region for the mean when dispersion matrix is known, 3.2 Wishart distribution (generalized case of chi-square) and its properties, Hotelling T^2statistics and uses of its distribution, Beharen- Fishers problem, confidence region for mean vector of multivariate normal distributions.	
Chapter 4		14 lectures
	4.1 MANOVA technique , Likelihood ratio test , Test for equality of dispersion matrices 4.2 Discrimenant analysis (by using prior probabilities , by using cost), Fisher Discriminate analysis, Mahalanobis D^2 Statistics	
Chapter 5	Experiential Learning	1 lecture

Reference Books

1. Anderson, T. W. (1984). Introduction to Multivariate Analysis, John Wiley

2. Fang ,K., Kotz, S., Ng K. W. (1990). Symmetric Multivariate and Related Distributions, Chapman and Hall

3. Härdle, W. K. &Simar, L. (2012). Applied Multivariate Statistical Analysis, Springer, New York

4. Härdle, W. K., Hlávka, Z. (2007). Multivariate Statistics Exercises and Solutions, Springer, New York

5. Johnson R.A. &Wichern, D.W. (1988). Applied Multivariate Statistical Analysis, Prentice Hall Inc.

6. Kotz, S., Balakrishnan N. and Johnson N. L. (2000). Continuous Multivariate Distributions, Volume 1, Models and Applications, John Wiley & Sons,

7. Kshirsagar, A. M. (1983). Multivariate Analysis, Marcel Dekker

8. Mardia,K. V. and Jupp, P. E. (2000), Directional Statistics, John Wiley & Sons

9. Morrison, D.F. (1990). Multivariate Statistical Methods, McGraw Hill Co.

Progressive Education Society's

Modern College of Arts, Science and Commerce (Autonomous), Shivajinagar, Pune – 5

First Year of B. Sc. Physics (2019 Course)

Course Code: 19ScStaP205

Course Name: Practical- II

Teaching Scheme: TH: 3 Lectures /Week **Credit: 02**

Examination Scheme: CIA: 50 Marks **End-Sem: 50 Marks**

Prerequisite Courses

- Regression analysis
- Multivariate analysis

Course Objectives

- To acquaint students with multivariate data analysis techniques using statistical software.

Course Outcomes

- After learning this course student will be able to apply regression analysis and multivariate analysis techniques to real life data.

Course Contents

Title and Content
1. Exploratory Multivariate data Analysis. (Sample mean, variance and covariance matrix, Correlation Matrix) 2. Principal component Analysis (covariance & Correlation technique and their interpretation) 3. Factor analysis (PCA., MLE, all Rotations and their interpretation) 4. Cluster analysis (Single, Complete, Average, Wards , k- mean linkage method) 5. Canonical correlation Multivariate Analysis. (Multivariate normality, Marginal, Conditional, Q-Q plot, contour plot) 6. Model Sampling from Multivariate Distribution, and computation of MLE's of Parameters. 7. Application of Hotelling T^2 Statistic 8. MANOVA technique 9. Likelihood Ratio Test(Equality of means, Equality of variance, R=0) 10. Discriminant Analysis (Fishers linear discriminant function) 11. Simple and Multiple Regression and Regression diagnosis 12. Selection of variables in Multiple regression and lack of fit 13. Transformation and weighting to correct model inadequacies. 14. Polynomial regression model (one and two regressors) 15. Multicolinarity and ridge regression. 16. Spline Regression 17. Logistic Regression 18. Poisson Regression 19. Application of Central Limit theorem and Weak law of large number